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SPECIAL ARTICLE

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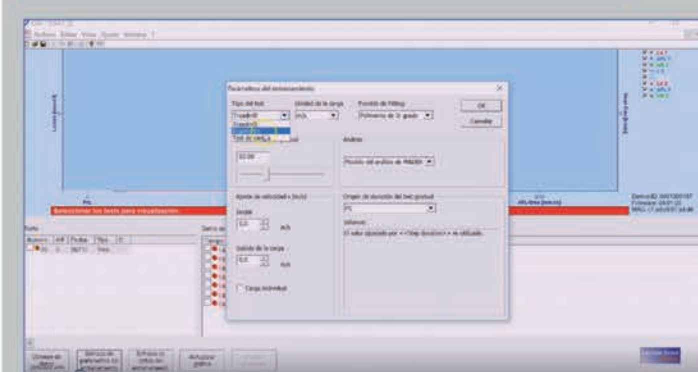

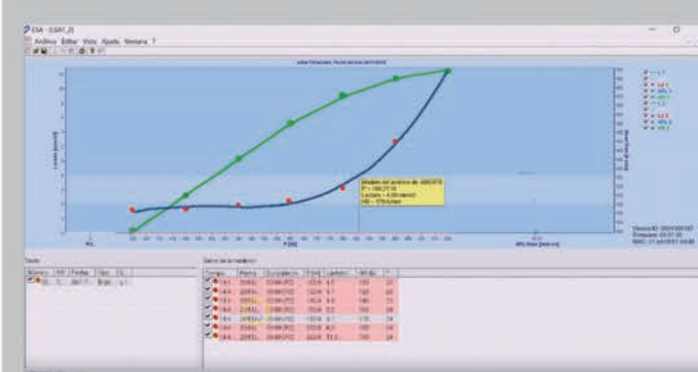

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Summary / Sumario

Jump training in sports medicine

Entrenamiento de salto en medicina deportiva

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Through evolution, several animal species, including humans, have evolved the ability to jump. Indeed, jumping actions are common for mammals, reptiles, and insects, among others. For humans, jumping allow them to perform a wide range of activities, from dancing to moon exploration. From a sports medicine perspective, jumps have been used by athletes as a training method in preparation for competitions at least in the last 3,000 years[1].

Jump training exercises

Jump training exercises (JTE) involves multi-joint drills and large muscle groups (e.g., quadriceps). Depending on the type of jump, these may involve a stretch-shortening cycle (SSC), with a considerable voluntary effort (i.e. near maximal or maximal) during the concentric portion of the jump (i.e. against the force of gravity). In addition, some jumps may also involve considerable eccentric forces upon landing, as high as 12 times body mass[2]. In this sense, highly trained athletes use some JTE most commonly, such as bounce drop jumps from relatively high drop heights (e.g. plyometrics). However, JTE can be adapted safely and effectively for older adults, children with cerebral palsy and Down syndrome, injured athletes, among other populations[3]. Adaptation strategies may involve the performance of the concentric-only portion of the jump, assistive devices (e.g., suspension training), submaximal jumps, among other. In this sense, jump training may involve a wide range of JTE, selected according to the participant's characteristics and goals, usually incorporated in a multi-component training programme (e.g., neuromuscular training), considering a long-term physical development approach.

Mechanisms of adaptation

Responses to JTE have been studied at least from the late 19th century[4]. Although concentric-only JTE may be used to induce significant responses such as increased electromyographic activation (EMG), traditional JTE involves a rapid stretch of the muscle during the eccentric portion of the SSC, stimulating the stretch reflex. The stretch reflex implicates the activation of muscle proprioceptors (e.g., muscle spindle), which might facilitate the activation of muscle fibres during the concentric portion of the jump, thus greater EMG. In addition, muscle-tendon elastic components may have a role in the storing-releasing energy process during the SSC. Further, aside from muscle-spinal responses, supraspinal mechanisms contributing to the SSC are also involved during JTE[5]. Such acute responses to JTE accumulated over time may lead to significant adaptations[6], including increased motor unit firing rate, intra-muscular coordination, inter-muscular coordination, muscle fibre hypertrophy, optimization of muscle fibres pennation angle and muscle-tendon stiffness, bone mass increase, among others. In addition, significant responses and adaptations are also achievable through JTE for biomechanical-related variables (e.g. dynamic knee control, landing impact amortization).

Physical fitness adaptations

Considering the above-mentioned physiological and biomechanical adaptations, is not surprising to observe improvements in several physical fitness outcomes after JTE programmes. In the scientific literature improvements have been reported, including muscle power, jumping (e.g. vertical, horizontal), linear sprinting (i.e. from 5-m up to 200-m), agility and change-of-direction sprint (CODs), repeated sprinting ability with and without COD, short-term endurance (e.g., up to 60-s), long-term endurance (e.g., Yo-Yo test; 3-km running time trial), reduced contact times while running, better running economy, maximal strength (e.g., dynamic; isometric), dynamic and static balance, sport-specific performance (e.g. soccer ball kicking speed), range of motion, coordination, among others[3,7].

Jump training in sports

Among youth sports, for both male and female, from pre-pubertal (e.g., <8 years old) to post-pubertal age, JTE have demonstrated be-

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neficial effects (e.g., physical fitness; physiological and biomechanical outcomes) on athletes from different sports. Such sports includes soccer, basketball, handball, volleyball, tennis, hockey, sprinters, combat sports, and artistic gymnasts, among others. The beneficial effects derived from JTE have been reported usually without adverse effects. Further, compared to adults, youth seems to experience reduced symptoms of exercise-induced muscle damage and a faster recovery after JTE[8]. Among adult athletes, for both male and female, JTE programmes have demonstrated beneficial effects on athletes from different sports, including those previously mentioned for youth athletes, in addition to swimmers, water polo, endurance runners, ice hockey, rugby, golf, netball, among others.

Jump training for health

Although commonly associated to athletes and sport competition, JTE also have demonstrated significant favourable effects on several health-related outcomes. Such improvements includes glucose metabolism markers (e.g. fasting glycaemia and insulin), fat mass reduction, skeletal muscle hypertrophy, and acute hypotensive effect. In participants with cerebral palsy and Down syndrome, improvements have been noted in neuromuscular control and body composition. During prolonged bed rest, adapted JTE preserved muscle mass and muscle power. In older adults, adapted JTE allow improvements in balance, rate of force development, maximal strength, muscle power and EMG. In addition, adapted JTE may reduce injury risk[9], through reduction in factors associated to injury, such as reduced knee abduction-adduction, improved balance, better neuromuscular control (e.g. landing technique), and reduced strength asymmetries between knee extensors/flexors. Moreover, in case of injury, JTE can be adapted and incorporated during rehabilitation programmes (e.g. neuromuscular training). Further, the incorporation of JTE in athlete's regular training schedules may reduce their injury recurrence.

Factors associated with JTE effectivity

Participant's characteristics (e.g., JTE technique proficiency; type of sport; training age; biological maturity; sex; participant nutritional/supplementation habits) are relevant factors for JTE prescription, particularly considering the inter-individual variability to JTE programmes. In addition, an adequate prescription of JTE should consider the total duration of the training programme (e.g., weeks), total volume (e.g., number of jump repetitions; foot contacts), and volume progression rate (e.g., weekly), in addition to taper strategies. Moreover, intensity and intensity markers such as reactive strength index, jump height, movement velocity, force-velocity profile, rating of perceived exertion, among other potential markers, should be considered during JTE prescription. Further, the type of JTE (e.g., bilateral; unilateral; vertical; horizontal; loaded; unloaded; combined), the JTE order randomization between training sessions, the specificity of JTE, sequencing (i.e., before vs after regular sport practice), and external load (e.g., heavy vs. light) should be also considered. Furthermore, the type of surface (e.g., wood; grass), recovery duration (e.g., inter-session; inter-JTE; inter-set; inter-repetition) and type of recovery (e.g., cluster set vs traditional set; active vs passive) may also affect the outcomes of a JTE programme. Additionally, the combination of JTE with other training methods, such as heavy resistance training (e.g., complex training) may be effective, potentially due to post-activation potentiation or post-activation performance enhancement mechanisms, with the advantage of combining training methods in a relatively short time period.

Potential advantages over other training methods

Although several training approaches are used to improve physical fitness and health outcomes, JTE seems to be equally (or even more) effective compared to other training methods (e.g., traditional resistance training) for the improvement of several outcomes[3,7]. In addition, the implementation of JTE may be inexpensive compared to other resistance training methods, requiring little or no equipment, usually involving drills with the body weight used as resistance. Additionally, JTE may be conducted in a relatively small physical space, which may be an important advantage during certain scenarios (e.g. encountering pandemic restrictions) where athletes may be forced to train at their homes[10]. Moreover, JTE may be considered more fun compared to other training methods (e.g., flexibility, endurance), particularly among younger athletes[11]. Further, JTE may reduce the risk of injury[12]. However, rather than an independent entity, JTE should be a component of an integrated approach to training, which targets multiple physical fitness and health attributes and aligns with the goals of long-term physical development strategies.

Research gaps and future research areas

Although JTE have been used by athletes at least in the last 3,000 years, the scientific literature regarding the acute effects of JTE seems to have emerge more recently (i.e., late 19th century)[4], and the study of the adaptations to JTE programmes even more recently (i.e. middle of the 20th century)[13]. Indeed, there seems to be a paucity of scientific literature related to the factors associated with JTE dose-response relationship[3,7]. In addition, it is relatively common among published articles related to JTE to include small sample sizes (i.e. ~10 participants per group), incomplete description of JTE, and lack of control and/or group randomization, among other methodological shortcomings. In this scenario, further efforts are needed to solve important gaps in knowledge related to JTE, particularly those related to dose-response relationship in different populations, involving long-term programmes (e.g., >12 weeks) and/or multi-component interventions, and associated mechanisms of adaptations.

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Original article

Study of the high prevalence and cardiovascular risk factors: students aged 11 to 16 years from Caceres-Spain and Paranavaí-Brazil

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Summary

Objective: to investigate the association of risk factors for the development of cardiovascular diseases in students from 11 to 16 years old in different contexts.
Material and method: Sample composed by students of Cáceres - Spain (n = 165) and Paranavaí - Brazil (n = 237). Body Mass Index, level of physical activity, blood pressure, total cholesterol, low- and high-density lipoproteins, triglycerides and fasting blood glucose were analyzed. For the analysis of variables, the Kolmogorov-Smirnov tests, Student t, Mann-Whitney U, Chi-square, and Odds Ratio were used, with a 95% confidence interval, a value of p <0.05 was considered statistically significant.
Results: Spanish students have higher average values of age, physical activity level, obesity in general, low- and high-density lipoproteins and fasting blood glucose (p <0.05). Brazilians had a greater accumulation of risk factors compared to the Spanish, specifically only 8.5% of Brazilians are exempt from RF compared to 28.2% of Spanish. It is observed that there is a higher prevalence of two RFs (G-BRA: 40.7% vs. G-ESP: 24.2%); and three or more RF (G-BRA 27.0% vs. G-ESP: 13.7%), considering a value of p <0.001. Being more active was associated with HDL levels among Brazilians. Although Spanish students had a higher prevalence of general obesity, they were more active.
Conclusion: Spanish students showed better results in physical activity levels, fasting glucose concentration, high and low density lipoproteins, in addition to a lower number cardiovascular risk factors, despite being mainly from public schools; with higher average age and higher general obesity prevalence, compared to Brazilians.

Key words:
Exercise. Cardiovascular diseases. Risk factors. Students.

Estudio de alta prevalencia de factores de riesgo cardiovasculares: estudiantes de 11 a 16 años de Cáceres-España y Paranavaí-Brasil

Resumen

Objetivo: Investigar la asociación de factores de riesgo para el desarrollo de enfermedades cardiovasculares en estudiantes de 11 a 16 años en diferentes contextos.
Material y método: Muestra compuesta por estudiantes de Cáceres - España (n = 165) y Paranavaí - Brasil (n = 237). Se analizaron el Índice de Masa Corporal, el nivel de actividad física, la presión arterial, el colesterol total, las lipoproteínas de baja y alta densidad, los triglicéridos y la glucosa en sangre en ayunas. Para el análisis de variables, se utilizaron las pruebas de Kolmogorov-Smirnov, *t* de Student, U de Mann-Whitney, Chi-cuadrado y *Odds Ratio*, con un intervalo de confianza del 95%. Un valor de p<0,05 fue considerado estadísticamente significativo.
Resultados: Los estudiantes españoles tienen valores promedio más altos de edad, nivel de actividad física, obesidad en general, lipoproteínas de baja y alta densidad y glucosa en sangre en ayunas (p<0.05). Los brasileños tuvieron una mayor acumulación de Factores de Riesgo en comparación con los españoles, específicamente solo el 8,5% de los brasileños están exentos de Factores de Riesgo en comparación con el 28,2% de los españoles. Se observa que existe una mayor prevalencia de dos Factores de Riesgo (G-BRA: 40,7% *vs*. G-ESP: 24,2%); y tres o más Factores de Riesgo (G-BRA 27,0% *vs*. G-ESP: 13,7%), considerando un valor de p<0,001. Ser más activo se asoció con los niveles de lipoproteínas de alta densidad entre los brasileños. Aunque los estudiantes españoles tenían una mayor prevalencia de obesidad general, eran más activos.
Conclusión: Los estudiantes españoles mostraron mejores resultados en niveles de actividad física, concentración de glucosa en ayunas, lipoproteínas de alta y baja densidad, además de un menor número de factores de riesgo para enfermedades cardiovasculares, a pesar de que provienen en su mayoría de escuelas públicas; con mayor edad media y mayor prevalencia de obesidad general.

Palabras clave:
Ejercicio. Enfermedades cardiovasculares. Factor de riesgo. Estudiantes.

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Introduction

Cardiovascular risk factors (RF) can be classified as unchangeable - such as inheritance, sex and age - and changeable - such as level of physical activity (LPA); Body Mass Index (BMI); blood pressure (BP); the plasma concentrations of total cholesterol (TC), of triglycerides (TG), high density lipoprotein (HDL) and fasting glucose (FG). A lack of physical activity is an important risk factor (RF) of morbidity and premature mortality, as well as the high costs of medical assistance associated with hypokinetic pathologies[1]. Cardiovascular diseases (CVD) can be linked to a lack of physical activity, particularly regarding diseases of multi factor-origin[2].

Society's lifestyle exposes its youngest members to RF at an extremely early age, leaving them vulnerable to develop morbidities that can continue well into adulthood. Infancy and adolescence are characterised as suitable periods for developing interventionist strategies in the fight against CRF, once there is scientific evidence that these illnesses may originate during this stage of life[2]. The careful planning and effective execution of interventions focused on promoting health, aiming to reduce the probability of suffering from CVD in adulthood, can be efficient with the early identification of the presence of these RF in children and young people[3].

The lifestyle of children and adolescents in different countries, such as Spain and Brazil, is directly linked to the obesogenic setting, as both Brazilians and Spaniards are influenced - for diverse reasons - to adopt unhealthy behavioural habits[4]. The obesogenic environment is characterised by the influence that the surrounding conditions have on opportunities and the lifestyle choices of individuals, which facilitate the development of obesity, as well as adopting inappropriate food choices and sedentary behaviour.

The option of carrying out a study linked to the lifestyle of children and adolescents from two mainland cities, was determined by the fact participants belonged to countries with differences, such as: country size, the number of inhabitants in the country, as well as cultural, social and economic differences, whilst also displaying similarities such as the number of schools and inhabitants in the city, and the strong Spanish influence - as colonizer of the city of Paranavaí[5] - bringing with it a similar yet geographically distant genetic inheritance, and above all, a lack of other research studies of these characteristics.

Comparisons related to the incident/prevalence rate of HR predisposing to CVD carried out on students from countries with the characteristics of this research study are relatively scarce, i.e., according to information from the United Nations[6], they can be found in different conditions of human development, with a Human Development Index (HDI) of values ranging from 0 to 1, considering health, income and education indicators. The closer to 0, the worse the human development of the city; in this perspective, the city of Cáceres (Spain) presented an HDI of 0.876 (very high), and the city of Paranavaí (Brazil), an HDI of 0.755 (high).

High-risk behaviour for cardiovascular health influenced by socio-demographic characteristics should be considered when promoting the health of children and adolescents[7]. An appropriate analysis of the prevalence of RF of changeable illnesses, both among Spanish and Brazilian students, far from large cities, is relevant in determining the prevalence and understanding the behaviour of these factors in these demographics, allowing for the innovation and re-development of interventions towards a healthy lifestyle.

In this respect, the aim of this study was to research the link between LPA and RF in the development of CVD in students aged 11 to 16 years in different contexts.

Material and method

This is a cross-cutting observational research study[8]; the sample groups comprised students from state and private schools in Spain and Brazil. In Spain, the data was collected between May and September 2015, from students in their 1st-3rd year of compulsory secondary education, whilst data was collected in Brazil in Paranavaí between July and August 2013, from students in their 6th year of primary education - 1st year of compulsory secondary education.

The sample size comprised 80 individuals, estimated a priori using G*Power software, version 3.1.9.2[9] with an alpha level defined at 0.05 and a statistical power of 95%.

The students that fulfilled the following criteria were included in the sample selection: aged between 11 and 16 years on the date of data collection; having signed a consent form to participate in the research study with their parents or legal guardian(s); participation in all the tests linked to the study; a school attendance rate of at least 75% on the date of data collection. All the students in the classes selected were invited to participate in the research study, however, those that did not fulfil the aforementioned inclusion criteria were excluded, as well as those that had any kind of impediment to performing sports - particularly health related - except for problems that constituted the focus of this research study Figure 1.

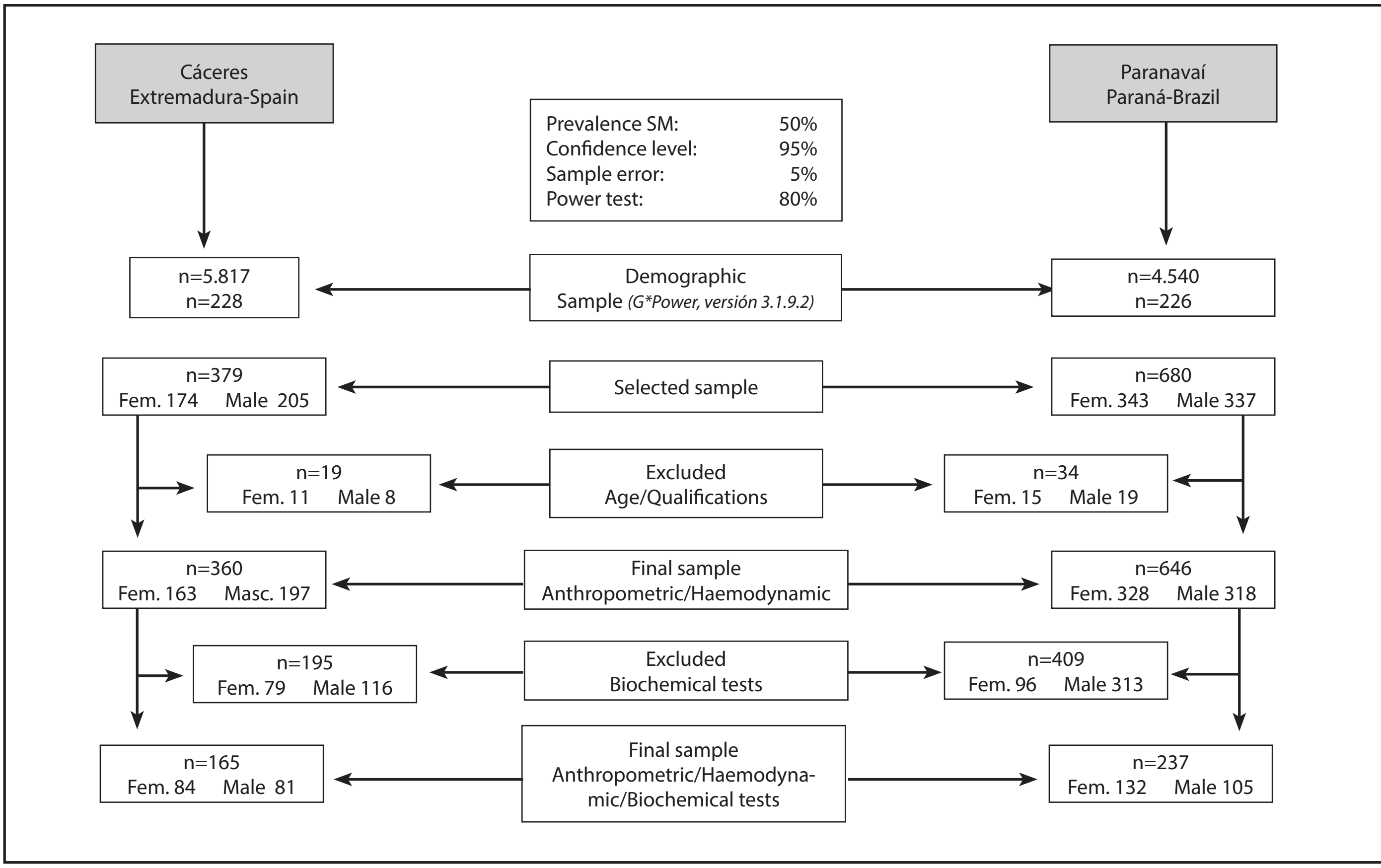
The predisposing RF to CVD analysed were LPA, determined as a behavioural-type factor, and in the biological field, information was used to discover the BMI, the resting BP, and circulating blood levels of CT, HDL, TG and FG.

The information about the LPA was assessed using the International Physical Activity Questionnaire – (IPAQ-A) modified for adolescents[10], referring to the previous week (barely active <300 min./week)[11].

Standing height was measured, using an aluminium stadiometer attached to scales with a reading precision of 0.01m; body mass was recorded in kg using a Filizola brand mechanical weighing scale, with 100 g precision, and a maximum capacity of 150 kg; the body mass index (ratio between body mass in Kg and the height squared in m.), in accordance with the cut-off points adjusted by age and sex proposed by Cole, *et al*[12].

The blood pressure measurement was taken using a correctly calibrated and validated instrument. Study participants remained seated for at

Figure 1. Representation diagram of the sample of students, SPA-G (2015) and BRA-G (2013).



least five minutes, with their feet on the ground and their arms resting at chest height. An appropriate-sized cuff was used (which circled at least 80.0% of the arm). Two measurements were taken: systolic blood pressure (SBP) and diastolic blood pressure (DBP), recorded using the auscultation method with the help of a mercury column blood pressure cuff, adaptable to the students' arm circumference size, taken whilst seated for at least five minutes. Two measurements were taken, the average score of which was used for the analysis corresponding to this study variable (high BP≥ 90 percentile)[13].

Serum levels of TC, HDL, TG and FG were measured using the colorimetric enzymatic method, with Gold Analisa kits. The Brazilian students underwent laboratory tests in the LEPAC and the Inflammation Laboratory of the Universidade Estadual de Maringá (UEM), whilst the Spanish students were tested in private laboratories in Cáceres. For the biochemical analyses, 10 ml samples of venous blood in the ulnar artery vein were taken, following a fasting period of at least 10 hours. Levels were considered of RF TC ≥ 200 mg/dL; HDL < 40 mg / dL; TG ≥ 150 mg/dL and FG ≥ 100 mg/dL[14].

The data collected was handled using the computerised package *Statistical Package for the Social Science* (SPSS), version 26.0. To analyse the numerical variables, descriptive statistic procedures were used (absolute and relative frequency), then, depending on the results of the Kolmogorov-Smirnov normality test, to identify the differences between sexes, the Student *t* test (averages comparison) was performed, along with the Mann-Whitney U test (distribution functions) for the variables with parametric and non-parametric distributions, respectively. Categorical variables (proportion based on the considered cut-off points) were analysed using crossed tables, with Chi-squared (X^2) and Cramer y Phi[15] V tests, to identify statistical differences between the groups (Bonferroni method)[16]. The Odds Ratio (OR) estimations, with a confidence interval of 95%, were performed to analyse the links between the different RF. A value of $p < 0.05$ was considered statistically significant for all the analyses.

The intervention protocols were authorised in Brazil by the Ethics Committee for research involving humans of the Universidade Estadual de Maringá, section 353,552, and in Spain by the Bioethical and Biosafety Commission of the University of Extremadura, registry number 52/2015. All parents or tutors of the students under 18 years, signed a free and informed consent form.

Results

165 students participated in the study in Cáceres Extremadura-Spain (SPA-G), 51.6% were boys, more than half aged between 15-16

years (53.2%), from state compulsory secondary education centres (80.6%). In Paranavaí, Paraná, Brazil (BRA-G) 237 students participated, of which 56.1% were girls, aged between 11-12 years (48.7%), from a private primary education centre (55.0%).

When comparing the groups, it was observed that the distribution of the variables for the markers associated with the RF in CVD was not the same, except between the average DBP values. The Spanish students had higher average values for: age, LPA, general obesity, plasma levels of HDL, LDL, and fasting glucose, as well as lower average values for: TC and TG compared to the Brazilian students. ($p<0.05$), results displayed in Table 1.

The comparisons between the proportions of students that presented cardiovascular risk indicators are displayed in Table 2. Both groups revealed a high prevalence of the majority of RF associated with CVD, with some values favourable to the students from the SPA-G - such as the proportion of "not very active" (40.3% compared to 51.9%, $p = 0.046$) - and subjects with high TC (3.2% vs. 46.0%, $p<0.001$) for Spanish and Brazilian students, respectively. No statistical differences were found between the proportions of the remaining RF.

The results of the simultaneous presence of one or more RF for CVD in each of the students and their respective proportions, are displayed in Figure 2. The BRA-G students displayed results with greater RF accumulations compared to the SPA-G, specifically, only 8.5% of the Brazilian students are free from RF compared to 28.2% of the Spanish students. Likewise, there is a higher prevalence of the two RF (BRA-G: 40.7% *vs.* SPA-G: 24.2%); and three of more RF (BRA-G 27.0% *vs*. SPA-G: 13.7%), considering a value of $p < 0.001$. With the complementary analysis of the number of RF by sex, statistically significant differences were observed, which continued in the two sub-groups; both the girls and boys from Spain had a lower prevalence in accumulating RF compared to the students from the BRA-G.

The association between LPA and biological indicators predisposing to CVD is displayed in Table 3. Just one link was observed between HDL and LPA in the BRA-G, with more active students approximately 3 times

Table 1. Description of the averages, means and tests referring to risk factors for cardiovascular disease, SPA-G (2015) and BRA-G (2013).

	G-SPA (n=165)			G-BRA (n=237)			
	Average ± dp	**Median**	**(min - max)**	**Average ± dp**	**Median**	**(min - max)**	***p*-value**
Age (years)	14.4 ± 1.2	14.6	(11.3-16.4)	12.7 ± 334.6	12.5	(10.6-16.4)	0.001**
LPA (min/week)	466.9 ± 386.1	360.0	(0-2310)	387.4 ± 334.7	270	(30-1470)	0.025**
BMI (Kg/m2)	21.0 ± 3.3	20.5	(15.0-3.3)	20.1 ± 3.6	19.7	(12.3-31.8)	0.009**
SBP (mmHg)	115.1± 13.4	114.3	(77-145)	111.1 ±15.9	111.0	(68-152)	0.018*
SBD (mmHg)	64.5± 8.4	64.7	(49.5-94)	65.5 ±12.3	64.0	(40-103)	0.730**
TC (mg/dL)	155.6 ± 22.7	154.0	(106-220)	200.0 ± 44.4	195.8	(98.2-317.4)	0.001*
HDL (mg/dL)	55.9 ± 12.0	56.0	(29-92)	49.0 ± 6.8	49.6	(29.9-61.8)	0.001**
LDL (mg/dL)	84.5 ± 19.9	85.0	(36-156)	59.6 ± 39.1	62.0	(6.4-192)	0.048**
TG (mg/dL)	76.4 ± 32.8	66.5	(27-218)	85.6 ± 42.2	74.5	(32.3-277.6)	0.048**
FG (mg/dL)	91.4 ± 6.0	91.0	(78-115)	78.8 ± 16.7	77.5	(45.1-121.2)	0.001**

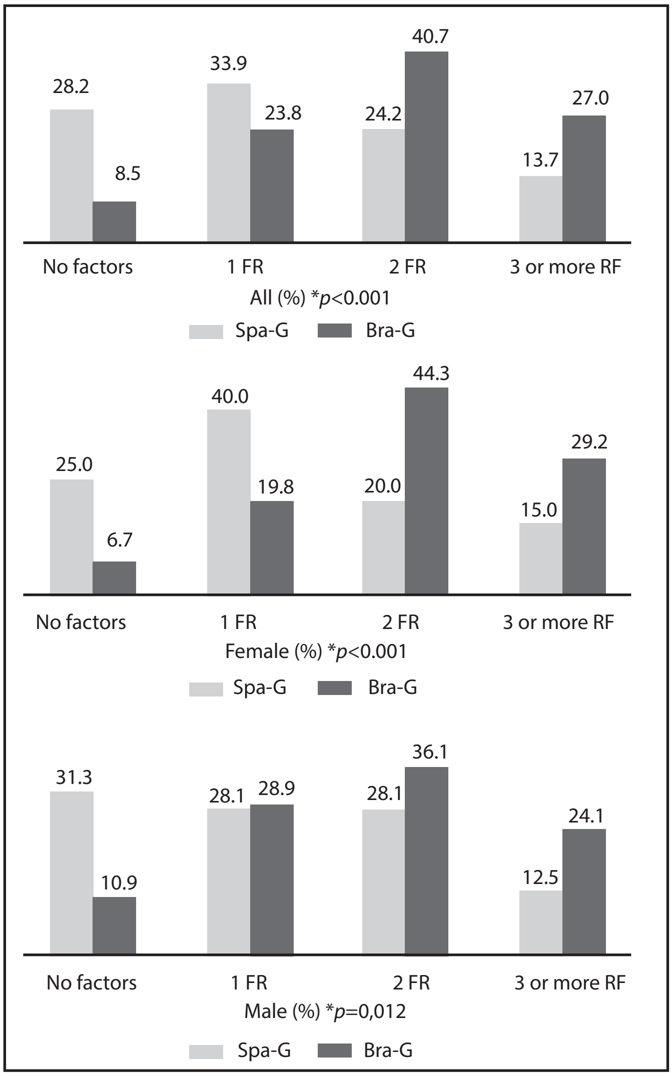
LPA: level of physical activity; BMI: Body Mass Index; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; HDL: high density lipoprotein; TG: triglycerides; FG: fasting glucose; SPA-G: Spanish Group; BRA-G Brazilian Group; SD: standard deviation. *t-Student Test; **Mann-Whitney Test.

Table 2. Proportion (%) of students that presented risk factors predisposing to cardiovascular diseases, SPA-G (2015) and BRA-G (2013).

	SPA-G (n=165)		BRA-G (n=237)			
	f	**(%)**	**f**	**%**	**X^2**	***p*-value**
LPA (<300 min/week)	66	40.3	123	51.9	3.993	0.046
BMI (≥25 Kg/m²)	37	22.6	59	24.9	0.215	0.643
BP (≥ 90 percentile)	47	28.2	74	31.2	0.319	0.572
TC (≥200 mg/dL)	5	3.2	109	46.0	66.534	<0.001
HDL (< 40 mg/dL)	9	7.3	23	9.5	0.488	0.485
LDL (≥130 mg/dL)	3	1.6	10	4.2	1.662	0.197
TG (≥150 mg/dL)	25	15.3	54	22.8	2.601	0.107
FG (≥100mg/dL)	12	7.3	30	12.7	2.350	0.125

LPA: level of physical activity; BMI: Body Mass Index; BP: blood pressure; TC: total cholesterol; HDL: high density lipoprotein; TG: triglycerides; FG: fasting glucose; SPA-G: Spanish Group; BRA-G: Brazilian Group; X2: Chi-squared Test.

Figure 2. Proportion (%) of students that simultaneously presented Risk Factors predisposing to cardiovascular diseases, SPA-G (2015) and BRA-G (2013).



*Statistically significant difference between groups.

more likely to have higher HDL serum levels than their peers (CI 95%): 1.059-9.078; p=0.039), with no other significant link between the other RF in any of the groups.

Discussion

When analysing the group averages, it was confirmed that regarding the RF for CVD, there were no differences between the DBP values, differing from trends found in other studies[17]. In turn, differences were found for the other averages, supporting findings from other epidemiological research studies also carried out on a demographic of students of a similar age[18]. These differences can be explained due to the typical hormonal changes that take place in this age group in both sexes[19]. For example, the temporary high concentration of TC and its fractions is due to a higher production of oestrogen occurring in females at this stage; whilst the greater production of testosterone in boys is linked to higher blood pressure levels[20]. Cultural, environmental and social models inherent to each region or country can also influence, and perhaps explain, the differences between the studies[21].

The TG values found were lower than those from other research studies[22]; also differing from an epidemiological study that did not find any differences between the averages[23]. The Spanish students revealed higher BMI and LPA averages than their Brazilian counterparts (21.0 ± 3.3 *vs*. 20.1 ± 3.6, p = 0.009) and (466.9 ± 386.1 *vs.* 387. 4 ± 334.7, p = 0.025) respectively, results that could be linked to the older average age of the SPA-G students.

On the other hand, when analysing the proportions found in the groups, high prevalence of physical inactivity observed in the two groups (SPA-G= 40,3%, BRA-G = 51.9%, p = 0.046), coinciding with a research study which in turn, revealed that girls were less active than boys[24]. The proportion of overweight and obese students (SPA-G = 22.6%, BRA-G = 24.9%, p = 0.643) is an aggravating factor, considering that excess body weight during childhood and adolescence usually becomes entrenched with

Table 3. Association between LPA and predisposing indicators to cardiovascular diseases, in students, SPA-G (2015) and BRA-G (2013).

	SPA-G (n=165)			BRA-G (n=237)		
	Value	(low-upp)	p-value	Value	(low-upp)	*p*-value
BMI (≥25 Kg/m²)	0.635	(0.261-1.548)	0.318	0.764	(0.395-1.480)	0.425
BP (≥perc. 90)	1.157	(0.524 90-2.558)	0.718	1.149	(0.620-2.130)	0.658
TC (≥200 mg/dL)	0.483	(0.049-4.780)	0.534	0.991	(0.559-1.756)	0.974
HDL (< 40 mg/dL)	0.833	(0.212-3.269)	0.794	3.100	(1.059-9.078)	0.039
LDL (≥130 mg/dL)	1.490	(0.091-24.385)	0.780	1.577	(0.366-6.796)	0.541
TG (≥150 mg/dL)	1.405	(0.526-3.751)	0.498	0.855	(0.433-1.689)	0.653
FG (≥100mg/dL)	1.200	(0.306-4.707)	0.794	0.625	(0.263-1.488)	0.288

BMI: Body Mass Index; BP: blood pressure; TC: total cholesterol; HDL: high density lipoprotein; LDL: low density lipoprotein; TG: triglycerides; FG: fasting glucose; SPA-G: Spanish Group; BRA-G: Brazilian Group; confidence interval; Low: lower; Upp: upper.

adulthood: just 20% of individuals tend to reduce and maintain body weight within expected levels when adults[25].

Students that perform very little physical activity can be influenced to simultaneously adopt other types of behaviour that are harmful to their health, such as smoking and/or alcohol consumption, sedentary lifestyles and the consumption of unhealthy foods; in this respect, the early prevention and monitoring of weight can be effective alternatives to fight most of these issues[26].

The elevated BP proportions (SPA-G = 28.2%; BRA-G = 31.2%; $p = 0.572$) are higher values than those found in similar studies carried out in Latin America[27] and Spain[28]. Related longitudinal studies regarding BP have demonstrated that young people with high BP levels tend to maintain these high levels and are diagnosed with high blood pressure in adulthood[29]. These high BP levels suggest that it could be a common characteristic in this age group (11-16 years).

The indicators associated with abdominal obesity - an important cardiovascular risk factor - were studied in the same sample and have been published in another article[30]. Another situation that requires special attention is the large proportion of students that displayed at least one RF predisposing to CVD (SPA-G = 71.8%, BRA-G = 91.5%), with the subgroup of BRA-G girls deserving particular attention due to the number of students exempt from RF (25.0% *vs*. 6.6%; $X^2 = 23.280$; $p < 0.001$; SPA-G *vs*. BRA-G, respectively). The possibility of CRF appearing and developing early is greater when there is a higher number of accumulated RF (three or more: SPA-G = 13.7%, BRA-G = 27.0%), even more concerning with scientific evidence that these RF identified during adolescence tend to remain in the future[31]. Likewise, the simultaneous presence of two or more RF is a highly noteworthy result in both groups, given the extremely young age of the subjects.

In the BRA-G, the least active students displayed a lower concentration of HDL than those with sufficient activity levels. This result supports the epidemiological study suggesting better results related to HDL concentration among those considered more active[32]. HDL levels tend to lower during adolescence in both sexes, but they are more accentuated among boys[33].

The groups presented similar characteristics in terms of a high prevalence of RF, not revealing links between the RF. On the other hand, it should be noted that the results from the Spanish students revealed that, even with a higher prevalence of excess weight, they were more active than their Brazilian peers.

In this study, particular attention could be given to the fact that similarities and differences were objectively presented between students from different countries, in terms of cultural, social and economic aspects, from an inland Spanish city compared to a city colonised by the Spanish located in inland Brazil. The research study provides results that confirm the increase of cardiovascular RF prevalence in samples of students aged 11 to 16 years, results that could be useful for developing and developed countries alike.

The methodology used and the use of instruments translated and adapted to assess the LPA and the analysis of the other RF, were the same in both groups. The students participating in the study were constrained to a narrow age band, a factor that could help minimise the potential effects of the pubertal differences in the parameters measured.

The cross-cutting conception of the research does not provide evidence about the causes, merely the presence or not of associations between the study variables; however, the results indicated the existence of occasional yet crucial differences, particularly regarding the RF.

Targeted efforts are necessary to benefit fully from this life phase, in which girls and boys are receptive to incorporating healthy lifestyle practices through to adult age, by developing actions in each of these countries in the context of school[34], socio-familiar, in the media, and by competent authorities designing regular and on-going educational programmes.

The prevalence of CVD RF found in Spanish and Brazilian students is concerning, both given the complexity of these factors as well as due to the students being young children, meaning they may be exposed to these factors for a much longer time, favouring undesirable outcomes in terms of health.

The SPA-G students were slightly older and were mostly from state schools, and, in theory, should have revealed worse results than their Brazilian counterparts. Countries with worse human development indices present less healthy data in cardiovascular risk factors, with the exception of the USA[35]. This result is considered to be linked to the type of environment in which the students live and are exposed to, as well as sedentary lifestyles and unhealthy eating habits

Conclusion

The Spanish students revealed better results in physical activity levels, fasting glucose concentration, high and low density lipoproteins, as well as a lower number of risk factors for cardiovascular diseases, despite most of the students attending state schools, with an older average age and higher prevalence of general obesity compared to the Brazilian students. It is key to encourage students to improve their lifestyles to reduce the evolution of these RF, and to develop strategies that lead to reduced risks, for example, in the form of regular physical exercise and a healthy diet.

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Conflict of interest

The authors claim to have no conflict of interest whatsoever.

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Study on the differences in quantitative ultrasound of the quadriceps between schoolchildren who practise different sports

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Summary

Objective: To evaluate the differences in quantitative ultrasound of the quadriceps in a sample of schoolchildren who practise different sports.
Material and method: A transversal, comparative and non-randomised study was carried out with an intentional sample of 184 schoolchildren, aged between 7 and 10 years. The sample was divided into three groups based on the sport practised: a) only soccer; b) volleyball, basketball, swimming, gymnastics and cheerleading; and c) no sport practised. The eco-intensity, thickness and pennation angle of some components of the quadriceps (rectus femoris, vastus lateralis and vastus intermedius) were measured using B-mode ultrasound imaging.
Results: There were significant differences between the 3 groups of children in the variables that measure the quality of the muscle: eco-intensity and fat percentage of the rectus femoris ($p < 0.05$), muscle thickness of the anterior ($p< 0.05$) and lateral ($p< 0.01$) vastus intermedius, and in the pennation angle of the rectus femoris (ARF) ($p< 0.05$) and of the vastus lateralis (AVL) ($p< 0.01$). Between groups b and c there were differences in the ARF in boys ($p< 0.01$) and in the AVL in girls ($p< 0.05$).
Conclusion: The way in which sport initiation is carried out in children between 7 and 10 years of age may cause differences in the quadriceps muscle, which can be demonstrated through the use of quantitative ultrasound. Moreover, such differences are related to the duration and frequency of the stimulus, which becomes a qualitative aspect to be considered when programming the training contents at these ages.

Key words:
Child. Ultrasonography. Sports. Muscle development. Quadriceps muscle.

Estudio sobre las diferencias en ecografía cuantitativa del cuádriceps entre escolares practicantes de diferentes modalidades deportivas

Resumen

Objetivo: Evaluar las diferencias en ecografía cuantitativa del cuádriceps en niños y niñas escolares practicantes de diferentes deportes.
Material y método: Se realizó un estudio transversal, comparativo y no aleatorizado. Se utilizó una muestra intencional compuesta por 184 niños escolares, entre 7 y 10 años. La muestra fue dividida en tres grupos según la modalidad deportiva practicada: a) un grupo que solo practicaba fútbol; b) otro grupo donde practican voleibol, baloncesto, natación, gimnasia y *cheerleading;* y c) un grupo que no practican ninguna modalidad deportiva. La eco-intensidad, el espesor y el ángulo de penneación de algunos componentes del cuádriceps (recto femoral, vasto lateral y vasto intermedio) fueron medidos usando una ecografía en modo-B.
Resultados: Hubo diferencias significativas al evaluar los 3 grupos en los niños, en las variables que miden la calidad del músculo: Eco-intensidad y porcentaje de grasa del recto femoral (v.p.< 0,05), el espesor muscular del vasto intermedio tanto anterior (v.p.< 0,05), como lateral (v.p.< 0,01), y en el ángulo de penneación del recto femoral (ARF) (v.p.< 0,05) y del vasto lateral (AVL) (v.p.< 0,01). Entre los grupos b y c se encontraron diferencias en el ARF en niños (v.p.< 0,01) y en el AVL en niñas (v.p.< 0,05).
Conclusión: La forma en la que se realice la iniciación deportiva en niños entre 7 y 10 años puede generar diferencias en el músculo del cuádriceps, que pueden hacerse evidentes mediante el uso de la ecográfica muscular cuantitativa. Esos cambios están además relacionados con la duración y la frecuencia del estímulo, lo cual supone un aspecto cualitativo para tener en cuenta durante la programación de los contenidos de entrenamiento en estas edades.

Palabras clave:
Niños. Ultrasonografía. Deportes. Desarrollo muscular. Músculo cuádriceps.

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Introduction

Skeletal muscle in growing children has not been thoroughly studied due to the requirement of invasive methods, such as biopsies, which, for ethical reasons, cannot be applied in minors. However, advancements in imaging techniques have progressively changed the situation and, nowadays, studies are being conducted with children and adolescents, even longitudinal studies, to analyse the muscle tissue at the metabolic and biochemical levels with magnetic resonance (MRI)[1], although there are still few data available. According to these studies, the estimated growth rate in the arm and leg muscle thickness of schoolchildren is similar before adolescence. During childhood, the muscle fiber of boys and girls has a similar diameter, and it is during adolescence when the adult fiber thickness is reached[2].

To evaluate the evolution of skeletal muscle in growing children, different measurements have been employed, such as muscle strength, muscle power, anthropometry, magnetic resonance imaging (MRI), computerised tomography (CT) and ultrasonography (US). US and dual energy x-ray absorptiometry (DEXA) can provide beneficial reference information for the follow-up of adaptations to training, nutritional regimes and injuries[3,4]. Some studies have demonstrated that the effects of strength training on the physiological cross-sectional area of the muscle and on strength in children have a similar direction and a different magnitude with respect to adults[5]. It has also been reported that muscle strength, muscle thickness and eco-intensity (EI) (the latter two measured by US) are affected by changes in body weight, height and age in minors. This influence only shows relevant changes in muscle strength and muscle thickness, since little is known about changes in muscle quality measured by EI. The few studies that have analysed these effects show significant changes in healthy children[6]. EI in adults increases along the years, whereas in children it is not associated with age. That is, throughout childhood, during the normal development of the muscles, EI does not change significantly[7,8]. In any case, there is little information about the effects of physical activity and sport training on muscle quality measured by US through EI.

Studies based on the evaluation of strength reveal that muscle quality is similar between genders during childhood, evidenced by the lack of differences when strength is expressed in relation to muscle mass or to the physiological cross-sectional area (PCSA). PCSA is a great predictor of strength in children[9] and muscle thickness measured by US, which is easy to carry out, has an excellent correlation with PCSA[10]. In fact, between 5 and 10 years of age, children accumulate lean body mass at a similar rate. However, environmental factors, particularly the intensity and duration of physical activity, are related to the small differences in motor performance that appear between genders at that age range[11].

The way in which schoolchildren are initiated in sports can be approached from different perspectives. On the one hand, specific or vertical initiation is characterised for focusing on the acquisition of learning and technical-tactical elements of a specific sport. Since there is a repetition of movements during the acquisition of such execution patterns, there is also specific stimulation of the muscle groups involved in those movements. On the other hand, there is a horizontal or non-specific initiation, also known as multisport initiation[12], which focuses on making use of the common characteristics of several sports, with the aim of acquiring competences and learning that can be extrapolated to other sports. Since there is variability in the proposed technical-tactical situations, the stimulation of the muscles involved in those movements is also multiple, and less specialised.

Therefore, the hypothesis proposed in this work is that the way in which a person is initiated in sports may influence the development of some of the muscles involved in the most repeated movements. Thus, the aim of the present study was to analyse the differences in quantitative ultrasound of the quadriceps in children who had been initiated in sports in different ways.

Material and method

Participants

The study was conducted in an intentional sample of 184 schoolchildren, 75 girls (9.41±0.91 years old) and 109 boys (8.97±1.14 years old), from two sports initiation schools and a primary education school of Medellin, Colombia. The exclusion criteria considered were: the presence of cardiovascular or metabolic disease, muscle-bone lesions or sexual maturation self-reported Tanner stage different from 1[13]. The children and their parents signed an informed assent and consent, respectively. The study protocol was approved by the ethics committee of the Jaime Isaza Cadavid Colombian Polytechnic University. The characteristics of the participant groups are shown in Table 1.

Table 1. Descriptive statistics.

	Boys			Girls		
	Soccer	Multisport	No sport	Soccer	Multisport	No sport
n	81	15	13	1	43	31
Age (years)	8.9±1.16	9.2±1.04	9.8±0.55	10.7	9.1±1.07	9.8±0.55
Hight (cm)	133.8±8.61	134.9±8.12	137.9±7.08	138	134.7±8.07	138.3±7.23
Weight (Kg)	31.5±8.40	32.5±7.79	34.9±6.65	29.4	32.2±7.81	34.9±6.62
Fat %	16.23±7.07	17.23±6.63	18.81±5.95	10.07	17.06±6.70	18.64±5.89
BMI (Kg/m^2)	17.4±3.19	17.7±2.96	18.3±2.90	15.44	17.6±3.05	18.2±2.85

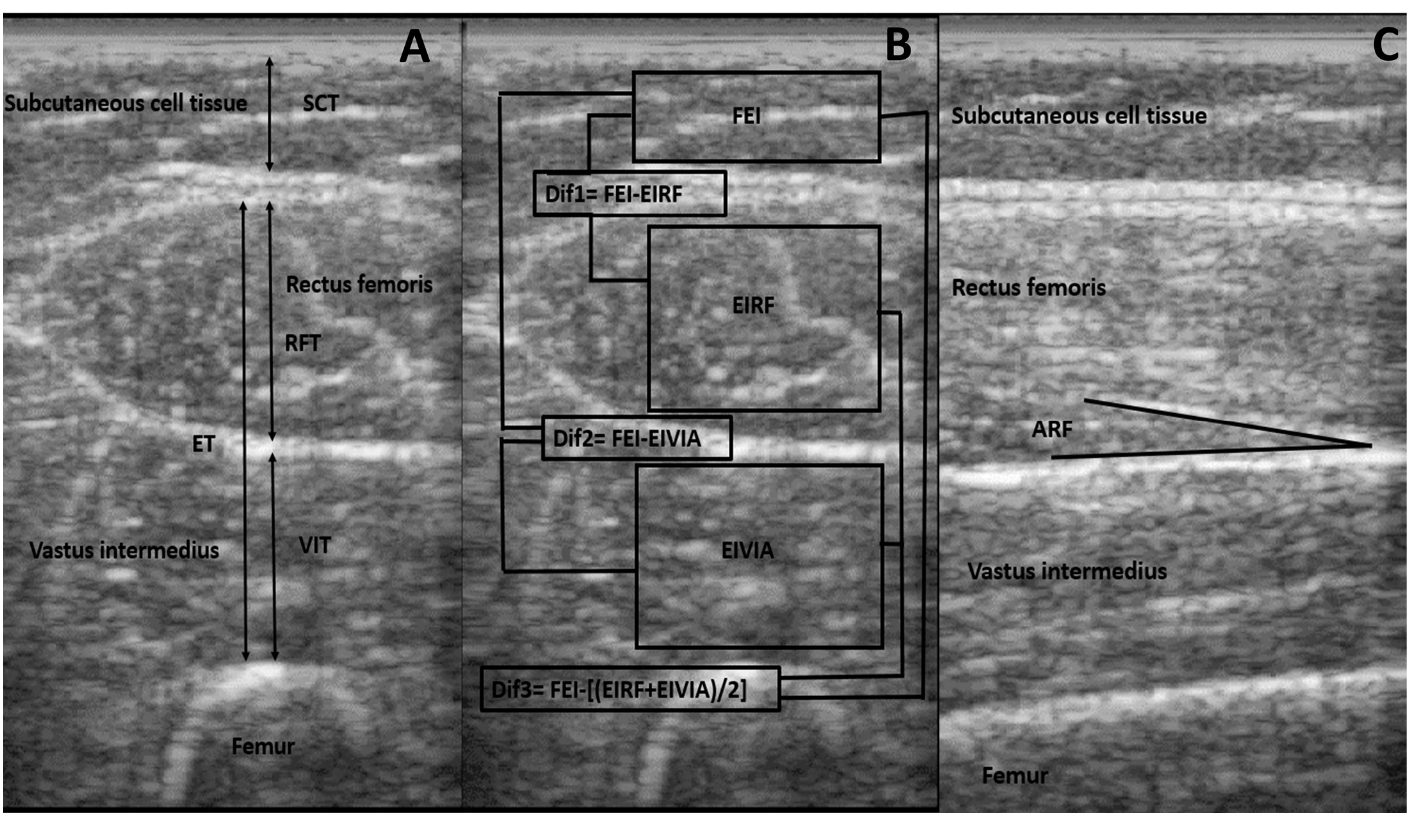
Design

A transversal, comparative, non-randomised study was carried out. All participants attended either the laboratory of the Jaime Isaza Cadavid Colombian Polytechnic University or a room adapted to serve as a laboratory in the facilities of the San José de las Vegas School and the Lucrecio Jaramillo School (all three institutions located in Medellin, Colombia), between October 2018 and March 2019, where the following anthropometric measurements were recorded: body weight, height and fat percentage. Then, ultrasound imaging was conducted on the right quadriceps of the participants. The study variables are described below.

Quantitative ultrasound

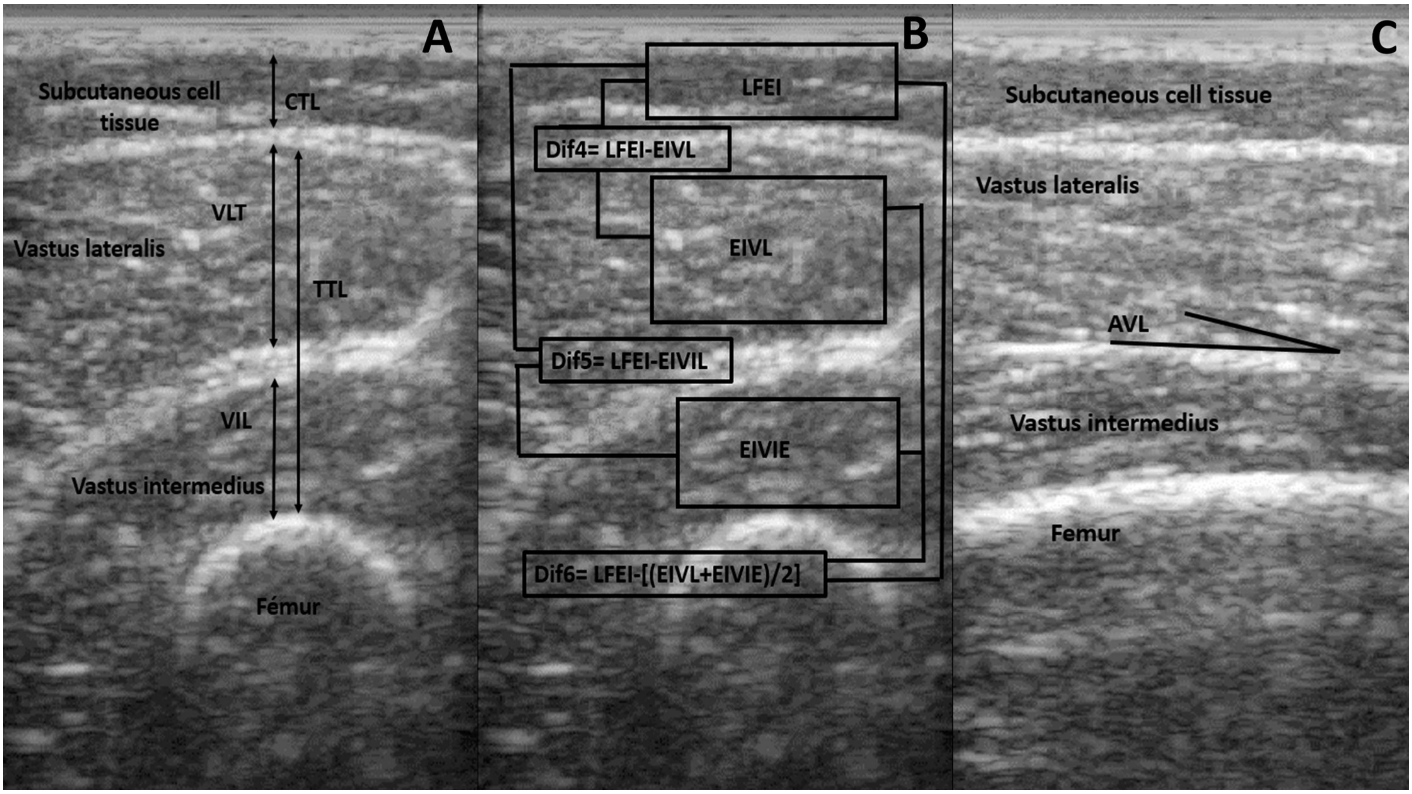
Transversal and longitudinal images were obtained for the quadriceps femoris of the right leg using a B-mode ultrasound imaging device (B-Ultrasonic Diagnostic System, Contec, CMS600P2, Republic of China). A linear transducer (gain: 58, frequency: 7.5 MHz; depth: 6 cm), covered with enough water-soluble transmitter gel to avoid the compression of the dermal surface, was placed on two anatomical points: 1) in the anterior region, at the middle point between the antero-superior iliac spine, and 2) in the lateral region, at the middle point between the antero-superior iliac spine and the superior-external angle of the patella. In each anatomical point, longitudinal and transversal ultrasound sections were performed to evaluate the femoral rectus and vast intermediate (anterior region)[14] and the vast lateral and vast intermediate (lateral region)[15]. The subjects were evaluated in supine position, at a minimum rest of 5 min, and they were asked to do no vigorous physical effort that day before the measurement. Two longitudinal and two transversal images were taken for each middle point. The frozen image was digitalised and later analysed using the ImageJ free software (National Institute of Health, USA, v.IJ 1.46). The anterior transversal images were used to measure the muscle thickness of the rectus femoris (lower margin of the anterior fascia of the rectus femoris to the upper margin of the posterior fascia of the rectus femoris), the thickness of the vastus intermedius (lower margin of the intermuscular fascia and the periosteum of the femur), and the total thickness of the anterior quadriceps (lower margin of the rectus femoris to the periosteum of the femur) (Figure 1)[14]. The lateral transversal images were used to measure: the muscle thickness of the vastus externus (lower margin of the anterior fascia of the vastus externus to the upper margin of the posterior fascia of the vastus externus), the thickness of the vastus intermedius in lateral view (lower margin of the intermuscular fascia and the periosteum of the femur), and the total thickness of the lateral quadriceps (lower margin of the vastus externus to the periosteum of the femur) (Figure 2)[15]. The transversal images were also used to determine the EI of the different muscles evaluated using the histogram tool in ImageJ. The region of interest was selected as the largest rectangular area of each muscle excluding fascia. The mean of the two images was expressed as a value between 0 (black) and

Figure 1. Images of the anterior region of the thigh.



A: transversal section, measurement of thickness. B: transversal section, areas of interest for the measurement of eco-intensity, the differences of EI with subcutaneous adipose tissue (Dif1 to Dif3) and the % of muscle fat. C: longitudinal section and measurement of the pennation angle.

Figure 2. Images of the lateral region of the thigh.



A: transversal section, measurement of thickness. B: transversal section, areas of interest for the measurement of eco-intensity, the differences of EI with subcutaneous adipose tissue (Dif4 to Dif6) and the % of muscle fat. C: longitudinal section, measurement of the pennation angle.

225 (white). The EI was correlated to the subcutaneous cell tissue, as suggested by Young, and the fat percentage was measured using the method proposed by the same author for every muscle[16]. Moreover, as a control strategy, the difference in fat EI with respect to each portion of the quadriceps evaluated was also determined (Dif1 to Dif6)[17]. The longitudinal images were used to determine the pennation angle of the rectus femoris and the vastus externus. The values used for the statistical analysis of the muscle thickness and the penetration angle were the mean of the two measurements of each image. The coefficient of variation of two measurements, at different moments of the same day for ten subjects, was 5%, 0.4% and 0.8% for muscle thickness, EI and pennation angle, respectively.

Anthropometry

Body mass and height were measured without footwear and in sports clothes. Body fat percentage was estimated following Lohman's method for skinfolds measured in two places: triceps and subscapula[18].

Sports

Sports practice was divided into three groups. The vertical sport initiation group (soccer), was composed of children who only practised soccer. This group trained 3 times per week (tuesday, thursday and saturday), for 120 minutes per session. The structure of the training session approaches physical, technical and tactical contents from an integral perspective, applying such contents to specific game situation. The training sessions were divided into 8 blocks, which included stretching, core proprioception and stability, strength, speed, aerobic resistance, general technique, specific technique, sectorial soccer and integrated competitive soccer. The horizontal sport initiation group (multisport) was constituted by children who practised volleyball, basketball, swimming, gymnastics and cheerleading. The training of the multisport group included mostly contents related to physical coordination attributes and, secondarily, physical condition attributes. Obviously, by working on the different motor capacities and abilities, the children also developed their physical condition. This group applied a global and playful methodology, with no special influence on the development of any attribute. The multisport children trained once per week, for 3 hours, rotating through different sports. Only the girls who practiced cheerleading trained twice per week, for 1.5 hours per session. The third group (no sport) did not practise any sport in a sport club on a regular basis.

Statistical analysis

The descriptive analysis of the sociodemographic and ultrasound aspects was carried out using absolute frequencies, relative frequencies and summary indicators such as arithmetic mean, standard deviation, median, interquartile range, and minimum and maximum values. The normality criterion of some variables was established using the Shapiro-Wilk test, and the homoscedasticity criterion was determined by the Levene test. To establish the relationship between the sociodemographic aspects (gender – sport group) and the ultrasound aspects, the Student T-test or the Mann-Whitney U-test was applied to compare two different groups, and for three-group comparisons, the single factor ANOVA test or the Kruskal-Wallis test was used, establishing p<0.05 as statistically significant. The entire statistical process was conducted using the Stata software (Statacorp, v.16.0, College Station, Texas, USA).

Results

The sample was divided into 3 groups according to the sport practised and also by gender. Due to the fact that only one girl practised soccer, she was excluded from the statistical analysis. Consequently, the statistical analysis of the girls only included two groups: multisport and no sport. Table 2 shows the results of the boys in the three groups, and Table 3 presents the results of the two groups for boys and girls.

Discussion

Eco-intensity

In this study, statistically significant differences were found between the children who practised soccer and the other two groups of participants in the EI of the rectus femoris and vastus intermedius (EIRF, FPRF, Dif1, Dif3). These differences appear in the measurements that include the rectus femoris. Previous studies without the type of sport initiation as a differentiating variable have shown that EI in children does not change during normal growth[19]. A study conducted by Jacobs *et al*. (2013), with 25 children aged between 0 and 12 years, concluded that eco-intensity was not influenced by weight, height or age in healthy children, since the changes observed were not significant[6]. Another study reported that no changes were observed in age in the grayscale level, since there were no abnormal deposits of fat or connective tissue[20]. As the muscle grows, the ultrasound images will start showing the different muscle membranes, which can increase the EI[6,7], although muscle fiber thickness increases, which decreases the contribution of fibrous tissue, thus increasing the muscle tissue and, consequently, decreasing the EI. In the

Table 2. Distribution of the quantitative ultrasound characteristics according to sport type (boys).

		Soccer (n= 81)	Multisport (n= 15)	No sport (n = 13)	p value
FEI*	Fat EI anterior region of the thigh	146.19 (13.19)	145.47 (11.36)	141.16 (11.57)	0.2021
EIRF	EI of the rectus femoris	155.41 ± 19.40	168.85 ± 13.89	164.72 ± 15.47	0.0162 †
FPRF	Fat % of the rectus femoris	19.12 ± 1.79	20.36 ± 1.28	19.97 ± 1.42	0.0162 †
EIVIA	EI of the VI anterior thigh	142.28 ± 16.82	145.28 ± 12.81	148.92 ± 11.54	0.3375
FPVI	Fat % of the VI	21.41 ± 1.90	21.72 ± 1.45	22.15 ± 1.30	0.3491
Dif1	Difference between FEI and EIRF	-7.99 ± 24.64	-24.61 ± 18.43	-21.46 ± 20.88	0.0148 †
Dif2	Difference between FEI and EIVIA	5.13 ± 20.34	-1.03 ± 17.31	-5.65 ± 16.49	0.1307
Dif3	Difference between FEI and median of EIRF and EIVIA	-1.43 ± 21.26	-12.82 ± 16.86	-13.56 ± 17.82	0.0351 †
LFEI	Fat EI lateral region of the thigh	135.07 ± 11.81	134.45 ± 11.19	138.55 ± 9.12	0.5631
EIVL	EI of the vastus lateralis	161.54 ± 18.11	168.23 ± 16.33	170.53±11.76	0.1207
FPVL	Fat % of the vastus lateralis	23.62 ± 2.05	24.37 ± 1.85	24.63 ± 1.32	0.1224
EIVIE	EI of the VI external thigh	139.14 ± 19.24	137.77 ± 13.77	142.16 ± 11.26	0.7986
FPVIE	Fat % of the VI external region	21.06 ± 2.18	20.90 ± 1.56	21.39 ± 1.28	0.8058
Dif4	Difference between FEI and EI of the VL	-26.47 ± 17.83	-33.78 ± 15.33	-31.91 ± 9.83	0.2101
Dif5*	Difference between FEI and EIVI external region	-6.06 (22.83)	-4.85 (32.32)	-5.01 (22.11)	0.9553
Dif6*	Difference between FEI and median of EIVL and VI external region	-16.61 (23.65)	-22.15 (24.64)	-19.28 (13.18)	0.7192
SCT*	Subcutaneous cell tissue	5.79 (4.71)	7.86 (3.79)	9.57 (5.43)	0.0216 †
RFT*	Rectus femoris thickness	18.86 (4.43)	20.07 (4.71)	20.93 (4)	0.2854
VIT	VI thickness anterior region	12.07 ± 2.80	12.81 ± 2.48	14.41 ± 3.38	0.0226 †
TT	Total quadriceps thickness (RFT + VIT)	33.01 ± 4.77	34.16 ± 5.06	36.08 ± 5.14	0.0985
CTL*	Subcutaneous cell tissue thickness lateral region	4.28 (3.93)	5.86 (2.93)	6.93 (4.43)	0.0343 †
VLT	VL thickness	14.04 ± 2.93	13.94 ± 3.47	14.34 ± 2.79	0.9325
VIL*	VI lateral region	10.71 (3.43)	12.43 (4.35)	13.57 (1.07)	0.0043 ††
TTL	Total thickness lateral region (VLT+VIT)	27.24 ± 3.93	27.86 ± 6.28	30.18 ± 4.96	0.088
ARF*	Penetration angle of the rectus femoris	12.87 (3.66)	12.6 (2.68)	10.79 (1.42)	0.024 †
AVL*	Penetration angle of the vastus lateralis	14.51 (3.97)	11.67 (2.43)	12.13 (1.46)	0.0018 ††

The data are presented as arithmetic measure ± standard deviation; *The data are presented as median (interquartile range); †p≤0.05; ††p≤0.01.

Table 3. Distribution of the quantitative ultrasound characteristics according to sport type.

	Boys			Girls		
	Multisport n= 15	No sport n = 13	p value	Multisport n= 43	No sport n = 31	p value
FEI*	145.47 (11.36)	141.16 (11.57)	0.6177	142.04 (11.49)	142.43 (9.91)	0.7306
EIRF	168.85 ± 13.89	164.72 ± 15.47	0.4629	169.60 ± 13.89	169.17 ± 15.40	0.9004
FPRF	20.36 ± 1.28	19.97 ± 1.42	0.4531	20.43 ± 1.28	20.39 ± 1.42	0.8997
EIVIA	145.28 ± 12.81	148.92 ± 11.54	0.4399	151.85 ± 14.67	153.15 ± 15.68	0.7149
FPV I	21.72 ± 1.45	22.15 ± 1.30	0.4406	22.49 ± 1.66	22.64 ± 1.77	0.7128
Dif 1	-24.61 ± 18.43	-21.46 ± 20.88	0.6753	-27.43 ± 16.42	-25.89 ± 19.28	0.7102
Dif 2	-1.03 ± 17.31	-5.65 ± 16.49	0.4777	-9.68 ± 16.21	-9.86 ± 18.91	0.9644
Dif3	-12.82 ± 16.86	-13.56 ± 17.82	0.9112	-18.56 ± 14.99	-17.88 ± 18.33	0.8604
LFEI	134.45 ± 11.19	138.55 ± 9.12	0.3027	138.56 ± 7.87	134.60 ± 5.64	0.0191†
EIVL	168.23 ± 16.33	170.53±11.76	0.6772	172.11 ± 13.42	171.01 ± 12.40	0.7206
FPVL	24.37 ± 1.85	24.63 ± 1.32	0.6859	24.81 ± 1.52	24.68 ± 1.40	0.7199
EIVIE	137.77 ± 13.77	142.16 ± 11.26	0.3689	150.70 ± 15.61	150.88 ± 13.23	0.9582
FPVIE	20.90 ± 1.56	21.39 ± 1.28	0.3756	22.37 ± 1.77	22.39 ± 1.50	0.9568
Dif 4	-33.78 ± 15.33	-31.91 ± 9.83	0.7191	-33.54 ± 11.71	-36.41 ± 13.03	0.3233
Dif 5*	-4.85 (32.32)	-5.01 (22.11)	0.9639	-14.70 (20.93)	-14.69 (14.94)	0.327
Dif 6*	-22.15 (24.64)	-19.28 (13.18)	0.7168	-23.09 (13.02)	-25.92 (15.61)	0.3377
SCT*	7.86 (3.79)	9.57 (5.43)	0.5942	8.42 (3.12)	7.78 (5.14)	0.7995
RFT*	20.07 (4.71)	20.93 (4)	0.413	17.61 (2.96)	16.36 (3)	0.0221 †
VIT	12.81 ± 2.48	14.41 ± 3.38	0.1624	13.26 ± 2.50	14.25 ± 3.23	0.1382
TT	34.16 ± 5.06	36.08 ± 5.14	0.3295	33.20 ± 4.28	32.62 ± 4.60	0.5718
CTL*	5.86 (2.93)	6.93 (4.43)	0.2124	6.36 (2.99)	5.78 (3.21)	0.5945
VLT	13.94 ± 3.47	14.34 ± 2.79	0.7437	12.57 ± 2.50	13.44 ± 2.57	0.149
VIL*	12.43 (4.35)	13.57 (1.07)	0.2589	11.21 (3.50)	11.14 (3.36)	0.659
TTL	27.86 ± 6.28	30.18 ± 4.96	0.2938	26.25 ± 3.85	26.94 ± 4.35	0.4667
ARF*	12.6 (2.68)	10.79 (1.42)	0.0052 ††	11.75 (3.28)	10.86 (2.13)	0.1419
AVL*	11.67 (2.43)	12.13 (1.46)	0.7168	12.48 (3.34)	11.29 (1.26)	0.0176 †

The data are presented as arithmetic measure ± standard deviation; *The data are presented as median (interquartile range); †p≤0.05; ††p≤0,01.

present study, the decrease of EI could be due to a muscle fiber increase, caused by the different type of sport initiation (practice regularity, training content orientation, etc.). According to the results obtained in this study, quantitative ultrasonography could accurately measure the changes in muscle size, especially muscle thickness, with an excellent correlation with the physiological cross-section area[21,22]. EI is modified by training in adult people[23], and fat replacement is the main cause of muscle EI increase in them[8]. The results of a different study indicate that, for adolescent children, leg muscle quality is not significantly influenced by maturation[24]. A study conducted with men aged between 19 and 68 years compared muscle fat, measured by US, with health and physical activity indicators, and concluded that intramuscular fat was inversely associated with physical activity[25]. In our study, the differences found in the analysed groups show that there is a relationship between physical stimuli and changes in muscle quality. The main difference was the decrease of EI, which has not been explained yet in children. A possible explanation would be the decrease of intramuscular fat, measured by ultrasonography, with an increase of muscle fiber size. According to these results, ultrasonography could be considered as a tool to measure the effects of exercise performed by children, in terms of proper stimuli to generate measurable muscle changes. The statistical difference in these components of the quadriceps may be due to the specialisation of the training carried out by the soccer group, who performed a larger number of specific kicking exercises, with a greater orientation to physical work for the muscle groups evaluated and, particularly, the rectus femoris. However, this did not happen in the multisport group, whose practice frequency was lower, as well as the orientation of their exercises, which were rather focused on coordination work and motor competence, with conditional capacities such as strength being less important. This fact suggests that there are no significant differences between the multisport group and the no sport group in both genders. It is worth highlighting the subtraction of fat EI minus muscle EI, measured in our study with variables Dif1 and Dif3, which showed statistically significant differences. As an internal reference of the subject, subcutaneous fat tissue EI allows its comparison with other ultrasound results, offering a way to better evaluate the changes generated by physical activity in schoolchildren. This could be a useful tool to determine whether the type of physical exercise performed by the child is enough to generate changes in muscle tissue, which is the main tissue involved in both movement and metabolic aspects.

Fat and muscle thickness

Mean fat thickness in the anterior and lateral regions was different and statistically significant between the three groups of children. The lowest values were obtained in the soccer group, whereas the highest values were shown by the no sport group, who did not perform any physical practice on a regular basis. These results corresponded to the fat percentage measured by skinfold (Table 1). Between the multisport and no sport groups, the differences were not significant, neither in boys nor girls. These results suggest that the specific components of sport and, specifically, the orientation of the training contents, could be intense, long and frequent enough to maintain the fat values under the values of children who do not exercise regularly. This could help to establish reference indicators, which, in addition, would be consistent with some of the recommendations found in the literature about the characteristics of exercise in minors[26].

The thickness of the vastus intermedius measured in the anterior and external regions (VIT, VITE) was significantly different between the three groups, with the lowest values in the soccer group. There were no differences in muscle thickness between the multisport and no sport groups in boys, whereas in girls there was a significant difference only in RFT. Muscle thickness and, particularly, the diameter of human muscle fibre, increase with age[6,27–29], which is in line with the results of our study, since the mean age of the groups is lower in the soccer group and higher in the no sport group, in both boys and girls (boys: "soccer": 8.9±1.16; "multisport": 9.2±1.04; "no sport": 9.8±0.55. Girls: "multisport": 9.1±1.07; "no sport": 9.8±0.55).

Pennation angle

The difference in pennation angle was statistically significant in boys for the two muscles evaluated, i.e., rectus femoris and vastus lateralis, between the three groups. Between the multisport and no sport groups, there were significant differences in ARF in boys and in AVL in girls. All these differences caused an increase in the pennation angle in the soccer group with respect to the other two groups, and in the multisport group with respect to the no sport group. These results are in line with the idea that a greater pennation angle is related to greater muscle strength[30,31]. In our case, the differences in the pennation angle could be determined by a higher frequency of sport stimuli (longer weekly practice time), which was different depending on the type of sport initiation of the evaluated sample. Despite the similarities in the use of the quadriceps in the different sports practised by the children of this study, such as jumping, running and changes of direction, the frequency of kicking in soccer makes those who practise this sport activate it more often in the training session, since this movement specifically stimulates the rectus femoris[32,33]. Thus, it would meet one of the principles of adaptation to training, i.e., the specificity principle[34], which would explain the obtained results. However, it must be taken into account that these results may be determined by the higher frequency and duration of the training in the soccer group with respect to the other two groups.

Conclusions

In view of the results obtained in this study, it can be asserted that the orientation of the training contents in sport initiation, in children aged between 7 and 10 years, may generate differences in the quadriceps, which can be shown by quantitative muscle ultrasonography. Such changes would be related to the duration and frequency of stimuli, which can be a useful tool for trainers in the planning of the training contents. This can induce a qualitative improvement of the effect of the exercises, determined by their specific orientation.

Limitations

Due to the inherent difficulties of research in our area, mainly caused by the scarcity of financial resources and the social conditions of the city, it was not possible to recruit a larger sample, to include, for instance, a greater number of girls in the soccer group. Furthermore, the results are determined by the difference in the number of practice days per week. Future studies should compare groups with different types of sport initiation and the same frequency of weekly practice.

Conflict of interest

The authors do not declare a conflict of interest.

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Original article

Upper body injuries and Key Performance Indicators in professional basketball players

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Summary

Introduction: Upper body injuries are less common than lower body injuries in basketball, but there is still a lack of knowledge about the relationship among their occurrence and the performance profile of professional basketball players. This study aimed to analyse the relationships between upper-body injuries and Key Performance Indicators (KPIs) of basketball players.
Material and method: 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 Spanish ACB *(Asociación de Clubes de Baloncesto)* professional competition were analysed for two seasons (2012-13 and 2013-14). Besided, injury reports were registered and injuries were categorized with OSICS-10 classification. The players who played the most minutes during the season were more likely to suffer lumbar spine, head, wrist, and hand injuries. The players injured in the thoracic spine obtained a better average in steals per minute. The players injured in the head or the elbow had better +/- performance per minute. The players injured in the neck had better means per minute in received fouls, free throws made and attempted.
Results: The players injured in the lumbar spine had better means, per minute played, in assists, probably by their continuous column twists to protect the ball with the body to avoid bumps. Players injured in the shoulder had more blocked shots per minute than those not injured, probably because the realization of a block involves a shoulder flexion and rotation. It would be interesting to carry out a specific follow-up in this type of player, for this type of injury. This information could be helpful to improve injury prevention with the use of KPIs of basketball.

Key words:
Basketball. Injury. KPI. Performance. Hand. Shoulder. Elbow. Neck. Head. Spine.

Lesiones de la parte superior del cuerpo e indicadores clave de rendimiento en jugadores profesionales de baloncesto

Resumen

Introducción: Las lesiones de la parte superior del cuerpo son menos frecuentes que las de las extremidades inferiores en baloncesto, pero aún existe la necesidad de conocer la relación entre su ocurrencia y los perfiles de rendimiento de jugadores profesionales. El objetivo de este estudio es analizar la relación entre la ocurrencia de lesiones de la parte superior del cuerpo y los factores de rendimiento clave *(Key Performance Indicators, KPIs)* en jugadores profesionales de baloncesto.
Material y métodos: Se ha analizado la información estadística de 554 jugadores (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. Los jugadores que jugaron más minutos durante la temporada fueron más propensos a sufrir lesiones en la columna lumbar, la cabeza, la muñeca y las manos. Los jugadores lesionados en la columna torácica obtuvieron un mejor promedio en robos por minuto. Los jugadores lesionados en la cabeza o el codo tuvieron un mejor rendimiento de +/- por minuto.
Resultados: Los jugadores lesionados en el cuello tuvieron mejores promedios por minuto en faltas recibidas, tiros libres realizados e intentados. Los jugadores lesionados en la columna lumbar tuvieron mejores promedios, por minuto jugado, en asistencias, probablemente por sus continuos giros de columna para proteger el balón con el cuerpo para evitar ayudas defensivas. Los jugadores lesionados en el hombro hicieron más tapones por minuto que aquellos no lesionados, probablemente porque la realización de un tapón implica una flexión y una rotación de hombro. Sería interesante realizar un seguimiento específico en este tipo de jugadores, para este tipo de lesiones. Esta información podría ser útil para mejorar la prevención de lesiones con el uso de KPIs en baloncesto.

Palabras clave:
Baloncesto. Lesiones. KPI. Rendimiento. Mano. Hombro. Codo. Cuello. Cabeza. Columna.

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Introduction

The upper body is not usually the anatomical region most injured in basketball[1], and that is the reason why the vast majority of studies focus on the incidence of lower extremity injuries, especially in ankle and knee joints[2,3]. However, they should be paid the same attention, since any kind of injury can produce persistent symptoms[4], lower performance and adverse psychological effects among athletes[5]. Although basketball is a sport in which the handling of the ball is done with the hands, injuries in the upper extremities are far less frequent than injuries in the lower extremities[6]. Injuries in the hands and arms predominate over those that occur in the shoulders or elbows[7]. Injuries in the upper extremities, in general, accounted for no more than 13% of basketball injuries at both amateur and professional levels[8,9].

Excluding stress injuries, the fingers of the hands are the place of the upper extremities in which a basketball player is more likely to suffer a fracture[10]. The interphalangeal joints are the most injured areas: injuries of the extensor and flexor tendons of the fingers, and fractures and dislocations are the most frequent lesions[7,11]. Lacerations due to the realization of dunks have also been reported. This type of injuries occurs due to the impact of the hands with the pointed edges of the hoops or the support that joins the hoop and the backboard[12].

Several studies have analysed the incidence of hand and wrist injuries in the NBA (National Basketball Association) competition. In one of these studies, it was reported that 3.9% of the total injuries were in the wrist or in the hand[13]. In a previous study, this kind of injury was divided into wrist (1.9%), fingers (1.8%), hand (1.8%) and thumbs injuries (1.6%), with a total percentage of 7.1%[9]. Other subsequent research also divided this type of injury in several sections, reporting 4.5% of injuries on hands, 2.4% on fingers and 2.2% on thumbs, with a total percentage of 9.1% of wrist and hand injuries[14]. In the North American college basketball competitions, these types of injuries have also been studied: wrist injuries were 1.6%, and thumbs 2.3%, obtaining a total of 3.9% of hand and wrist injuries[15]. In Europe, there was reported a 9.7% of finger injuries in basketball players, although there was not used such an extensive system of classification[16].

Back injuries are relatively common in basketball players: despite their relative frequency, a large percentage of these injuries are usually muscle strains[6]. Several longitudinal studies conducted in the NBA obtained similar results: lumbar injuries accounted for 6.8% of the total (and 11.0% of total days lost due to injury), ranking fourth in importance in both occurrence as in days of convalescence[9]. 9.0% of lumbar spine injuries with respect to the total, only behind the occurrence of knee injuries (19.1%) and ankle injuries (16.9%) in NBA[14]. In a study conducted in Europe with professional and non-professional players[16], the incidence of back injury was 1.3 injuries per 1000 hours of training time. Lumbar injuries are usually among the four most common injuries, usually behind knee and ankle injuries.

Thoracic spine, head, neck, shoulder, elbow, thorax and forearm injuries have not been traditionally catalogued as predominant in professional basketball. Thoracic spine injuries have not exceeded 2% of incidence with respect to the total, with results of 1.1%[17], 1.3%[9] and 1.6%[14] in the NBA. Head injuries have been more frequent than those of the thoracic spine. If face and skull lesions are added, percentages of 1.9%[9], 5.3%[17], and 5.7%[14] were obtained with respect to the total. Neck injuries have accounted for 1.5% of total injuries[9], although in other studies[14,17], neck injuries have been classified as part of cervical spine injuries and there are no precise results on this anatomical region. Injuries in the shoulder joint have been also studied and accounting for an incidence of 3.7%[14], 3.4%[17] and 3.0%[9]. Elbow injuries have not been high in terms of incidence since they usually do not exceed 2% of all injuries. Specifically: 2.0%[13], 1.9%[14], and 1.5%[9]. Chest injuries do not usually exceed 2% of incidence. Specifically, they accounted for 1.9%[17], 1.8%[14] and 1.0%[9]. Forearm injuries are not usually recorded individually. In a study in which the arm injuries were recorded (without taking into account the joints), a percentage of 0.9% was obtained with respect to the total number of injuries[17]. Finally, abdominal injuries are very unusual and do not normally reach 1% of the total. Specifically, percentages of 0.7%[17] and 0.6%[9,14] have been obtained.

Basketball injuries have been traditionally studied according to their epidemiology: injuries per hour of exposition in both practices and games[1,9,16,18], different competitive levels[16,19,20], anatomical region or type of injury (muscular, concussion, ligamentous distension, etc.)[1,9,14], biomechanics and anthropometry[12,14,16,17,20]. Differences in performance after a long-term injury with surgery have been also studied in NBA competition[21,22], but not many researches have studied the relationship between the occurrence of injuries and the performance of players in games[3]. A wider knowledge about the relationships between Key Performance Indicators (KPIs) and the occurrence of injuries could help strength and conditioning coaches, to develop a specific preventive work with the profiles of players most prone to injury. Moreover, this information could help to improve the rules in basketball, in order to decrease the occurrence of injuries.

Therefore, the aim of this study is to analyse the occurrence of upper body injuries and their relationship with KPIs in basketball players of the ACB (Asociación de Clubes de Baloncesto) professional competition.

Material and method

Design

To analyse the injuries of basketball players in the ACB league, a cross-sectional, descriptive and retrospective methodology was used to study the upper body injuries and the performance of the players, based on the information provided by the official website of the ACB league[23] in each of the injury reports parts prior to each game of the 2012-13 and 2013-14 seasons.

Participants

The sample was the total number of ACB players during the 2012-13 and 2013-14 seasons. It was established as a requirement to be included in the study: (1) to have played at least one match of the ACB league and (2) not to have played on another team of the same competition during the season. They fulfilled both requirements a sample of 554 players from the ACB league during the 2012-13 and 2013-14 seassons, therefore they all were included in this study.

Procedure

We reviewed the information of "News and Medical Report" on the official website of the ACB Basketball League[23], corresponding to the Regular Season of 2012-13 and 2013-14, adding a total of 68 league days registered games. All the injury reports of all the disputed days were obtained. From this information, it was identified which players of the competition had suffered each type of injury, registering the anatomical region. The OSICS classification was used for the categorization of injuries[24].

Subsequently, the total individual statistics of each player were obtained for each of the two seasons[23]. The statistics collected the performance of the players for each variable in absolute values (total of the season) and per game played. As the risk of injury increases with minutes of exposure in matches[25], from the original data the individual statistics per player minute were calculated. Thus, the effect of time on the existing correlation between actions and game time was controlled.

Statistical analysis

The normality of the variables was checked with the K-S test for a sample. The data are shown as mean±standard deviation. To determine if there were significant differences (in the different performance variables during the matches), between the players who suffered a type of injury during the season and those who did not, a mean comparison was made using the t test in the case of variables with normal distribution and the Mann-Whitney U statistic for those nonparametric variables. The level of significance was established at $P < 0.05$ for all cases. The statistical program PASW Statistics 18 was used to carry out the statistical analysis.

Results

The variables of statistical performance relevant to the occurrence of upper body injuries are shown in Table 1.

Statistically significant differences have been found, relative to the total minutes played, between the set of players who presented a hand or wrist injury, and the group that did not present this type of injury

Table 1. Significant KPIs in upper body injury occurrence.

KPIs	Kind of Injury (injured or not)	N	Mean	Standard Deviation	*P*
Total minutes	Wrist or hand (No)	525	434.91	301.22	.020*
	Wrist or hand (Yes)	29	554.66	286.75	
Total minutes	Lumbar spine (No)	535	435.44	303.23	.018*
	Lumbar spine (Yes)	19	602.95	186.33	
Assists	Lumbar spine (No)	531	.063	.057	.008*
	Lumbar spine (Yes)	19	.091	.055	
Ranking	Lumbar spine (No)	531	.330	.381	.052
	Lumbar spine (Yes)	19	.424	.200	
Total minutes	Thoracic spine (No)	542	437.57	302.16	.059
	Thoracic spine (Yes)	12	604.50	217.21	
Steals	Thoracic spine (No)	542	.585	.405	.017*
	Thoracic spine (Yes)	12	.840	.275	
Total minutes	Head (No)	539	437.48	301.44	.034*
	Head (Yes)	11	624.00	248.16	
+/-	Head (No)	539	-.081	.517	.028*
	Head (Yes)	11	.094	.267	
Free throws attempted	Neck (No)	539	.091	.130	.005*
	Neck (Yes)	11	.124	.042	
Free throws made	Neck (No)	539	.068	.125	.005*
	Neck (Yes)	11	.095	.036	
Received fouls	Neck (No)	539	.099	.076	.003*
	Neck (Yes)	11	.135	.036	
Ranking	Neck (No)	539	.329	.380	.003*
	Neck (Yes)	11	.503	.131	
+/-	Elbow (No)	545	-.080	.515	.046*
	Elbow (Yes)	5	.158	.145	
Blocked shots	Shoulder (No)	541	.014	.019	.011*
	Shoulder (Yes)	9	.023	.013	

KPIs: Key Performance Indicators.

(P = 0.020). As with the results of the injuries studied previously, the group of injured players on the wrist or hand played more minutes during the regular season (119.75 minutes more than average). However, no other variables associated with the statistically significant performance have been found in the occurrence of wrist or hand injuries.

The group of injured players in the lumbar spine played more minutes on average during the regular season (specifically 167.51 more minutes). Significant differences have also been found regarding the assists performed per minute played. The group of players with a lumbar spine injury, performed more assists per minute during the season (P <0.05). There is a tendency towards significance in the case of the ranking per minute. The group of players with lumbar spine injury obtained the highest score per minute during the season (P = 0.052).

The injured players in the thoracic spine performed more steals per minute of play than the non-injured players during the regular season (P = 0.017). In addition, a tendency towards significance has been found in the minutes played: players injured in the thoracic spine played more minutes on average during the season (P = 0.059).

Injured players in the head played more minutes than the non-injured players during the regular season (P = 0.034). In addition, they obtained better results in the plus-minus statistics (P = 0.028).

Players injured in the neck tried and converted more free throws per minute than those not injured during the regular season (P = 0.005 in both cases). In addition, they suffered more fouls per minute (P = 0.003) and obtained a better ranking per minute (P = 0.003).

Players injured in the shoulder performed more blocked shots per minute than those that did not suffer shoulder injuries during the regular season (P = 0.011).

Injured players in the elbow obtained better plus-minus statistics per minute than non-injured players during the regular season (P = 0.046).

The variables of statistical performance irrelevant to the occurrence of upper body injuries are shown in Table 2.

Minutes played and received fouls per minute were studied for each anatomical region, except for those regions in which any of these variables were found significant for the occurrence of an injury, in which we included the analysis of an extra KPI that could be related to the injury (i.e. field goals attempted and wrist/hand

Table 2. Not significant KPIs in upper body injury occurrence.

KPIs	Kind of Injury (injured or not)	N	Mean	Standard Deviation	*P*
Field goals attempted	Wrist or hand (No)	525	.300	.114	.759
	Wrist or hand (Yes)	29	.293	.063	
Received fouls	Wrist or hand (No)	525	.099	.076	.944
	Wrist or hand (Yes)	29	.098	.040	
Total minutes	Elbow (No)	545	440.09	302.06	.371
	Elbow (Yes)	5	561.40	203.34	
Received fouls	Elbow (No)	545	.099	.075	.864
	Elbow (Yes)	5	.093	.041	
Total minutes	Shoulder (No)	541	439.39	301.34	.276
	Shoulder (Yes)	9	549.89	302.25	
Received fouls	Shoulder (No)	541	.099	.076	.821
	Shoulder (Yes)	9	.105	.035	
Total rebounds	Lumbar spine (No)	531	.158	.104	.483
	Lumbar spine (Yes)	19	.141	.164	
Received fouls	Lumbar spine (No)	531	.099	.076	.338
	Lumbar spine (Yes)	19	.115	.046	
Total minutes	Thoracic spine (No)	542	437.57	302.16	.058
	Thoracic spine (Yes)	12	604.50	217.20	
Received fouls	Thoracic spine (No)	542	.099	.076	.668
	Thoracic spine (Yes)	12	.108	.046	
Dunks	Head (No)	539	.010	.019	.699
	Head (Yes)	11	.008	.009	
Received fouls	Head (No)	539	.099	.075	.755
	Head (Yes)	11	.106	.048	
Total minutes	Neck (No)	539	437.90	301.66	.071
	Neck (Yes)	11	603.36	249.69	
Blocks made	Neck (No)	539	.013	.018	.441
	Neck (Yes)	11	.018	.019	

KPIs: Key Performance Indicators.

injury, since a field goal attempt involves the movement of the wrist/hand).

There were no differences in minutes played and received fouls per minute between the players injured in the elbow, the shoulder, and the thoracic spine, and those who did not suffer an injury.

There were no differences in field goals attempted and in received fouls between the players that suffered an injury in the wrist or the hand and those not injured.

There were no differences in total rebounds and in received fouls between the players that suffered an injury in the lumbar spine, and those not injured.

There were no differences in dunks and in received fouls between the players that suffered an injury in the head, and those not injured.

There were no differences in total minutes and in blocks made between the players that suffered an injury in the head, and those not injured.

Discussion

The aim of the present research was to study the occurrence of upper body injuries and their relationship with Key Performance Indicators (KPIs) for the players of the ACB professional basketball competition.

The actions of shooting have not been significant in the occurrence of hand and wrist injuries. The realization of a shot in basketball involves the flexion of the wrist and the use of the fingertips, so it could be assumed that this type of action would be relevant to suffer wrist and hand injuries: these findings suggest that this action is not sufficiently traumatic. Although the performance of dunks involve some risk of injury to the hands and wrists[12], the relative infrequency of this action in game time could be the main reason why dunks were not relevant to the occurrence of wrist and hand injuries. The playing time (total minutes) has been significant in the occurrence of this type of injuries. Exposure to injuries in games has been pointed out in several studies as a determining factor in the occurrence of lesions[1,8,16,26]. The results of this study coincide with the scientific literature, but no other aspects of statistical performance have been found that help identify profiles of players prone to suffer this type of injury. Many of the joint injuries in fingers and thumbs originate in the reception of a pass: the speed of the ball, the accuracy of the pass, and the speed of the hands of the receiver are factors that can be related to this type of injury. However, the reception of passes is not registered in the official statistics, as it is not an action that determines the performance of a player. Therefore, it would be convenient to monitor this aspect to determine if there are relationships between it and hand injuries.

Players injured in the lumbar spine have played more minutes during the season and have performed more assists per minute than the uninjured in this anatomical region. In addition, a tendency towards the significance of better ranking scores in injured players has been observed than in those not injured in the lumbar spine. If the playing time (total minutes) is analysed in the occurrence of lumbar spine injuries, exposure to injuries in matches has been pointed out in several studies as a determining factor in the occurrence of lesions[1,8,16,26]. Although performing a jump to catch a rebound involves the action of the lumbar region, we did not report that the players that were injured in the lumbar spine had better means in total rebounds.

The highest number of assists and ranking per minute played for the injured players in the lumbar spine, are relationships difficult to explain. In general, these variables coincide with the profiles of players who create and make plays on their teams, and not necessarily spot-up or catch and shoot players. This analysis suggests that players injured in the lumbar spine tend to have the ball in their hands and that are important in team attacks, receiving defensive helps from the weak side to assist the open teammate. Therefore, it can be noted that playmakers (habitual ball handlers) can suffer this type of injury by having to perform continuous column twists to protect the ball with the body and avoid defensive helps. It would be interesting to carry out a specific follow-up in this type of players, for this type of injuries. The use of magnetic resonance could be useful to clear up these relationships[6].

Players injured in the shoulder have performed significantly more blocked shots per minute than those not injured in this anatomical region. This result makes a lot of sense, since the realization of a block involves raising the arms and a rotation of the shoulder to try to avoid the shot of the opponent. However, the players injured in the shoulder did not play more minutes nor received more fouls per minute than those not injured. Therefore, it seems that the most related KPIs to shoulder injuries are the blocks made.

Players injured in the neck have suffered significantly more fouls per minute than those not injured in this anatomical region. This relation has to do with the significant greater realization of attempted and made free throws (since many of the fouls involve the realization of free throws). Better scores per minute have also been found in players injured in the neck. In general, it can be said that injured players in the neck are important for their teams and often receive fouls frequently. However, those players injured in the neck did not play more minutes per game, although this fact could be related to the low occurrence of this injury. Future studies with a greater sample should clarify this aspect.

The injured players in the elbow and the head obtained significantly better results in the plus-minus statistic. This relationship indicates that they are important in the overall performance of their teams. In addition, players injured in the head played significantly more minutes during the season, which suggests that this type of injury also has something of chance and that a longer exposure in matches implies more risk of injury, coinciding with several studies[1,8,16,26]. However, caution should be exercised in establishing relationships with these injuries, since they have not had much incidence. In this sense, some studies indicate that to find strong associations, it is advisable to register at least 30 cases of injury[27].

Even though those players that suffer an injury usually must stop their participation during the following games, those players that suffered an injury had higher means of total minutes played during the season. These results suggest the importance of playing time in games (rather than in trainings) as crucial to increase the risk of being injured.

As limitations of the present study, on the one hand, the reasons why the injuries have occurred (contact, non-contact, jumps, accelerations, etc.), and the types of injury (muscular, bone, tendon, ligament, etc.) have not been recorded. This record would have allowed a deeper analysis of injuries in professional basketball. On the other hand, there has been no access to the minutes of exposure in training of each player, so that only exposure to injuries in competition has been considered. These limitations are due to the design of this research. However, the information provided may be of interest to advance the knowledge of injuries in professional basketball, by collecting the injuries produced in all teams of the highest competition in Spain for two full seasons, providing a new way of studying injuries and relate them to KPIs. It would be convenient to conduct studies prospectively, although it would be difficult to perform with reliable data from all the professional teams involved.

Conclusions

The players who played the most minutes during the season were more likely to suffer lumbar spine, head, hand and wrist injuries. The players injured in the lumbar spine had better means, per minute played, in assists. The players injured in the thoracic spine obtained better average in steals. The players injured in the head or the elbow had better +/- performance per minute. The players injured in the neck had better means of received fouls, free throws made and attempted. The players injured in the shoulder had better means of blocked shots. It would be interesting to carry out a specific follow-up in these types of players, and these types of injuries. This information could help to improve injury prevention.

Conflict of interest

The authors do not declare a conflict of interest.

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Original article

Analgesic effects of physical exercise in patients with chronic musculoskeletal pain during confinement by the COVID -19 pandemic

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Summary

Introduction: The confinement experienced during the COVID-19 pandemic in Spain for more than two months, could severely affect the condition and quality of life of patients suffering from chronic musculoskeletal pain. Taking into account the analgesic effects that physical exercise can generate, a large part of the population has carried out some kind of physical exercise at home as a mechanism for pain control, during this period.
Objective: The objective of this study was to know the type and dosage of the exercise performed, as well as the perception of the patient´s pain during the confinament period.
Material and method: An ad hoc survey by a Google Form was conducted in 86 patients to find out the health status of the patients, the type of exercise they performed and the dossage of the exercise, as well as whether they had perceived a reduction in their pain during the period of confinement.
Results: The pain intensity was reduced significantly (p = 0.001) when some kind of exercise was done. Strength exercise exclusively was chosen by 51% of the population, and the frequencies and session time were not significantly different between the subjects who felt a reduction in pain and those who did not.
Conclusion: A schedule of physical exercise 4 days a week, for at least 50 minutes and with intensities around 77% of HRmáx of aerobic or strength training would be recommended in patients with chronic pain, as a strategy for pain reduction. The results of our study do not advise, for patients with chronic pain, combined therapy sessions, regardless of the primary location of the pain.

Key words:
Analgesia. Central nervous system. Chronic pain. Coronavirus. Physical exercise.

Efectos analgésicos del ejercicio físico en pacientes con dolor crónico musculoesquelético durante el confinamiento por la pandemia COVID-19

Resumen

Introducción: El confinamiento vivido durante la pandemia del COVID-19 en España durante más de dos meses, podría afectar severamente a la condición y calidad de vida de los pacientes que sufren dolor crónico musculoesquelético. Teniendo en cuenta los efectos analgésicos que el ejercicio físico puede generar, gran parte de la población ha realizado ejercicio físico en sus domicilios como mecanismo del control del dolor, durante este periodo.
Objetivo: El objetivo de este estudio fue conocer el tipo y la dosis de ejercicio físico realizado, así como la percepción de los pacientes en la reducción del dolor, durante el periodo de confinamiento por el COVID-19.
Material y método: Se realizó una encuesta *ad hoc* a través de Google Forms a 86 pacientes para conocer su estado, el tipo de ejercicio que realizaron y la cantidad de ejercicio, así como si habían percibido una reducción de su dolor durante el periodo de confinamiento.
Resultados: La intensidad de dolor disminuyó de forma significativa (p=0,001) cuando se hizo algún tipo de ejercicio físico. El ejercicio de fuerza fue elegido por el 51% de la población de forma exclusiva, y las frecuencias y el tiempo de sesión no fueron diferentes de forma significativa entre los sujetos que sintieron una reducción del dolor y los que no.
Conclusión: Una programación de ejercicio físico de 4 días a la semana, durante al menos 50 minutos y con intensidades del 77% de FCmax de ejercicio aeróbico o de fuerza sería recomendable en un paciente con dolor crónico, como estrategia para la reducción del dolor. Los resultados de nuestro estudio no aconsejan, para pacientes con dolor crónico, sesiones de terapia combinada, independientemente de la localización primaria del dolor.

Palabras clave:
Analgesia. Sistema nervioso central. Dolor crónico. Coronavirus. Ejercicio físico.

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Introduction

Chronic musculoskeletal pain affects 35.7% of the European population, resulting in high socioeconomic costs[1]. The relationship between chronic pain and impact on the central nervous system (CNS) has been widely reported in the literature, describing the central and peripheral sensitisation mechanisms as two great pillars in the understanding of chronic pain[2]. Although chronic musculoskeletal pain is not site-specific, patients generally have an area of pain that is either predominant, recurrent or producers greater nociception[3,4]. The biopsychosocial model is currently one of the treatments used to deal with chronic pain[5].

Within this model, the performance of physical exercise is one of the key strategies to control pain. Although many studies have highlighted the clinical changes produced in the perception of musculoskeletal pain following exercise, such as isometric exercise for tendinopathies, aerobic exercise or strength programmes, the dosage of exercise and optimal frequency are not clear[6,7].

It is known that the result of exercise induces the production of endogenous analgesia. However, for this to happen, certain intensities, exercise times or frequencies need to be achieved in order to stimulate the organism to produce it[8]. Furthermore, it should be taken into account that subjects exhibiting chronic pain are often associated with established patterns of kinesiophobia. Therefore, the first days or weeks of exercise could be key to achieving exercise adherence[9]. Moreover, within the basic training principles we find the neural adaptations that are generated at the start of physical exercise, which would help to create a suitable motor pattern that could improve the perception of safety and confidence with regard to the performance of physical exercise[10]..

During the COVID-19 pandemic, the world's population was subject to a lockdown that may have reduced the quality of life of patients suffering from chronic pain by restricting certain aspects related to their daily living activities and which helped them to control their pain. On the other hand, a large part of the population has started self-care patterns, either because it has more time available or due to a need to increase its physical activity at home. Likewise, during lockdown, many people started a physical activity that they were either not accustomed to or, for varying reasons, they did not do on a regular basis, or as a therapeutic response to try and control their pain. The endogenous analgesic mechanisms are known to show dysfunctions in subjects with chronic pain, as has been demonstrated in knee osteoarthritis processes[11-13]. Lannersten & Kosek (2010) reported how patients with fibromyalgia chronic pain will exhibit alterations in the endogenous analgesic mechanisms generated by exercise[14].

A number of studies have confirmed how exercise is able to reduce pain[15] and to reduce nociceptive sensitivity[16] in subjects that do not exhibit chronic pain. Likewise, systematic reviews and clinical studies have confirmed that strength exercise, aquatic therapy and aerobic exercise are better strategies than inactivity in the control of chronic musculoskeletal pain[17-19]. There are many clinical studies in which, based on the pathology studied and the type of exercise performed, positive effects have been reported in the reduction or control of chronic pain. However, it has yet not been possible to establish the best dose of exercise to achieve this objective, given that all have been shown to be beneficial[20].

Study objective

This study is directed at learning about the dosage and types of exercise performed for analgesic purposes by patients with chronic musculoskeletal pain during the COVID-19 pandemic lockdown.

Material and method

A cross-sectional, descriptive analytical study was conducted, in which the snowball sampling technique was used to recruit patients with chronic pain, with signs and symptoms during the month of April 2020.

The inclusion criteria were those described by Gatchel *et al.*[21] and Siddall & Cousins[22] on chronic musculoskeletal pain: subjects exhibiting musculoskeletal pain that persists for more than 3 months, independently associated with the primary cause of pain persisting for more than 3 months, fear of movement, catastrophising, impairment and sensitisation of the nervous system. Additionally, the study subjects must be aged between 18-75 years, be able to read and understand Spanish, and have started to do physical activity and/or exercise during the COVID-19 pandemic lockdown, declared in Spain on 14th March 2020. The study excluded all those who suffered from chronic pain that was not musculoskeletal in origin, those who did not record their physical activity and/or exercise, recent post-surgery patients and pregnant women.

A 21-item ad-hoc questionnaire was prepared using a form from Google Forms, of which 6 items were to describe the sample, 7 items to learn about the aspects relating to the investigation (such as the type of exercise, frequency, volume or pain) and the 8 remaining items were to compare data for the purpose of checking whether the subject met the inclusion/exclusion criteria for the study.

The questionnaire was launched electronically and the data were stored up to 26th April 2020.

The ethics committee was unable to review the study, given that the authors were under lockdown and considering the exceptional measures in place at the time. As a result, the authors closely followed similar prior studies, as well as compliance with the Declaration of Helsinki. Likewise, before completing the questionnaire, the participants had to give their informed consent, which appeared on the first page thereof.

Data analysis

All the variables were analysed by descriptive statistics: continuous variables and their relationship through the t-test, and categorical variables and their relationship through the chi square test. The quantitative variables were analysed through descriptive statistics, with the calculation of central tendency, dispersion and frequency. The level of significance was set at *p* <0.05 for all cases. The SPSS version 22 program was used for the statistical analysis of the data obtained.

Results

129 patients were recruited, of which 43 patients were excluded as they met some of the exclusion criteria. Finally, 86 patients were included in the study, of which 43 were female and 43 male. Table 1 shows the ages and anthropometric characteristics of the study sample.

A Student t-test was performed for independent samples in order to determine whether exercise intensity reduces the perception of pain, giving statistically significant differences (*p*=0.001) between a reduction in the perception of pain and intensity.

The contingency tables related to the type of exercise and whether or not the perception of pain was reduced showed that those doing strength exercises had the greatest perception of a reduction in pain, with 51.1%, followed by those doing aerobic exercises, with 35.6%. When both types of exercise were combined in the same session, only 8.9% of the subjects considered that exercise reduced the pain. For other exercises, such as pilates and mobility exercises, 2.2% of participants found that this reduced the pain. With regard to the 2 participants doing the walking activity, neither found that this activity reduced the pain.

For the inter-group analysis between those subjects who perceived a reduction in pain and those who did not, an independent sample student t-test was performed in order to determine whether the frequency of exercise reduces the perception of pain. The frequency of the group that perceived a reduction in pain was 4.88±1.43 sessions/week (n=45), while the group that felt no reduction in pain was 4.89±1.64 sessions/week (n=37); with no significant differences between the groups (*p*=0.993). The relationship between the variables for session time and reduction in pain showed that the group that perceived a reduction in pain was 53.88±26.45 minutes/session (n=45), while the group that felt no reduction in pain was 57.72±30.03 minutes/session (n=37), with no significant differences between the groups (*p*=0.540). Finally, the relationship between reduction in pain and intensity of exercise showed for the group that did perceive a reduction in pain, trained at 77.66±12.64% of maximum heart rate (max HR), while the group that felt no reduction in pain trained at 50.40±15.47% of max HR, obtaining a statistically significant difference between the groups (*p*=0.001).

With regard to the activity they performed, based on their most severe pain, it can be seen how 31.4% of participants suffer from low back pain and that they mostly selected aerobic exercises (14%), followed by 10.5% who did strength exercises, while 51.9% reported that pain was not reduced with exercise. Cervical pain was the second most predominant site, accounting for 18.6%, where the subjects did resistance and aerobic exercises in the same proportion, observing how 56.2% felt that exercise did reduce pain. Patients with shoulder pain account for 14%, with 35% of these subjects choosing resistance exercises, with 66.7% of patients considering that their pain was reduced. Knee pain accounted for 8.1% of patients, who opted for strength exercises and the combination of aerobic and strength exercise to control the pain, with positive results for 57.1%. The remaining sites account for less than 5% each, with the strategy to combine aerobic and strength exercises being the most predominant, and obtaining the highest percentages in the reduction of pain after exercise, except for those patients with pain in their hands and wrists, who saw no reduction in the sensation of pain.

Table 1 Demographic variables of the sample (n=86).

Age	43.87±14.45
Sex (M/F)	43/43
Weight	70.76±19.94
Height	170.08±8.65
BMI	24.2 ±2.8

Discussion

The results obtained show that the reduction in perceived pain through physical exercise could initially be dependent on intensity, having found that those patients who exercised at a greater intensity (>75% max HR) are the ones to show a greater reduction in exercise-induced pain.

These results are in line with other investigations, such as the one by Macefield & Henderson (2015), who used functional magnetic resonance imaging (fMRI) to investigate the cortical and subcortical sites involved in the sensory processing of musculoskeletal pain. Their results demonstrated that muscle sympathetic nerve activity (MSNA) increases right from the start of the contraction and is dependent on the intensity of the same, determining the signalling of the central command in the fMRI[23]. In any case, Boulton et al. determined that MSNA is dependent on the intensity of exercise with regard to its amplitude but not with regard to its frequency, also affirming that post-exercise ischaemia does not appear to be significantly affected by this intensity[24]. In this regard, it is important to underscore that, although a greater intensity of exercise could be more effective in reducing pain in patients with chronic musculoskeletal pain, it could also involve a greater risk of infection by triggering an immunosuppressive response[25], and could therefore be contraindicated for patients with a risk of infection and/or in situations in which the appropriate preventive measures cannot be guaranteed.

However, the analgesic effect of physical exercise is well-known. Sabharwal et al. demonstrated in mice that just 5 days of exercise could prevent the development of autonomic dysfunction and reduce the pain threshold induced by chronic musculoskeletal pain through, among other mechanisms, the induction of analgesia by central mechanisms that release endogenous opioids from the periaqueductal grey matter (PAG) and from the rostral ventromedial medulla (RVM)[25], with this latter structure being one of the possible areas related to the participation in the facilitation of the spinal nociceptive processing and the generation of hyperalgesia in models of inflammatory and neuropathic pain[26].

In this same line, Brito *et al.* affirm that the practice of exercise involves a reduction in pain through the central inhibitory mechanisms involving the opioidergic and serotonergic systems in the presence of acute nociceptive effects, demonstrating that systemic naloxone, PAG naloxone and RVM naloxone reverse the anti-nociceptive effects of physical exercise in mice with induced muscle pain. Likewise, these authors also determined that exercise reduces the expression of the serotonin (SERT) receptors in these mice, which could contribute to a reduced perception of musculoskeletal pain. These studies could support the endogenous analgesia mechanisms induced by exercise, although for patients exhibiting chronic pain, these analgesic pathways could be conditioned by the central sensitisation process that accompanies pain. Therefore, dosage dependent on exercise intensity appears to be fundamental in the triggering of the endogenous mechanisms[27].

The correlation results between the frequency and session time variables showed that, although not statistically significant, both variables could be related when planning physical exercise microcycles, so that there could be models in which the frequency of sessions could be increased per week without changing the total number of minutes, as discussed by Polaski *et al.* (2019)[8]. Along these same lines, the session time appears to be related to an increase in the intensity of the session, whereby exercise needs to be performed at high intensities in order to trigger the endogenous analgesic mechanisms, disregarding the proposals for exercises with a long duration at medium and/or low intensities maintained over time, as it seems that this therapeutic strategy would not trigger the opioid systems through the release of plasma β-endorphins[28].

Aerobic exercises could be a suitable strategy for reducing chronic pain, given that they increase the heart rate with relative ease and make it possible to stay at parameters with high intensities with a greater control of the exercise. However, anaerobic-based exercises are a good alternative for reducing perceived pain, and this physical exercise method is the one used by many individuals in their homes through bodyweight exercises, having demonstrated that this could be sufficient to control and improve chronic pain given that the levels of β-endorphins achieved are similar to those of aerobic exercises[29].

One of the limitations of our study is that the data were obtained through a self-recording process using the Google Forms platform, with no observer present to help subjects to complete the questionnaire, when in doubt.

Conclusion

A programme of aerobic or strength exercises for 4 days a week, for at least 50 minutes and with intensities of 77% max HR would be recommendable to patients suffering from chronic pain, as a pain reduction strategy. For patients with chronic pain, the results of our study do not advise combined therapy sessions, regardless of the primary site of the pain.

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Conflict of interest

The authors have no conflict of interest at all.

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Original article

Body composition profile of young inline speed skaters

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Summary

The aim of this work was to determine the body composition profile of children and young roller skaters. 516 athletes (361 males and 155 females) between the ages of 5 and 21 years old, who belong to official clubs in Colombia and Venezuela, were evaluated longitudinally. The anthropometric variables were taken according to ISAK, using the Holtain© caliper for the skin folds (triceps, anterior thigh and medial leg) and the Sanny© tape for the perimeters (relaxed arm, medial thigh and leg). The treatment for the estimation of the percentage of body fat (%F) and muscle mass (%MM) was performed under the protocol of the GREC and processed by means of SPSS 24.0. The results point to the existence of significant differences (p<0.05) between sexes for %F and %MM. For the development of the profile the methodology of smoothed curves was used with the application of the software LMS Chart Maker© and to generate cut points for the percentiles 3, 10, 75, 90 and 97. It is concluded, that the classification for the proposed body composition, without trying to be a unique norm to establish the typification of the status of the body composition of a skater, allows to distinguish and to categorize with rigor and objectivity, the characteristics of the body composition of the skaters independently of the age and competitive level. This work is recommended as a starting point for future studies in larger populations with established probability sampling and ethnicity.

Key words:
Anthropometry. Body composition. Body fat. Muscle mass. Speed skating.

Perfil de composición corporal en niños y jóvenes patinadores de velocidad sobre ruedas

Resumen

El objetivo del presente trabajo fue determinar el perfil de composición corporal en niños y jóvenes patinadores de velocidad sobre ruedas. Se evaluaron, longitudinalmente, 516 deportistas (361 Femeninos y 155 Masculinos) con edades comprendidas entre 5 y 21 años, patinadores de velocidad sobre ruedas, pertenecientes a clubes oficiales en Colombia y Venezuela. Las variables antropométricas se tomaron de acuerdo a lo dispuesto por ISAK, utilizando el calibrador Holtain© para los pliegues cutáneos (tríceps, muslo anterior y pierna medial) y la cinta Sanny© para los perímetros (brazo relajado, muslo medio y pierna). El tratamiento para la estimación del porcentaje de grasa (%G) y de masa muscular (%MM) se ejecutó bajo el protocolo del GREC y procesados mediante el SPSS 24.0. Los resultados apuntan hacia la existencia de diferencias significativas (p<0,05) entre sexos para el %G y el %MM. Para el desarrollo del perfil se utilizó la metodología de curvas suavizadas con la aplicación del software LMS Chart Maker© y generar puntos de corte para los percentiles 3, 10, 75, 90 y 97. Se concluye, que la clasificación para la composición corporal propuesta, sin pretender ser una norma única para establecer la tipificación del estatus de la composición corporal de un patinador, permite distinguir y categorizar con rigurosidad y objetividad, las características de la composición corporal de los patinadores independientemente de la edad y nivel competitivo. Se recomienda al presente trabajo como punto de partida a futuros estudios en poblaciones más amplias, con muestreo probabilístico y origen étnico establecido.

Palabras clave:
Antropometría. Composición corporal. Masa grasa. Masa muscular. Patinaje de velocidad.

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Introduction

As one of the 11 sports disciplines of the World Skating Federation, World Skate[1], inline speed skating has experienced a considerable boom over the last decade with an ever-increasing number of skaters. As a result, the competitive level has evolved constantly in all continents and, with the exception of Africa, the other four continents all have countries that have successfully competed in world championships. In Europe, particular mention should be made of countries such as Italy, France, Germany, Holland, Belgium, Switzerland and Spain. In Asia: South Korea, Chinese Taipei. In Oceania: Australia, New Zealand. In North and Central America: USA, Mexico and Guatemala and South America with Argentina, Chile, Ecuador and Venezuela.

This increase in competitive performance requires the correct monitoring and control of the morphological development of athletes, given that this helps to ensure athletic longevity, and the gradual increase and stability of their performance. Anthropometric monitoring is among the controls to be made on athletes and it represents an important tool in the world of sport, making it possible to determine the morphological characteristics of the subjects. Anthropometric measurements can serve as markers of adiposity, or the distribution of fat[2], as well as indicators of robustness in relation to the ideal muscle mass for athletic performance.

However, with regard to sport, the achievement of objectives depends on a number of related factors, studied through applied sports sciences. In the case of Inline Speed Skating (ISS), mention could be made of the anthropometrics that have been studied in order to characterise this population and optimise methodological decision-making in training and physical preparation[3–8]. Given that an adequate shape and body composition represent morphological optimisation[9], this is expressed in the improved performance achieved by athletes dependant upon a representative model of success in their sports speciality.

In the case of young athletes, the anthropometric variables are considered to be a factor that interacts with performance[10]. These variables therefore need to be monitored in order to identify changes related to sports training. Body composition can be monitored by the somatotype of young athletes6, as well as the measurement of adipose skinfolds[11,12], skinfolds by site or by upper and lower body[13,14] and the percentage of fat and muscle mass[15]. Due to its aforementioned qualities, Body Composition (BC) is considered to be a control element of the training load[16].

In the athletic population, the analysis of BC is often made through the percentage of fat mass, by competition category[17,18], as well as by age[19] and muscle mass[20], including ISS from the lower categories[5,21,22] up to high performance[14,23–25]. These values of the BC components can affect the result and athletic performance.

In this regard, the characterisation of a variable by percentile curves makes it possible to observe the behaviour of the population according to age. Considering the gap in the research literature relating to the characterisation of the BC profile with normative criteria for fat mass and muscle mass in sport in general and in speed skating in particular, trainers and professionals involved in the biomedical monitoring of ISS training need to be able to interpret the BC results with a greater probability of making the right diagnosis and subsequent training programme. Therefore, the objective of this study is to determine the BC profile of young inline speed skaters who are members of the official clubs in Colombia and Venezuela.

Material and method

Design and participants

This is a descriptive study with a field investigation design, conducted within a quantitative paradigm. A longitudinal study was made of 516 athletes practising ISS, whose core variables are given in Table 1. The athletes were skaters and members of one of four (4) clubs in Colombia and two (2) in Venezuela, with sports experience of one (1) to five (5) years at national and international levels and with a training frequency of three (3) to five (5) days a week, depending on the organisation of each club and category.

The inclusion criteria were as follows: - be an athlete practising ISS, physically healthy at the time of the study; - have a systematisation of training of at least 1 month prior to each assessment; - record of participation in a regional, national or international event over the last year prior to each assessment. The exclusion criteria were as follows: - exhibit physical impediments to practising sport during the last month; - no basic command of skating skills; - be ill or suffer from some type of sports injury at the time of the assessments.

Procedure

For the Anthropometric data collection, the standards proposed by the International Society for the Advancement of Kinanthropometry

Table 1 Descriptive statistics of the basic variables of inline speed skaters according to sex.

Sex	Variables	n	Mean	SD	Min.	Max.
Female	Decimal age (years)	361	10.6	3.3	4.2	18
	Body mass (kg)	361	35.8	12.9	14.9	69
	Height (cm)	361	139.6	17.5	101	182.3
Male	Decimal age (years)	155	13.3	4.3	5.2	22.9
	Body mass (kg)	155	46.6	17	16	75
	Height (cm)	155	153.6	20.7	102.6	185.2

(ISAK) were applied with the measurements of: body mass (kg), height (cm), skinfolds (triceps, anterior thigh, medial leg) using the skinfold callipers of the Holtain© brand (0.2 mm) and circumferences (relaxed arm, mid-thigh and leg) using the anthropometric tape of the Sanny brand (0.1 cm). For the assessment of the body composition, the study followed the methodology proposed by the Spanish Group of Kinanthropometry (GREC)[15], applying regression equations to estimate percentage fat 26 and muscle mass percentage[27].

The data were collected over an 8-year timespan (from 2011 to 2018) during the kinanthropometric assessment and training control processes programmed for each club on either an annual or six-monthly basis, considering two (2) or more assessments per subject in an interval of more than four (4) months. The tests were conducted by two (2) ISAK level-2 certified anthropometrists. The ethics committee of the Observatory of Research in Sciences of Physical Activity and Sport (OI-CAFD) gave its approval to conduct the study and to use the software tool to make the calculations. Prior to each assessment, the parents or guardians of the children and young people were informed of the objective of the anthropometric test, the procedures to follow and their rights, before, during and after the assessment, in line with the Helsinki protocol, giving their written consent to participate together with their children and charges.

Statistical analysis

The SPSS v24 was used for the statistical processing of the data, with the description of the body composition for % fat (% F) and muscle mass % (% MM) with the mean, standard deviation, minimum and maximum values. The comparison of the means between sexes was performed using the Student *t*-test for independent samples. The percentile curves were plotted using the LMS method, making it possible to plot the percentile reference curves, showing the distribution of a measurement and its changes according to some co-variable, in this case age.

Moreover, this method summarises the distribution changes for three (3) curves, representing Assymetry (L), the Median (M) and the Coefficient of Variation (S), where L is expressed as a Box-Cox power[28], whose transformation adapts the distribution of the collected data to a normal distribution, minimising the effects of asymmetry[29]. The method was applied using the LMS Chart Maker software©[30].

Results

The descriptive values of the core variables for the study group are shown in Table 1. The test of normality was made for the body composition variables, indicating that these variables fit the normal curve. Parametric tests were then conducted (student t-test) to compare the means (Tables 2 and 3).

The descriptive statistics for %F are shown in Table 2 and for %MM in Table 3. With regard to %F, the female group had lower values than the male group, with significant differences ($p<0.05$) for those aged 9 and from 12 to 17 years. For its part, the male group showed significant greater values ($p<0.05$) for %MM in relation to the female group.

Table 4 gives the LMS values, respectively, for the %F by sex as well as the 3, 10, 25, 50, 75, 90 and 95 Percentile values by age. It can be highlighted that the males have a lower %F for P3 (♂=6.0; ♀=10.7) however, for P97 the value for the males is higher than for the females (♂=30.6; ♀=26.3). Proportionally, the difference for P90 changes from 7% less in females at 5 years, to 31.3% greater at 13 years and 42.8% greater at 17 years.

Table 2. Descriptive statistics and means comparison of %F for inline speed skaters according to sex.

Age	Female					Male					Means comparison	
	n	Mean	SD	min.	max	n	Mean	SD	min.	max	t-value	*p*
4	6	15.37	3.42	12.4	21.0							
5	23	16.30	4.11	11.8	26.5	5	15.42	5.63	11.3	25.3	-0.4	0.689
6	27	16.74	3.21	11.2	23.4	5	14.38	5.70	6.9	21.6	-1.3	0.192
7	32	16.79	6.25	10.6	35.6	11	14.25	6.65	7.6	28.2	-1.1	0.259
8	40	17.14	4.72	10.0	28.3	7	14.46	5.53	9.8	26.7	-1.4	0.183
9	43	19.19	5.73	10.0	39.3	12	14.41	4.68	8.4	22.3	-2.7	0.011
10	31	18.80	4.17	11.2	27.1	13	16.11	7.34	8.4	30.4	-1.5	0.130
11	36	19.46	5.77	10.6	39.9	10	15.54	4.02	9.1	24.5	-2.0	0.051
12	34	23.26	5.63	10.6	38.7	3	12.90	0.56	12.4	13.5	-3.1	0.003
13	22	19.97	4.26	14.3	31.9	16	13.88	3.32	8.4	18.6	-4.8	0.000
14	28	20.81	5.27	13.6	35.6	14	13.43	5.83	6.9	26.0	-4.1	0.000
15	20	21.18	3.94	9.4	25.8	20	11.71	2.28	8.4	17.5	-9.3	0.000
16	9	21.52	4.48	16.7	32.6	11	12.71	1.19	10.6	14.2	-6.3	0.000
17	10	22.00	5.03	16.1	28.9	7	11.31	1.13	9.8	12.8	-5.5	0.000
18						7	10.06	3.81	6.9	17.2		
19						3	14.00	4.87	8.4	17.2		
20						1	15.70		15.7	15.7		
21						3	8.60	1.11	7.6	9.8		
22						7	6.14	1.85	3.9	9.1		

Table 3. Descriptive statistics and means comparison of %MM for inline speed skaters according to sex.

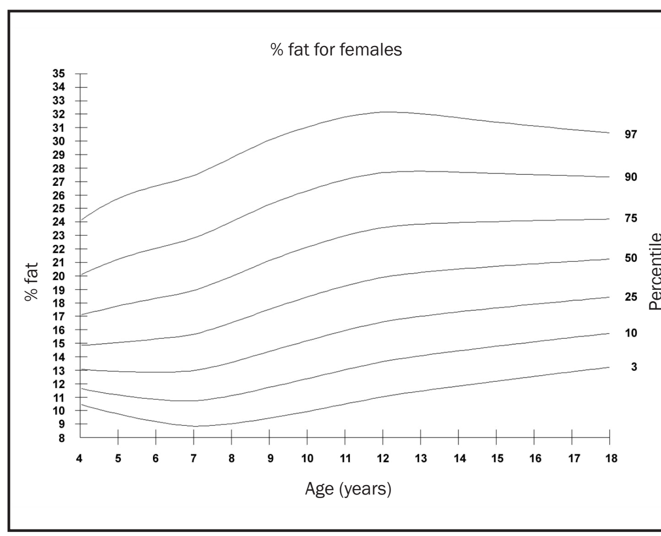
Age	Female					Male					Means comparison	
	n	Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.	Value of t	*p*
4	6	33.2	2.6	29.6	36.8							
5	23	34.3	2.1	30.3	37.7	5	46.4	3.4	42.3	50.2	10.6	*0.000
6	27	35.5	2.3	31.7	40.0	5	47.2	1.1	45.6	48.4	10.9	*0.000
7	32	36.0	1.8	32.0	39.8	11	45.0	3.0	38.8	48.7	12.1	*0.000
8	40	37.3	2.1	32.6	42.9	7	46.5	1.2	45.3	48.1	10.9	*0.000
9	43	37.7	3.3	25.1	47.2	12	45.9	1.6	42.8	48.3	8.2	*0.000
10	31	38.9	3.9	34.7	56.9	13	47.3	2.7	43.8	55.0	7.0	*0.000
11	36	38.9	2.3	34.9	45.5	10	45.8	3.2	41.2	50.9	7.6	*0.000
12	34	38.2	2.1	33.9	41.8	3	43.7	0.3	43.4	44.0	4.5	*0.000
13	22	38.5	2.1	35.5	42.6	16	45.8	1.7	42.2	48.6	11.3	*0.000
14	28	40.1	2.7	36.1	47.0	14	45.0	2.4	39.4	49.6	5.9	*0.000
15	20	39.9	2.7	31.6	43.3	20	46.1	2.0	41.5	50.2	8.4	*0.000
16	9	40.0	2.4	36.6	44.4	11	46.1	2.3	39.8	48.4	5.8	*0.000
17	10	40.9	2.0	37.2	43.9	7	47.1	1.5	44.6	49.4	6.8	*0.000
18						7	47.0	3.0	42.6	49.5		
19						3	49.5	1.5	47.9	50.7		
20						1	49.3		49.3	49.3		
21						3	47.7	2.3	45.2	49.8		
22						7	42.8	7.0	27.4	48.3		

*Significant differences at 0.05.

Likewise, Table 5 gives the values for LMS for %MM by sex and the P values from 3 to 97, as described above. Comparing the sexes in all the percentile values and ages, the males have greater values than the females. This proportion decreases in percentage terms with age. So that, at 5 years, the P90 for males indicates 34% more %MM than the females, while this difference is 15% at 13 years and 13% at 18 years. However, irrespective of sex, the groups show an increase with age.

Figures 1 and 2 show the smoothed LMS curves for %F, observing how this increases with age for females and decreases for males. For females, the %MM shows a more pronounced increase with age (Figure 3) while the %MM for males shows a moderate increase with age for skaters (Figure 4).

Figure 1. Smoothed percentile curves for %fat for female inline speed skaters.



Discussion

This study was directed at determining the BC profile of young ISS. So, firstly, a comparison of means between sexes was made for %F and %MM, finding significant differences ($p<0.05$) for %F at 9 years and from 12 years onwards. While, for %MM, there were significant differences ($p<0.05$) between sexes irrespective of age. The classification by body composition curves was then made (%F and %MM), taking five (5) cut-off points in accordance with the percentile points of the smoothed LMS curves and assuming the following classification: less than P3: Very low; up to P10: Low; up to P75 Normal; up to P90: High and P97 and above: Very high. Therefore, the findings of this study make it possible to establish a body composition profile with the classification for %F and %MM in both sexes, with ages ranging from 4 to 18 years for females and from 5 to 22 years for males.

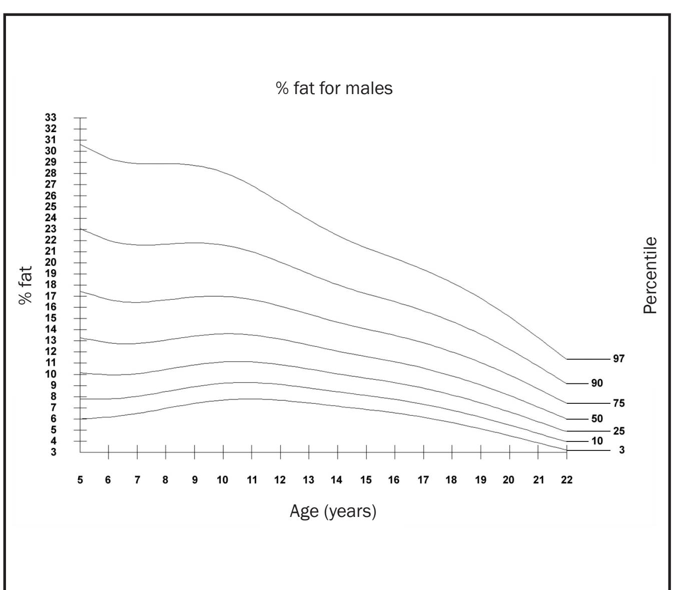
It was found that, when compared to this study, European male long-distance skaters are located at P75 of the curves for %F and short-distance skaters at P90; these values are high given that it is competition time and they are in the top 8 of the 2009 European championships[7]. In a study on women skaters in the Valle del Cauca league selection, with a mean age of 18 years, the mean fat was found to be 15.8%[31]. When compared to this study, it was placed at P10, which is normal for the proposed classification.

Another study on young skaters in Bogota, aged between 11 to 13 years, showed a mean % fat of 15.99% and, for the group aged 14 to 16 years, a mean % fat of 22.5%[23], locating both values in the normal area of the proposed classification, specifically between P10 and P75. Likewise, for 12-year-old girls competing at a national level, mean fat

Table 4. LMS values and percentile points of the %F by sex for inline speed skaters.

Age	L	M	S	3	10	25	50	75	90	97
Female										
4	-1.491	14.531	0.197	10.7	11.6	12.9	14.5	16.8	20.3	26.3
5	-1.172	14.886	0.224	10.4	11.5	13.0	14.9	17.5	21.5	28.1
6	-0.924	15.112	0.244	10.1	11.4	13.0	15.1	18.0	22.3	28.9
7	-0.726	15.303	0.258	9.9	11.3	13.0	15.3	18.4	22.7	29.2
8	-0.544	16.124	0.265	10.1	11.7	13.6	16.1	19.4	23.9	30.1
9	-0.371	17.233	0.266	10.6	12.3	14.5	17.2	20.7	25.2	31.2
10	-0.201	18.242	0.264	11.0	13.0	15.3	18.2	21.8	26.3	31.9
11	-0.042	19.119	0.259	11.4	13.6	16.1	19.1	22.7	27.1	32.3
12	0.111	19.804	0.253	11.8	14.0	16.7	19.8	23.4	27.6	32.4
13	0.261	20.200	0.246	11.9	14.3	17.1	20.2	23.7	27.7	32.1
14	0.406	20.465	0.239	12.0	14.6	17.4	20.5	23.9	27.6	31.7
15	0.542	20.694	0.231	12.1	14.8	17.6	20.7	24.0	27.5	31.3
16	0.665	20.911	0.224	12.3	15.0	17.9	20.9	24.1	27.5	31.0
17	0.779	21.114	0.218	12.4	15.2	18.1	21.1	24.2	27.4	30.7
Male										
5	-0.060	13.271	0.407	6.0	7.8	10.1	13.3	17.5	23.1	30.6
6	-0.160	12.809	0.388	6.2	7.8	9.9	12.8	16.7	22.0	29.4
7	-0.252	12.763	0.369	6.5	8.0	10.1	12.8	16.5	21.6	28.9
8	-0.319	13.070	0.350	6.9	8.5	10.4	13.1	16.7	21.7	28.9
9	-0.356	13.430	0.333	7.4	8.9	10.8	13.4	16.9	21.8	28.7
10	-0.367	13.627	0.318	7.7	9.2	11.1	13.6	17.0	21.6	28.1
11	-0.358	13.531	0.305	7.8	9.3	11.1	13.5	16.7	21.0	26.9
12	-0.338	13.146	0.295	7.7	9.1	10.9	13.1	16.1	20.1	25.4
13	-0.313	12.621	0.288	7.4	8.8	10.5	12.6	15.4	19.0	23.8
14	-0.287	12.075	0.284	7.1	8.4	10.0	12.1	14.7	18.0	22.5
15	-0.261	11.594	0.282	6.9	8.1	9.7	11.6	14.1	17.2	21.3
16	-0.233	11.126	0.282	6.5	7.8	9.3	11.1	13.5	16.5	20.4
17	-0.204	10.551	0.286	6.1	7.3	8.8	10.6	12.8	15.7	19.4
18	-0.174	9.854	0.291	5.7	6.8	8.1	9.9	12.0	14.7	18.2
19	-0.140	9.044	0.297	5.1	6.2	7.4	9.0	11.1	13.6	16.8
20	-0.104	8.102	0.303	4.5	5.5	6.6	8.1	9.9	12.2	15.2
21	-0.067	7.063	0.309	3.9	4.7	5.8	7.1	8.7	10.7	13.3
22	-0.030	5.996	0.315	3.2	3.9	4.9	6.0	7.4	9.2	11.3

Figure 2. Smoothed percentile curves for %fat for male inline speed skaters.



values of 12.2% were found[21]. Along these same lines, 13-year-old male and female skaters were found to have 10% and 19% fat respectively[5]. All the values mentioned above are located in the normal area for this current proposal.

However, when making the analysis with regard to competitive level, it can be seen that the speed skaters in the National Games of Venezuela 2005 exhibited a %F of 18.6% for males and 17.3% for females, while long-distance skaters had 19.7% for males and 19.2% for females[4]. On the other hand, skaters from the Colombian department of Norte de Santander, taking part in the national games of 2012 exhibited a percentage fat of 18.8% for females and 10.8% for males[24]. However, when comparing competitive performance, it was observed that youth medallists (mean age of 17 years) had 7.8% fat compared to non-medallists with 9.8% fat. The above indicates that the fat values closer to the lower area (under P10) are an indicator of a probable improvement in the skater's performance, making the caveat that any extremely low values (under P3) are not at all beneficial to the athlete's health.

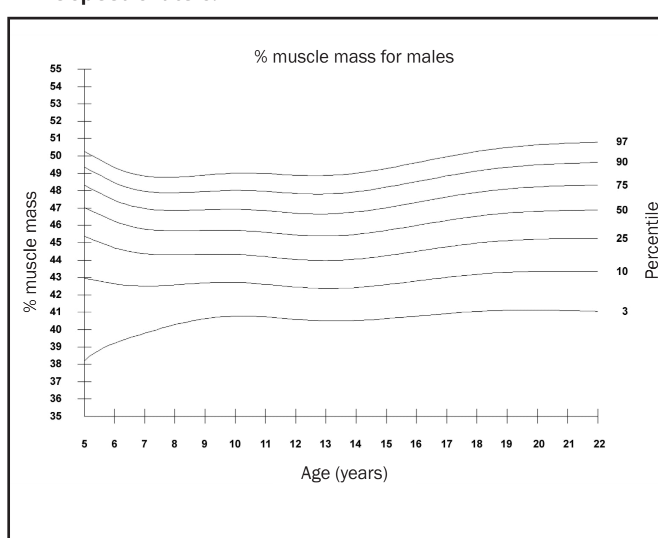
With regard to the %MM as an indicator of the skater's BC, studies with national level skaters have reported values of 44.9% for females and

Table 5. LMS values and percentile values for the %MM by sex for inline speed skaters.

Age	L	M	S	3	10	25	50	75	90	97
Female										
4	0.408	32.597	0.064	28.6	29.9	31.2	32.6	34.0	35.5	36.9
5	-0.119	33.796	0.062	29.9	31.1	32.4	33.8	35.2	36.7	38.3
6	-0.480	34.812	0.061	30.9	32.1	33.4	34.8	36.3	37.8	39.5
7	-0.619	35.744	0.061	31.8	33.0	34.3	35.7	37.2	38.8	40.5
8	-0.637	36.618	0.061	32.6	33.8	35.2	36.6	38.2	39.8	41.5
9	-0.603	37.263	0.061	33.1	34.4	35.8	37.3	38.8	40.5	42.3
10	-0.503	37.677	0.061	33.5	34.8	36.2	37.7	39.3	40.9	42.7
11	-0.309	37.953	0.061	33.7	35.0	36.4	38.0	39.5	41.2	43.0
12	-0.032	38.199	0.061	33.8	35.2	36.7	38.2	39.8	41.4	43.2
13	0.298	38.535	0.061	34.0	35.5	37.0	38.5	40.1	41.8	43.4
14	0.677	38.942	0.061	34.3	35.8	37.4	38.9	40.5	42.2	43.8
15	1.087	39.352	0.061	34.5	36.1	37.7	39.4	40.9	42.5	44.1
16	1.482	39.749	0.061	34.8	36.5	38.1	39.7	41.3	42.9	44.5
17	1.856	40.135	0.061	35.0	36.8	38.5	40.1	41.7	43.3	44.8
18	2.210	40.506	0.060	35.2	37.1	38.8	40.5	42.1	43.6	45.1
Male										
5	9.334	47.029	0.046	38.2	43.0	45.4	47.0	48.3	49.4	50.3
6	8.773	46.227	0.044	39.2	42.6	44.7	46.2	47.4	48.4	49.3
7	8.038	45.791	0.042	39.8	42.5	44.4	45.8	47.0	48.0	48.8
8	7.118	45.692	0.042	40.3	42.6	44.3	45.7	46.9	47.9	48.8
9	6.233	45.713	0.042	40.6	42.7	44.3	45.7	46.9	48.0	48.9
10	5.516	45.715	0.042	40.8	42.7	44.3	45.7	46.9	48.0	49.0
11	5.020	45.601	0.043	40.7	42.6	44.2	45.6	46.8	48.0	49.0
12	4.758	45.443	0.044	40.6	42.4	44.0	45.4	46.7	47.8	48.9
13	4.673	45.388	0.044	40.5	42.4	44.0	45.4	46.7	47.8	48.9
14	4.695	45.487	0.045	40.5	42.4	44.1	45.5	46.8	47.9	49.0
15	4.762	45.713	0.045	40.6	42.6	44.3	45.7	47.0	48.2	49.3
16	4.835	45.996	0.046	40.8	42.8	44.5	46.0	47.3	48.5	49.6
17	4.882	46.284	0.046	40.9	43.0	44.8	46.3	47.6	48.8	50.0
18	4.903	46.530	0.047	41.0	43.2	45.0	46.5	47.9	49.1	50.3
19	4.904	46.705	0.047	41.1	43.3	45.1	46.7	48.1	49.3	50.5
20	4.894	46.806	0.048	41.1	43.3	45.2	46.8	48.2	49.5	50.6
21	4.877	46.858	0.048	41.1	43.4	45.2	46.9	48.3	49.6	50.7
22	4.858	46.885	0.049	41.0	43.3	45.2	46.9	48.3	49.6	50.8

Figure 3. Smoothed percentile curves for % muscle mass for female inline speed skaters.

Figure 4. Smoothed percentile curves for % muscle mass for male inline speed skaters.



48.2% for males[24]. 12-year-old boys have been reported to have 45.5% and girls 44.1%[5] while values of 49.9% were found in 12-year-old boys in Neiva-Colombia[22]. On analysing these values, based on competitive performance, the young male medallists had 48.4% while non-medallists had 48.3%[14]. It can be seen that the values indicated are located between P10 and P90 of this study.

Taking the findings into account and the fact that the proposal presented is not intended to be a unique rule to characterise the BC of a skater, it is appropriate to consider that the classification presented makes it possible to identify and to precisely and objectively classify the BC characteristics of skaters irrespective of age and competitive level. By considering the interpretation in accordance with the time of training, whether at the start of preparation or close to a competition, this tool is equally useful in the biomedical, nutritional or physiological diagnosis, as it is compared with other variables such as maturity, growth, age, competitive level, performance, training and functional aspects.

It is important to point out that, irrespective of the formula used, the personnel involved in the monitoring and control of the training frequently handle body composition references that are from studies with focal populations (with regard to age, sex, competitive level or training time), even for other sports or from overweight prediction models in multi-sport groups[32] for the purpose of comparing and establishing a diagnosis and deciding on the appropriate training programme. Therefore, some of the strengths of this study include the number of longitudinally-assessed subjects, the age range assessed, all are skaters from official clubs within their federations, and the data were directly collected by the author, together with qualified assessors having extensive experience in the handling of anthropometric assessments with large populations.

Finally, it is argued that one of the major limitations lies in the non-probabilistic sample. However, this study can be considered to be a starting point for future studies on larger populations, with probabilistic sampling and considering their ethnic origin. It would also be possible to classify the gross value of skinfolds and circumferences to make it easier for biomedical personnel (sports doctors and nutritionists) as well as exercise physiologists to interpret the anthropometric data.

Conclusions

The values found in this study are in line with the evidence available in the literature. Thus, the classification presented, without aiming to establish the population parameters, makes it possible to identify and to precisely and objectively classify the BC characteristics of skaters irrespective of age and competitive level. Therefore, any interpretation resulting from the comparison with this present proposal is left to the discretion of the professional using it, as considered advisable for the subjects being assessed.

Conflict of interest

The authors have no conflict of interest at all.

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Special article

Medical arguments for and against the liberalization of doping

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Summary

The use of doping has been banned for almost a century due to the risk involved to the athlete's health. Since then, the criterion of prohibiting substances has been reinforced to improve performance, becoming a rarely controversial issue nowadays. However, opinions defending the liberalization of doping has been sometimes given based on various arguments. One of the most common is the impossibility of completely eradicating doping and that this can be safe, from the point of view of health, if it is done by qualified doctors.

This paper presents the arguments against the liberalization of doping from a medical point of view, contemplating various aspects.

Those related to the use of substances such as: lack of clear criteria for inclusion in the list of prohibited substances and the unclear margin between the use of medication for treatment and for doping.

Arguments related to health protection such as: the risk of sport for the athlete, the healthy sport, doping substances have few health risks, the use of medications, allow genetic doping because it is inevitable, risks of self-medication or use of medication without a prescription.

Arguments related to sports performance such as: Doping products do not improve performance, doping is comparable to other performance improvement techniques, match genetic differences among athletes.

And other arguments such as: prohibition favours doping, the control of doping increases the risks of doping itself, the high cost of anti-doping fight or the few anti-doping resources.

The proposal for liberalization of doping under medical control is analyzed and discussed as well as the effects of liberalization on children and adolescents. At the end the medical ethical aspects related to doping are presented to conclude with the opposition of the medical profession against doping and its liberalization.

Key words:
Doping prohibition. Liberalization. Health. Medical ethics. Medical deontology.

Argumentos médicos a favor y en contra de la liberalización del dopaje

Resumen

El dopaje está prohibido desde hace casi un siglo debido al riesgo que implica para la salud del deportista. Desde entonces, el criterio de prohibición de sustancias se ha reforzado para mejorar el rendimiento, convirtiéndose en un tema poco controvertido en la actualidad. Sin embargo, a veces se han emitido opiniones en defensa de la liberalización del dopaje basadas en diversos argumentos. Uno de los más habituales es la imposibilidad de erradicar por completo el dopaje y que éste puede ser seguro, desde el punto de vista de la salud, si lo practica médicos titulados.

Este artículo presenta los argumentos en contra de la liberalización del dopaje desde el punto de vista médico, contemplando diversos aspectos.

Los relacionados con el uso de sustancias tales como: falta de criterios claros para su inclusión en la lista de sustancias prohibidas y el margen poco claro entre el uso de medicamentos para tratamiento y dopaje.

Argumentos relacionados con la protección de la salud como: el riesgo del deporte para el deportista, el deporte sano, las sustancias dopantes tienen pocos riesgos para la salud, el uso de medicamentos, permitir el dopaje genético porque es inevitable, los riesgos de automedicación o uso de medicación sin prescripción.

Argumentos relacionados con el rendimiento deportivo tales como: los productos antidopaje no mejoran el rendimiento, el dopaje es comparable a otras técnicas de mejora del rendimiento, diferencias genéticas entre los deportistas.

Y otros argumentos como: la prohibición favorece el dopaje, el control del dopaje aumenta los riesgos del dopaje, el alto coste de la lucha antidopaje o los escasos recursos antidopaje.

Se analiza y discute la propuesta de liberalización del dopaje bajo control médico y los efectos de la liberalización en niños y adolescentes. Al final se presentan los aspectos éticos médicos relacionados con el dopaje para concluir con la oposición de la profesión médica al dopaje y su liberalización.

Palabras clave:
Prohibición del dopaje. Liberalización. Salud. Ética médica. Deontología médica.

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Introduction

The origin of the fight against doping can be attributed to the International Amateur Athletic Federation (IAAF) that in 1928 prohibits the use of doping, and specifically the use of stimulants [1]. The International Olympic Committee, in 1960, set up the first Anti-Doping Commission and, together with some international sports federations, established the reasons for the anti-doping policy that are: to maintain and preserve the ethics of sport, to guarantee the physical health and mental integrity of the players and ensure that all competitors have an equal opportunity to compete[2]. Nowadays, the institution responsible for the World Anti-Doping Program is the World Anti-Doping Agency (WADA-AMA) with the legal support of UNESCO[3], which highlight that the purposes of the World Anti-Doping Code[4] the athletes' fundamental right to participate in doping-free sport, to promote health, and thus to ensure fairness and equality in sport for all athletes around the world.

However, there is still a debate as to whether it would not be better to liberalise their use and leave the decision on whether or not to doping to the athlete's discretion, rather than taking all the measures involved in implementing anti-doping regulations

Doping tests are not supposed to identify all athletes using doping substances or methods[5-7]. Doping is more widespread than is indicated by reports of adverse analytical results (AAR) from laboratories accredited by the World Anti-Doping Agency (WADA)[8] and as reflected in surveys of anti-doping attitudes and behaviour[9]. Thererfore, is a strong suspicion that some sporting achievement is achieved through doping[10].

Some authors believe that due to the fact that current rules have failed to prevent doping, and it is much more prevalent than the current data reflects, doping probably could not be eradicated. From this point of view, liberalising the use of prohibited substances would be the best way of avoiding the problem of doping[10-13]. But, on the other hand, the supporters of this proposal realise that a total liberalisation of doping would have major risks for the health of the general public, affecting a very large number of subjects[12], including amateur athletes who already have an alarming and very high prevalence of doping use[14-17]. As a final proposal by these authors, performance-enhancing drugs should be allowed under medical supervision in elite athletes[12].

This document presents the arguments for and against the liberalisation of doping that relate to health aspects, as well as the position of sports medicine in relation to the proposal to create a doping system by doctors.

Arguments related to the use of substances and prohibited methods

Lack of clear criteria for inclusion in the list of prohibited substances

Lack of clear criteria for inclusion on the list of prohibited substances

One argument used by supporters of liberalization is that the criteria for inclusion on the lists of banned substances are unclear[11,13]. Criticism has been made of allowing the use of painkillers such as paracetamol[11] since it might improve the athlete's physical capacity. However, there are scientific proof tha paracetamol is an analgesic that does not improve performance and the athlete has the right to treat painful conditions. Surprisingly, the better knowledge of the use of some substances leads to findings that could force a reconsideration of the banning of substances such as painkillers, as it has been found that pre-competition users of painkillers may be particularly prone to the use of doping substances[18].

The removal of caffeine from the lists of banned substances after it had been banned for years has also been criticised[11]. There is also criticism of other substances such as nicotine or tetrahydrocannabinol[12,19].

When analysed anaylse these substances, there is only evidence of performance enhancement in the case of caffeine[20] and possibly their non-inclusion on the banned list is due to the widespread use of coffee, given that 75% of sportsmen and women consume coffee before or during competition, but only 0.6% have urinary concentrations above 12 µg-mL^{-1}, which could be a high concentration[21]. In addition, the WADA monitoring program does not show significant consumption for doping purposes[22].

More research is needed to provide greater evidence of any harmful effects of performance-enhancing technologies to deter potential users rather than coerce them. Additional actions might include placing substances on the banned lists with greater knowledge of their effects[23] and also carrying out doping controls more effectively[7].

The blurred margin between the use of medication for treatment and for doping

It has been argued that medical treatment for athletes can be problematic when there is a need to use medicines included in the doping list, even if outside the sporting context these are medicines for regular and licit clinical use. It has also been argued that the system of therapeutic use exemptions (TUE)[24] is expensive and may in some cases deprive the athlete of adequate treatment[25]. In some cases, there have been difficulties in treating some athletes, as was the case with the use of beta2-agonists for the management of asthma[26]. However, this case has now been resolved by allowing the use of most of these preparations in clinical and inhalation doses without limitation. Additionally, the TUE system has been questioned since it is suspected that it might be a way of favouring the use of substances, not for therapeutic purposes but for doping[27].

Doping has also been criticised by questioning whether so-called performance enhancing treatments are banned for athletes but allowed for other individuals, whether there are any relevant differences between therapeutic and performance enhancing treatments, and whether bans on performance enhancing treatments should be reconsidered on the basis of sporting disciplines[11].

The first years of application of anti-doping regulations resulted in a time when certain medications could not be used for the legitimate and fully justified treatment of certain pathologies in athletes. The implementation of the TUE system was an enormous success that has allowed Medicine to treat patients, even if they are athletes, with prohibited medications, following the established rule which, in general terms, is adequate and sufficient.

What cannot be agreed upon is the differentiation between treatments for therapeutic purposes and those for improvement. In medicine there are prescription criteria for processes and diseases that are established by medical practice and evidence. There are no indications for improving treatment and, very possibly, the performance of this type of action by the doctor could be considered malpractice and, therefore, susceptible to constitute a lack of ethics.

The use of doping substances for therapeutic purposes has been suggested as a way of avoiding the consequences of sporting activity[28] and would be designed to protect the athlete from the potential great damage that training and the competitive calendar cause at such high levels of competition.

This therapeutic concept does not exist in clinical practice and the allegedly serious consequences of competitive sport have not been described either.

Arguments related to health protection

The argument of the risk of sport for the athlete

One of the arguments for banning doping is to protect the health of the athlete.

Supporters of liberalisation have several objections to this. They point out that, since sport has even fatal risks, there is no justification for using this argument in favour of control of doping. They consider that the argument of the health of the athlete is paternalistic and is not in agreement with the unhealthy aspects and risks associated with the practice of elite sport[23]. They understand that there is no knowledge of possible future harmful effects[29]. Finally, the abolitionists say that the argument for banning doping on health grounds, as is the case with banning alcohol from driving vehicles, is not an argument for banning doping because driving under the influence of alcohol endangers the lives of others and is therefore a public health offence, and this does not seem to be the case with doping. For them, what is dangerous is not the use of doping procedures, such as the use of substances or even blood transfusion, but the clandestiny, without medical supervision and without the athlete being aware of the risks and possible future effects. In addition, due to the fact that harmful effects on health may be greater with a ban than with tolerance accompanied by medical supervision and information to athletes, they justify liberalisation since this would considerably reduce the risks[11,29].

Sport is an activity whose essence is competition[30], which places the athlete at the limit or above his possibilities and therefore generates risks that are inherent to sport itself. This is why the federations adopt rules to reduce the risks and not to take new risks, such as doping. It is precisely because of the risk inherent in sport that the argument for banning doping is fully justified so as not to add to the risks to the athlete beyond those already posed by the sport itself. Moreover, the risks of doping are additional and avoidable, whereas some of the risks of sport are unavoidable[31] such as in diving, combat sports, caving, mountaineering and motor sports.

Moreover, the use of some doping substances is not only a risk to the health of the athlete who is doping, but also to others, for example:

- Cocaine and anabolics increase the aggressiveness of the sportsman or woman over other sportsmen or women. It could involve a risk in boxing and other combat sports, fencing, olympic shooting, archery and biathlon.
- Narcotics, by lowering the level of awareness, can endanger the lives of other athletes or other people (climbing, mountaineering, caving, canoeing, bobsleigh) and in circumstances that make the athlete lose control and impact on other athletes or spectators as in motor sports (motor racing, motorcycling, jet skiing, even cycling).
- The same applies to other products that lower the level of attention of the sportsman or woman.

Doping also has other effects on others. Some athletes resort to doping because they are certain that their opponents are doping, and if they do not do so too, they will be at a disadvantage[32]. This is the so-called coercion or "moral damage" argument[33] whereby the depositor who dopes harms "clean" depositors by forcing them to dope, which is a form of coercion that harms others and is a further argument for refusing doping. According to this argument, doping should be banned because it forces athletes to use it if they want to compete at higher levels. Since clean athletes are being coerced into doping, they are not fully responsible for their actions. Thus, if they cannot withstand the pressure exerted on them both by other competitors and by the elite sport system itself, they are not autonomous in their actions. Only the intervention of sports institutions can protect their autonomy and allow them to decide not to use drugs when competing at elite level. Rejection of doping therefore safeguards the autonomy of competitors.

Moreover, athletes who are convinced that their opponents are doping are the most vulnerable group to use doping procedures[34].

Finally, a risk for the athlete would be that they would be pushed into doping without being clearly indicated that he is being doped, which can happen in two circumstances:

- Children. As occurred in the former German Democratic Republic[35], which had very serious consequences. At least one case of sex change from woman to man, the virilizations of anabolized women, has been known and the pain of muscular rigidity experienced by children when subjected to processes of anabolization, to name only a few, has been described.
- Adults. In general, the athlete has knowledge and experience and the minimum commitment to knowledge at least of the doping rules is assumed so that he or she is not misled by others into doping. However, it may be that in some cases there is a lack of vigilance in the advice given to him or her to take substances and get caught up in a doping procedure.

It is therefore important that there is a procedure for checking that athletes are not being exploited by others[36]. It should be remembered that athletes have confidence in the people around them, who are not always totally concerned with their well-being and may be the ones who lead them to take drugs in order to maintain performance, bearing in mind that support depends on sporting success[37] and that athletes are over-motivated to achieve better marks, along with very high economic incentives and sometimes political and social pressure[11].

A very important part of Sports Medicine is to take measures and propose actions to prevent or at least minimise the risks inherent in sport. What cannot be accepted is the argument that, since sport has risks, those that may arise from the medically controlled use of doping substances are accepted[12]. Doctors should not adds risk to the athlete. This goes against his professional precepts and his code of ethical conduct.

The healthy sport argument

The argument of banning doping on health grounds has been considered by supporters of liberalisation to be a false moral argument indicating that there are sports involving real health risks[12].

It has already been pointed out that the risk is inherent in sport and is thus accepted by society as a whole. The fight against doping seeks to avoid risks that are additional to those inherent in sport, and the argument to that effect is therefore misplaced.

Today's medical work is not the "picturesque image of an ideal harmony between beauty, strength and health devised by the first Olympic movement"[12] but the work of prevention in all aspects to prevent the problem from appearing.

There is no need to insist on the principle that it should not be the doctor who favours attitudes or strategies, such as the proposal of medically-directed doping that lead a person to self-destruction.

Doping substances have few health risks

It has been indicated that the effects of doping substances are not as harmful as claimed, that there is little evidence available on the long-term effects of anabolic steroids and that the medical profession has little credibility regarding the consequences of anabolic steroid use because they are based on athlete comments and advice from other drug users[23].

The scientific literature now offers many scientific evidence on health risks of prohibited substances and methods. The following description is not intended to be a comprehensive review of the harmful health effects of doping substances and methods but, it might be sufficient for the reader to appreciate the risks inherent in the use of various doping procedures.

Athletes who use doping often use a combination of several drugs in high doses, which are constantly changing, leading to interactions and counter-actions. Among the biomedical side effects of doping, cardiovascular effects are the most harmful because they can increase morbidity and mortality[38] (Tables 1, 2).

Table 1. Describes the side effects of ephedrine.

Side effects of ephedra and ephedrine[39]
– Arrhythmias.
– Sudden death.
– Myocardial infarction.
– Vasospasm.
– Hypertension.
– Myocardial hypertrophy.
– Cardiomyopathy.
– Myocardial necrosis.
– Cerebral vascular accident.

Table 2. Describes the side effects of anabolic androgenic steroids.

Side effects of anabolic androgenic steroids[38-40].	
Cardiovascular	– Arrhythmias – Sudden death – Thrombosis – Peripheral embolism – Myocardial infarction – Coagulation disorders – Polycythemia – Coronary atheromatous disease/dyslipaemia – Hypertension – Myocardial hypertrophy – Cardiomyopathy – Myocardial necrosis – Cerebral vascular accident – Coronary Arterial Ectasia – Heart failure
Liverworts	– Inflammatory phenomena and cholestasis – Peliosis – Neoplasms
Neuroendocrines (male)	– Suppression of the hypothalamic-pituitary-adrenal axis – Hypogonadism by withdrawal AAS – Gynecomastia – Prostatic hypertrophy – Prostate cancer
Neuroendocrines (female)	– Virilization
Neuropsychiatry	– Major mood disorders: mania, hypomania, depression – Aggression, violence – Dependence – Neuronal apoptosis, cognitive deficits
Musculoskeletal	– Premature epiphyseal closure – Tendon ruptures
Renal	– Acute renal failure due to rhabdomyolysis – Focal segmental glomerulosclerosis – Neoplasms
Immunology	– Immunosuppressive effects
Dermatologicals	– Acne – Stretch marks

The terrible consequences on the health of thousands of athletes, especially women and children, of the anabolisation programme in the former German Democratic Republic must not be forgotten[35,41].

Regarding erythropoietin and similar products, miscalculations in dosage and dehydration can lead to haematocrit values as high as 80%, resulting in severe hyperviscosity with risk of encephalopathy, stroke, tissue hypoxia, as well as high blood pressure and possible heart failure[42]. There is also a severe risk of hypercoagulability with risk of pulmonary embolism, myocardial infarction and formation of peripheral thromboembolisms. Cases of sudden death have been reported that are probably related to the above-mentioned adverse effects[39,43].

Excessive use of growth hormone can cause side effects such as hypertension, cardiomegaly, ventricular hypertrophy and dyslipaemia[44].

The adverse effects of insulin-like growth factor (IGF-1) include acromegaly, myalgia, oedema, dyspnoea and hypoglycaemia and might have cardiac effects similar to those of growth hormone[44].

Table 3. Side effects of gene doping[45].

– Plasmid DNA. Immunological alterations with inflammation and fever.
– Growth hormone. Oncogenesis.
– IFG-1. Oncogenesis, development of solid cancers and increased tumour growth.
– Overexpression of Epo. Increased hematocrit, increased blood viscosity, heart overload, microcirculation block, stroke and heart failure.
– Complete blockade of myostatin activity. Decrease in mass specific muscle force and shift to a faster more glycolytic phenotype suggesting impairment of the oxidative capacity of the muscle. Decrease in mass specific muscle force and shift to a faster glycolytic phenotype suggesting impairment of the oxidative capacity of the muscle[46] (effects observed in mice).

Blood doping, and also artificial oxygen carriers or plasma expanders, cause tachycardia and increased post-loading of the heart, which can lead to hypertension, myocardial infarction and heart failure[42] and an increased risk of thrombosis.

Gene therapy has a clear morbidity in humans and some risk of mortality after vascular administration. The risks of gene doping are of two types: those arising from the procedures for delivering the product and those arising from the uncontrolled expression of the genes. The risks are summarised in Table 3.

The work of Pärssinen *et al.*[47] finds an increase in premature mortality in competitive powerlifters who used ALE with a 4.6-fold increased risk (95% CI 2.04-10-45; p = 0.0002) compared to the group of powerlifters who had not used ALE.

The use of medicines

The use of many medicines depends on doctor's prescription. Prescription is a medical act resulting from a diagnosis. If there is no diagnosis, there is no prescription, and there can be no prescription on demand, especially if the individual is not ill, has no pathology or does not need a preventive prescription.

The Spanish Code of Medical Deontology[48], which establishes compulsory rules for doctors, indicates that the primary duty of the doctor is to care for the health of the individual and will never intentionally harm the patient.

The doctor must respect the patient's refusal, in whole or in part, of treatment, but if the patient demands from the doctor a procedure which the doctor, for scientific or ethical reasons, judges to be inappropriate or unacceptable, the doctor, having been appropriately informed, is dispensed from acting.

The doctor must have the freedom to prescribe, respecting scientific evidence and authorised indications, which allows him to act independently and guarantee quality.

An additional case would be to treat the athlete to restore the alterations that occur during training, and which could show values of variables at lower than normal levels. This might happen with hormone levels after hard competition or strenuous training. It is clear that among the qualities of the sportsman or woman that can differentiate him or her from others, is his or her capacity to restore homeostasis, so therapeutic aids (hormonal contribution, for example) in this sense would be a clear interference in the normal physiological processes involved in sports practice.

Moreover, it is not deontologically acceptable that the doctor contributes fraudulently to the improvement of the athlete's performance. The assessment of the suitability to practice sport must be based on criteria of care for the health and physical and psychological integrity of the subject. In this respect, doping by sports medicine societies is also prohibited[49,50].

Allowing gene doping because it is unavoidable

There is an argument for liberalisation which argues that, since gene doping is inevitable, what needs to be done is to allow it by regulating its use[51]. The justification for this proposal is that the improvement that gene doping causes in the body can be described as legitimate since this intervention is not within the scope of the harm argument (because its risk is not excessive) nor does it affect the spirit of sport. At least provisionally, genetic modifications affecting the germ line should only be prohibited until scientific evidence can certify that these genetic modifications do not affect the health of the offspring.

It has already been indicated in the previous section that gene therapy is not free from significant risks and it is more than evident that the peculiarities of this therapy should be reserved not only for medical problems under strict prescription but also for truly serious diseases for which there are no other effective forms of treatment.

Risks of self-medication or use of medication without a prescription

In addition to the risks of using doping substances, there is the use of non-medically prescribed substances as is the case with opiates in adolescent women[52], which has important consequences on their health and on the foetus when used in pregnancy[53]. There is also a high risk of neuropsychological dysfunction among students who abuse stimulants without a prescription[54].

Decriminalisation is also being considered in professional and high-performance sport because the clandestine practice of doping leads to many professional sportsmen and women and aspirants to health insecurity[13]. Additionally, the use of doping substances, in many sports and on all continents, has become a major public health problem due to the lack of quality controls[55].

The answer to these arguments is that the responsibility for clandestine use lies with those who practise it and that liberalisation would undoubtedly promote doping among young people and amateurs. The argument based on leaving it to the good judgement of athletes not to use doping in the knowledge of its negative consequences for their health is not sustainable. In fact, prohibitive and punitive strategies have shown the best results in terms of abandoning substances or actions which could endanger the health of the general population, as has been the case with smoking or road speed control.

In cases where doping is not monitored, it is very worrying to know that up to 50% of atheltes would agree to doping in the knowledge that they would die within five years if they were sure that by doping they would achieve great success[56]. Thus, these circumstances are a further argument for considering that liberalising doping would increase its current negative consequences.

Arguments related to sports performance

Doping products do not improve performance

It has been argued that the banning of doping substances is incorrect and immoral since it is doubtful to produce performance improvements or are non significant to improve results in competition. In addition, it would take large cohort and double-blind studies to prove that they actually cause performance improvements[57]. However, it should be remembered that it is difficult for ethics committees to authorise studies on the effects of supra-physiological doses for non-clinically approved uses[58].

It is obvious that if the effects of the different forms of doping were not effective, they would not be used. The most striking case may be the discovery that the effects of anabolic steroids are dose-dependent[59]. There were many studies that found no effect of AAS on increasing muscle size and strength[60,61], but with higher doses AAS have been found to cause a 5-20% increase in muscle strength and a 2.5 kg increase in body weight[62].

As far as oxygen availability enhancers are concerned, the effects of blood re-infusion on exercise have been known for almost 50 years[63] and recently Lundby *et al*[64] indicated that the effects of blood doping on performance were very significant.

Doping is comparable to other performance-enhancing techniques

It has been argued that doping is no different from performance-enhancing techniques such as shaving the body of swimmers or refractive surgery to improve visual acuity in precision sports[57]. Moreover, it is surprising that the use of oxygen availability enhancers, such as EPO, are banned, but that hypoxia tents or training at altitude, which have similar effects, are not[65].

The answer to the first arguments is simple. Firstly, athletes have the right to have their pathologies treated, such as the correction of myopia. Secondly, the improvements in performance are marked by the rules of each sport (in swimming, shaving is allowed, but not certain swimming suits or adhesive therapy strips, for example[66]. With regard to the use of oxygen availability enhancers, each athlete can follow the best training to stimulate the physiological processes that improve his performance. The use of hypoxia workouts has not been forbidden, but the use of EPO and blood transfusion is prohibited because their effects do not respond to physiologically activated stimuli and therefore without control of the homeostasis processes, which can add a risk. Their use is reserved for patients generally suffering from serious illnesses.

There is no doubt that the rules in sports have a point of arbitrariness, but the interpretations of the rule make it precisely that sport and its achievements are valued[58]. The importance of sporting rules is easy to explain: nobody would understand if, in order to encourage basketball players, the diameter of the basket were increased to make the game easier[58]. JW Levine[57] wondered ,referring to the discussion on the liberalisation of doping, that why athletes had to use their legs if they would be go faster by cycling. Obviously, everyone understands the need for rules. The athlete needs a difficulty and the spectator values the natural aptitudes and preparation of the athlete.

Matching genetic differences between athletes

Another argument in favour of liberalisation is that doping would make it possible to even out the differences between athletes resulting from natural, genetically determined qualities, which is known as the natural lottery of the most gifted[67]. Genetic lottery prevent everyone from competing on the same level[10].

This argument highlights the lack of awareness that in sport it is essential to exalt the diversity of natural talents and that the skills and dedication of competitors is decisive[58]. Different sports emphasise different natural abilities and in this sense, differences in people's aptitude for different sports are not a reason to try to match them artificially, for example through doping, but to highlight the wide variety of sports and equally the great diversity of human beings.

Moreover, this argument is inconsistent, because if the use of doping substances were allowed, they could also be taken by the most gifted, unless these athletes were prohibited from doing so. This would mean that sporting success would be determined by the decision of the persons or bodies deciding on the use of substances. On the other hand, the doctor, who according to the promoters of this initiative would be the one to administer the substances, cannot decide who deserves to improve and who does not, nor is it up to him to level the attitudes between athletes[31].

Other arguments

The argument that banning encourages doping

This argument is based on what happened at the beginning of the 20th century in the United States of America (USA) with the dry law that prohibited the manufacture and marketing of alcohol[68,69]. The argument is that prohibitions have a call effect, that they promote clandestine business and that they favour the consumption of prohibited substances. It is therefore argued that doping control increases the risk by favouring the clandestine business of doping substances[10].

While it may be thought that prohibition increased the consumption of alcoholic beverages, the reality is that it decreased mortality and hospital admissions due to the consequences of alcoholism, as well as annual per capita alcohol consumption to less than half of that prior to the prohibition period, and created an atmosphere of understanding of prohibition by society[70]. These beneficial effects were maintained after the ban was lifted[69].

Furthermore, it has been considered incorrect to say that the experience of this ban would always result in failure. Subsequent experience shows that partial bans can produce substantial public health benefits at an acceptable social cost[68].

The comparison between the dry law and the ban on doping seems unfortunate and not at all comparable for two reasons. Firstly, because in the USA there has been a shift from no ban on alcohol consumption to a total ban on it. However, doping has always been banned. Furthermore, there have been bans that have proved effective, such as the ban on smoking in Spain, which has reduced the risk of people exposed to tobacco, its sale and consumption and the rates of acute myocardial infarction, ischemic heart disease and asthma[71,72].

Doping control increases the risks of doping

It has been argued that doping leads to dangerous behaviour that would not occur if its use were liberalised[12]. For example, the detection of oil-based esters of nandrolone, which belong to a class of anabolic steroids with few side effects and little risk of liver disease, has led to the use of oral analogues with more side effects but which are eliminated more quickly, making them difficult to detect. Figure 1 lists the adverse analytical findings (AAR)[8] from WADA-accredited laboratories that indicate the most commonly used parenteral AAR detections. Nandrolone is the only AEA for parenteral use that has decreased, according to the criteria expressed by Kayser *et al.*[12], from more than 250 detections to less than 200. However, the rest of the AEA for parenteral use (methenolone, boldenone and trenbolone) have greatly increased their detections, exceeding by far the use of nandrolone and increasing the total consumption of AEA for parenteral use (in 2015 there were 176 detections of nandrolone, compared to 216 of the other three products). The use of oral AADs has also increased for most products.

It has also been argued that recombinant erythropoietin, being detectable, has led to increased use of other oxygen-transport enhancing substances with greater potential health risks[25].

For these reasons, it is suggested that these consequences of anti-doping practices may cause more health problems than they are intended to prevent.

The above argument is inconsistent and infantile, and it has not been demonstrated that the use of doping substances has more risks associated with these alleged changes in use. The responsibility for the use of doping substances cannot be attributed to the fight against doping but to the athlete who dopes as well as to those who induce or assist him/her in doing so.

The high cost of the fight against doping

Proponents of the liberalisation of doping argue that the cost of the fight against doping is very high and that its effectiveness is questionable. Furthermore, it targets a small population group, and that this involves an ethical dilemma of greater importance and relevance than the ethical argument of anti-doping practice[12,23].

We understand that the costs of the fight against doping can indeed be high. The current anti-doping policy is therefore aimed at rationalising resources and directing control strategies towards specific areas of high risk of doping[4]. But while we believe that doping cannot be entirely eradicated, the data do indicate that it has been reduced to the lowest level of all available records[8].

Figure 2 shows the increase in HAA detections in WADA-accredited laboratories, highlighting a decrease in Olympic sports, where there is more anti-doping pressure, compared to non-Olympic sports which since 2013 are detected more than the previous ones.

Figure 3 shows that the percentage of HAA has progressively decreased from about 2% in the first half of the 2000 decade to about 1.2% nowadays. The decline is greater in Olympic sports, which are below 1% since 2008.

We agree that the problem of doping is much more worrying among amateur athletes because they are much more numerous and outside any kind of medical control, even among very young athletes[73-76].

The use of anti-doping resources for a few

It has been argued that it is ineffective to target anti-doping resources when it affects many amateurs and that doping control is targeted at very few subjects[12].

The approach of liberalising doping through its prescription by specialised doctors would be more expensive, but would also justify without any arguments the use of doping methods to the whole population. Thus, this would increase their use over today's values what

Figure 1. Parenteral AAS.

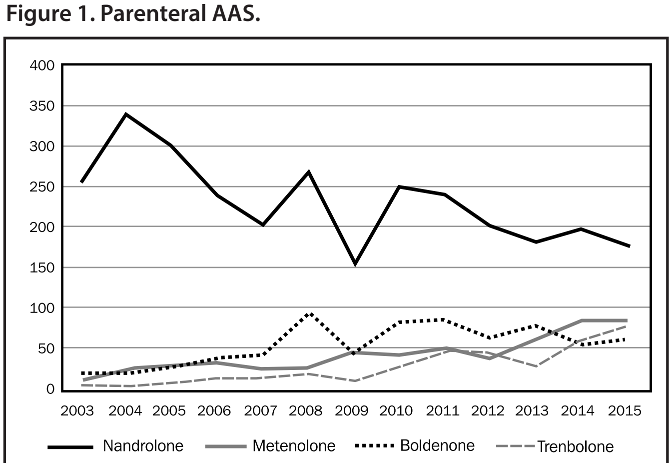


Figure 2. Number of HAA sports Olympic and non-Olympic.

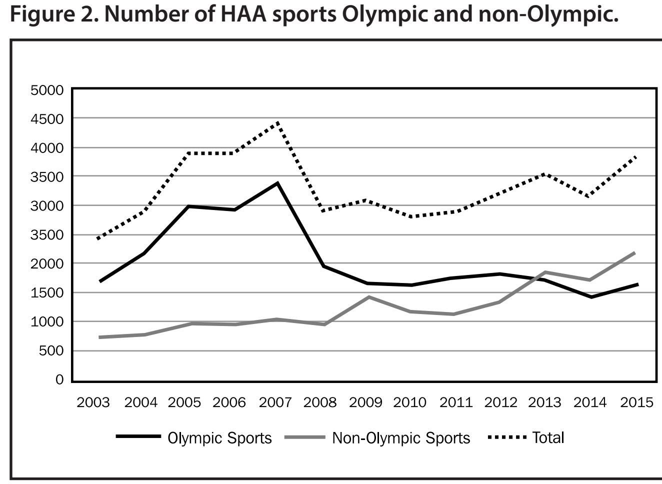
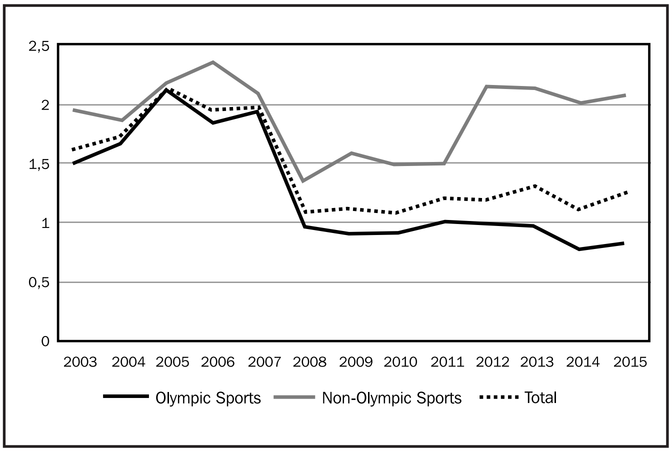


Figure 3. Percentage of HAA sports Olympic and non-Olympic.



already seems very remarkable. Defending the values of sport and seeking ways of controlling the use of doping substances by amateur athletes is needed.

It has been suggested[11] that the health protection arguments for banning doping are of less importance than those based on protecting sport. In this respect, it is sufficient to refer to the highest legal standard in the world, the Universal Declaration of Human Rights, which states that everyone has the right to health, medical care and health insurance[77]. Without diminishing the importance of sport as a major activity, it is not mentioned in the above declaration.

The proposal to liberalise doping under medical supervision

In the light of the above arguments, and in view of the fact that doping should be liberalised, it has been proposed that sports doctors should be able to test athletes for doping[10-13]. However, the risks of total permissiveness in the use of substances should be avoided, This measure would increase doping, but there would be less morbidity and mortality by increasing safety and reducing clandestinity. This would be done under the principle of non-maleficence and protection of privacy[12].

It seems that the first time this argument was used was in the context of the German Democratic Republic, where there was a massive state doping system in which doctors minimised the dangers of substances, especially anabolics, as long as they were performed under medical supervision[78,79], which would be less harmful than clandestine doping performed by the athlete himself.

This criterion is widespread among some sports doctors worldwide and is not an exclusive feature of East German medicine at that time. There is a culture of doping among some doctors which is not only justified by the fact that the risks are minimised by medical supervision. Perhaps the real argument lies in economic reasons, and even in the fact that the results achieved by their athletes are notorious.

Proponents of the legalisation of "medically supervised" doping believe that this relationship is comparable to the traditional doctor-sick relationship. The reality is that this relationship can subordinate medical judgment and client health to performance requirements. This flawed relationship is exacerbated when the doctor becomes dazzled by the athlete's celebrity and successes, causing the doctor to identify so strongly with the athlete's goals and to cause such satisfaction of the athlete's celebrity that he abandons medical standards in favour of the ambitions of the athlete-client who is now in charge of his medical "treatment"[79]. This can lead to a two-way emotional dependence when the doctor succumbs to the charismatic appeal of the athlete and the athlete reveres the doctor as if he were an infallible guru. In his memoir The Secret Race, doped cyclist Tyler Hamilton writes that the famous Italian doper Michele Ferrari "was our trainer, our doctor, our god"[79,80].

The work of the doctor in competitive sport is carried out within a complex ethical framework that invites reflection, because it is not exempt from problems arising from the pressure of the interests of those involved such as the coach, the sponsors and the athlete himself to achieve results[12]. In this context, the role of the doctor is to preserve the athlete's autonomy, to strike a balance between performance and health and to maintain the lifestyle chosen by the athlete.

This leads to situations where optimisation of performance conflicts with the preservation of health, such as when therapeutic measures are applied to keep an athlete competing despite an injury.

While not an easy task, this problem is addressed by maintaining proportionality between the benefits and risks reported to the athlete and the answer to the difficult question of what kind of health risks are acceptable for the athlete to assume.

Regarding performance enhancement, even using currently prohibited procedures, supporters of the liberalisation of doping argue that, in line with the principle of autonomy, the doctor should be at the athlete's service in order to enhance performance. As a result, a doctor in the role of performance enhancer must be responsible for the harmful effects of the use of any medical technology. This would be analogous to the usual role of physicians. They are free in their choice of intervention, pharmacological or otherwise, as long as it is in accordance with current medical knowledge and without iatrogenic disordered effects. Rather than speculating on anti-doping testing procedures, resources should be invested in protecting the integrity of physicians making such judgements.

If doping were permitted under an ethical structure based on the principle of non-maleficence, there would probably be an increase in the use of ergogenic aids, i.e. products currently considered as doping, but this would not lead to an increase in morbidity and mortality[12]. In order to differentiate this strategy from the one implemented in the former German Democratic Republic[35,41], it would be necessary to ensure better information for athletes on the risks they would have and to guarantee the transparency of this practice, thus preventing a given nation from having advantages for its athletes. Furthermore, doping in a non-clandestine manner could have positive effects on the restricted world of elite sport. In fact, doping practices in the world of amateur sport could be less dangerous and thus the overall incidence of health problems caused by doping could be reduced.

This system of doping supervised and carried out by doctors would not lead to total liberalisation in order to avoid health risks. In fact, supporters of liberalisation recognise that doping has risks, even fatal risks, which are considered too high a price to pay for sporting success, even in a society which allows self-destructive behaviour[31]. A certain level of ban would therefore remain. Determining what the limit of the ban should be is very difficult, since not many consequences of the use, especially of the new banned substances, are known. In such cases, medicine dictates the prudence that an unresearched substance should not be considered safe or without side effects, even if its side effects are presumed to be rare.

In case of legalisation, the permissible limits of the use of these substances should be determined outside the individual judgement of the physician. If this were the case, athletes would go to the most daring doctor who would give more products or in higher doses, which would cancel out the principle of equal opportunity, as well as increase the risk of side effects. This would require new rules and an international authority to monitor them. The limit on the use of substances, according to the advocates of liberalisation, would be "safety"[5], which would entail maintaining regulations and a control system that, according to the promoters, should be more frequent and complex, which would increase expenditure, and which would furthermore add to the risk of using prohibited substances even if they were under control[10].

The worst thing would be that all athletes would be forced to take drugs, since the rest would do so and it would be impossible to achieve sporting results without taking drugs.

Another likely result would be an acceleration and aggravation of the pressures on athletes to use higher doses and new combinations of substances in order to stay ahead of competitors. The same dynamic, similar to the arms race, which currently motivates some athletes to take prohibited substances, would lead them to more extreme forms of use if the bans were lifted. It is likely that one of the supposed advantages of lifting the ban (ths safer use) would be offset or overcome by the drive to increasingly use combinations of substances for which it is not known whether they are safe to use. The unknown risks to athletes currently using these substances would be multiplied. As irresponsible experimentation aimed at boosting athletic performance spreads from elite athletes to amateurs who admire and want to emulate their heroes, the public health impact would be amplified.

The dynamics of competition in sport, the effort to constantly seek to gain a competitive advantage, means that, without effective anti-doping programmes, athletes will be driven to adopt an increasingly extreme and experimental doping regime in the interests of competitive advantage. No one can predict with certainty the outcome of such a "race of doping substances", but it is almost certain that it will not be benign and that the health of sportsmen and women, elite or amateur, adults or young people, will be put at risk[58].

It is obvious that the authors of the paper are absolutely against the establishment of a doping system by doctors.

Effects of liberalisation on children and adolescents

Children and adolescents deserve special attention and it is a medical obligation to provide them with special surveillance and care to avoid the possible negative consequences of practising sport. Surprisingly, there are supporters of the liberalisation of doping who say that if children are allowed to train as professional athletes, then they should be allowed to take the same medication, provided that it is not more dangerous than training[10,81].

The boundless willingness of doping would have devastating effects. The elimination of the ethical principles of fair play, in an activity in which young people willingly accept the rules that sport represents in its most noble essence, would cause society to lose a large part of these principles and the value of effort and talent in young athletes would be lost. Moreover, it would not be possible to ban doping among young sportsmen and women as long as it was authorised among adults and would encourage the already high level of use of doping substances among the most vulnerable sections of society, such as adolescents and other groups at risk[82].

From a medical point of view, this reasoning is absolutely unacceptable, because the immediate and long-term effects of pharmacological interventions such as those carried out in doping procedures on under-18 athletes (the cut-off age in most federations) are not known.

Furthermore, training and competition need not be similar to that of adults. They might be harmful and can be changed, while the effects of doping cannot be ignored.

The only reasonable behaviour for people who are concerned about the welfare of children and who wish to preserve the "educational credibility" of sport is to ensure that the unavoidable risks are minimised as much as possible and to avoid the clearly avoidable risks associated with sport for children, including the risks associated with doping[31]. Attempting to justify an additional, pointless evil by pointing to the existence of another inevitable evil is not a persuasive argument.

Medical ethics

The principles of the medical profession come from the Hippocratic Oath, dating from the 12th century, which implies a commitment by the physician to society. According to these principles, which are fully in force, the profession is exercised for the benefit of the patient and without causing him/her any harm[83].

The Geneva Convention, in various adaptations, establishes as inherent duties of the physician, among others, that he must look after the health of the patient, maintain the noble traditions of the medical profession and not use medical knowledge to contravene human laws, indicating that all this is destined to the fulfilment of the purposes of medicine, among which the prevention of disease and the promotion and preservation of health are the principal ones[83].

The evolution of society means that the principles of the Hippocratic J have been adapted to the present day in the following aspects, among others[83]:

- The well-being of the patient which takes precedence over other values and which requires that the interest of the patient alone be served. It should not be influenced by social, administrative or other currents or pressures (including economic ones, as is the case with doping).

- Patient autonomy. Physicians must respect the decisions of their patients, provided that they do not violate medical ethics or lead to improper practice.
- Social justice. The doctor is responsible for promoting justice within the health system and also for denouncing injustices or possible discrimination in the provision of health services based on unjustifiable principles (gender, race... or any other, as is the case with doping).
- Appropriate relationships with patients. The aim is not to maintain an advantageous relationship with patients. The situation of dependency with the doctor can lead to illegal and unethical situations of gain, on any level. This could happen in the case of physician-sponsored doping.
- Improving access to health care. Its actions include health promotion and disease prevention.
- Professional responsibilities. Not only leading to the continuous improvement of care and the qualities of care (quality, efficiency, equity, etc.) but they also seek to uphold the principles of the medical profession. They must participate in the establishment of controls in the exercise of the profession in accordance with certain values, and in the correction of deviations if they occur. This means that physicians have individual responsibility for the practice of their profession, but also collective responsibility.

Doctors must reaffirm their loyalty to the principles and commitments of professionalism which are their principles and which allow them to exercise their profession with dignity.

The Spanish Law[84] indicates several mandates that must be taken into account by doctors who will be guided in their actions by the service to society, the interest and health of the citizen to whom the service is provided, the rigorous fulfilment of the deontological obligations, determined by the professions themselves in accordance with the legislation in force, and the criteria of standard practice or, where appropriate, the general uses proper to their profession.

It is essential to emphasise these later concepts of prevention, promotion and conservation of health, because they include as the object of the doctor's work not only patients or the sick, but also healthy individuals, including sportsmen and women[85], who are the special object of the work of sports medicine[86].

To satisfy these principles, not everything is valid. Physicians carry out their profession through a commitment to medical science and to the sick, and these commitments are established through a contract with society. The basis of that contract is professionalism, the principles of which must be respected by the physician himself and by society.

It has been said that the health risk of doping, under appropriate supervision (in which the doctor would facilitate the doping procedure and would play a very important role), would be easier to justify and that the doctor cannot simply assume that doping is, per se, more dangerous than the risks of participating in elite sport[12]. The doctor does his job by treating the athlete, like any patient, for any medical problem, whether or not it stems from the risk of the sport. What is not part of their job or ethics is the assumption that it may indicate patterns of doping in elite sport, since the risks are lower than those of some sports for their own practice.

Although this paper focuses on the medical aspects of the controversy over the use of prohibited substances, including the ethical aspects that have to do with medicine, it does not seem inappropriate to recall that the vast majority of athletes practices sport in search of the values it embodies. In addition, spectators enjoy and admire the forms of human excellence that are developed in this activity[58]. Moreover, the values of sport continue to be a model for most citizens[31].

Consideration of the risks of doping relates to the question of whether the doctor's actions in this context are consistent with his professional essence of establishing the health of the patient as his first concern, in a similar way to what happens with cosmetic surgery. In this case, when surgery is considered, there is an inevitable risk from the surgery itself, but in the case of sports performance enhancement the risks of doping substances are unnecessary.

In contrast, the risks involved in the use of performance enhancing drugs in sport are unnecessary, which means that doctors would be unnecessarily exposing their patients to risks in an attempt to make sport more attractive. If doctors were to administer unauthorised doping agents, they would be involved in a violation of the rules of sport[31].

Conclusions

The doping control system, although it has been greatly improved in recent years, needs to be refined in certain respects such as the system for detecting substances and the reasons for their inclusion on the prohibited lists. However, partial liberalisation of doping under supervision would not only fail to solve the problem but would aggravate it by increasing the consumption of substances and spreading it throughout the athlete population.

Moreover, the doctor is a professional whose work is much more important than satisfying the impulse and pretensions of some individuals, and should not be separated from his or her deontological principles, which is the only way to make medicine a respected and extraordinarily useful profession for society.

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Conflict of interest

The authors do not declare a conflict of interest.

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Review

Intradialytic physical exercise in chronic kidney disease: a systematic review of health outcomes

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Summary

Introduction: Chronic kidney disease (CKD) is a general term for heterogeneous disorders that affect the structure and function of the kidney. Complications of CKD significantly limit exercise (Ex) tolerance by reducing functional capacity, endurance, and strength. However, the practice of regular Ex contributes to delaying the progression of CKD and stimulating improvements in health-related quality of life (HRQOL). Ex performed during the period of hemodialysis may be the best option when stimulating adherence and being under medical supervision. The purpose of the paper is to examine the effectiveness of intradialytic (iHD) Ex on health outcomes in patients with CKD by identifying the most appropriate component of Ex.
Material and method: Systematic review, based on PRISMA guidelines, performing a structured search in Medline, SciELO and Cochrane Library Plus databases. Publications from the last 5 years relating iHD Ex and CKD up to 31 December 2019 were included. The methodological quality of the articles was evaluated using the McMaster critical review form.
Results: We found 7 articles that described increases in endurance, upper and lower limb muscle strength, and HRQL of CKD patients providing emotional, social and psychological improvements. In addition, iHD Ex is able to control oxidative stress, inflammation, improve the lipid profile and stimulate endothelial progenitor cells, which together reduce the risk of mortality associated with multiple comorbidities in CKD patients, especially cardiovascular ones.
Conclusions: Ex provides improvements in physical function and capacity, HRQL and biological markers. Aerobic Ex, muscle strength Ex and combined Ex programs are used.

Key words:
Chronic renal disease. Physical exercise. Hemodialysis. Physical capacity. Health-related quality of life. Biomarkers.

Ejercicio físico intradialítico en la enfermedad renal crónica: Revisión sistemática sobre los resultados de salud

Resumen

Introducción: La enfermedad renal crónica (ERC) es un término general para los trastornos heterogéneos que afectan la estructura y la función del riñón. Las complicaciones de la ERC limitan considerablemente la tolerancia al ejercicio físico (EFi) al reducir la capacidad funcional, la resistencia y la fuerza. Sin embargo, la práctica de EFi regular contribuye a retrasar la progresión de la ERC y, estimular mejoras en la calidad de vida relacionada con la salud (CVRS). EFi realizado en período de hemodiálisis podría ser la mejor opción al estimular la adherencia y estar bajo la supervisión médica. El propósito del trabajo es examinar la efectividad de EFi intradialítico (iHD) sobre los resultados de salud en pacientes con ERC identificando el componente del EFi más adecuado.
Material y método: Revisión sistemática, basada en las guías PRISMA, realizando una búsqueda estructurada en las bases Medline, SciELO y Cochrane Library Plus. Se incluyeron publicaciones de los últimos 5 años que relacionaran el EFi iHD y la ERC hasta el 31 de diciembre de 2019. La calidad metodológica de los artículos se evaluó mediante el formulario de revisión crítica de McMaster.
Resultados: Se encontraron 7 artículos que han descrito incrementos de la resistencia aeróbica, la fuerza muscular de los miembros superiores e inferiores, y sobre la CVRS de los pacientes de ERC proporcionando mejoras emocionales, sociales y psicológicas. Además, el EFi iHD es capaz de controlar el estrés oxidativo, la inflamación, mejorar el perfil lipídico y estimular las células progenitoras endoteliales, lo que conjuntamente permite reducir los riegos de mortalidad asociada a las múltiples comorbilidades de los pacientes ERC, especialmente las cardiovasculares.
Conclusiones: EFi proporciona mejoras de la función y la capacidad física, la CVRS y los marcadores biológicos. Se emplean programas de EFi aeróbico, de fuerza muscular y EFi combinado de ambos.

Palabras clave:
Enfermedad renal crónica. Ejercicio físico. Hemodiálisis. Capacidad física. Calidad de vida relacionada con la salud. Biomarcadores.

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Introduction

Chronic kidney disease (CKD) is a general term covering heterogeneous disorders that affect the structure and function of the kidneys. CKD is classified according to the states of seriousness, which are assessed using the glomerular filtration rate (GFR), albuminuria, and clinical diagnosis (cause and pathology)[1].

In CKD, the increase of oxidative stress (OS), generalised inflammation, metabolic acidosis, uraemic syndrome, hormonal and haematological alterations, directly affect the cardiovascular system, the skeletal muscle, bone structure, the nervous system and haematopoiesis, considerably limiting tolerance to physical exercise (iPE) by reducing functional capacity, resistance, and strength[2,3]. For these reasons, CKD patients have been dissuaded from performing iPE as it could cause added deterioration to renal function resulting from a reduction of blood flow to the kidneys and increased proteinuria[4]. However, physical inactivity is the cause and effect of the progression of CKD because it directly contributes to the decrease in GFR[5].

It has been reported that the regular practice of iPE establishes changes to the renal haemodynamic[1] as a result of increased cardiac output, increased heart rate and greater venous return, which potentially contributes to slowing the progression of CKD[6]. iPE for patients with CKD subject to HD can be performed at two different times, interdialytic and intradialytic (iHD)[7]. iHD iPE performed in the HD period is the best option for CKD patients undergoing HD, because extra time is not required as iPE and HD are performed simultaneously[8]. Furthermore, patients are under medical supervision, which means any complication can be detected and treated at the time[9]. iHD iPE can increase blood flow to the muscles, enabling the elimination of solutes and toxic agents with a better performance for dialysers[10]. iHD iPE also stimulates sweat and respiratory activity, increasing the elimination of excess body fluids and products deriving from the metabolism, allowing the re-establishment of the homeostasis acid-base[9]. This way, iPE during HD could reduce the physiological and psychological impact of treatment on patients, leading to better conditions during the wait for a future transplant[11].. However, iPE is not free from complications in CKD patients undergoing HD, increasing the risk of suffering a fracture due to alterations of the bone metabolism, and mortality through cardiovascular accident[12].

In Spain, there are currently no standardised and/or documented programmes for iHD iPE. Therefore, we intend to determine the potential effects of iHD iPE on health outcomes (linked to physical function, HRQOL and biological markers), aiming to identify the most suitable iPE component.

Material and methods

Search strategy

This study is a systematic review that focuses on the impact of performing iHD iPE on CKD patients. It was performed following specific methodological guidelines, Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA)[13], and the PICOS question model to define the inclusion criteria: D (demographic): "patients with chronic kidney disease undergoing haemodialysis", I (intervention): "performing intradialytic physical exercise", C (comparison): "same conditions with/without physical exercise", O (outcomes): "Physical, biological and quality of life modifications induced by undertaking physical exercise programmes", S (study design): "controlled design without placebo".

Table 1. Databases used and key words entered for each of the searches.

Search number	Database	Search term
1	Medline (PubMed) / Cochrane library plus / SciELO	Chronic kidney disease AND hemodialysis AND physical exercise
2	Medline (PubMed) / Cochrane library plus / SciELO	Chronic kidney disease AND hemodialysis AND physical activity
3	Medline (PubMed) / Cochrane library plus / SciELO	Chronic kidney disease AND hemodialysis AND physical training

A search was carried out structured on the following electronic databases: Medline (PubMed), SciELO and Cochrane Library Plus. Publications from the previous 5 years were included, linking iHD iPE and CKD, to 31st December 2019. The search criteria included a mixture of Medical Subject Headings (MeSH), and free text words for key concepts related to CKD and iPE (Table 1).

Inclusion and exclusion criteria

To select the studies, the following inclusion criteria were applied: i) Represent a well-designed experiment that included iPE in patients with CKR undergoing HD; ii) Performing iHD iPE; iii) An identical situation of patients with CKD without performing iPE; iv) Documents with a publication date within the past 5 years; v) Publications whose study subjects were humans aged over 18 years with CKD; vi) Languages were restricted to English, German, French, Italian, Spanish and Portuguese. The exclusion criteria applied were: i) Publications not related to CKD and iPE; ii) Duplicate documents, iii) Studies published more than 5 years ago; iv) Not performed on humans with CKD; v) No filter applied regarding previous level of physical condition, or capacity to perform physical activity; vi) The studies were narrative or systematic reviews; vii) Articles with poor methodological quality were excluded, ≤8 points in accordance with the McMaster[14] critical review formula for quantitative studies.

Methodological quality assessment

The methodological quality of the articles was assessed using the McMaster[14] critical review formula. Points were obtained varying from 11 to 15 points, representing a minimum methodological quality of 68.8% and a maximum of 93.8%. Of the 7 studies, 5 achieved "very good"

Table 2. Methodological quality assessment.

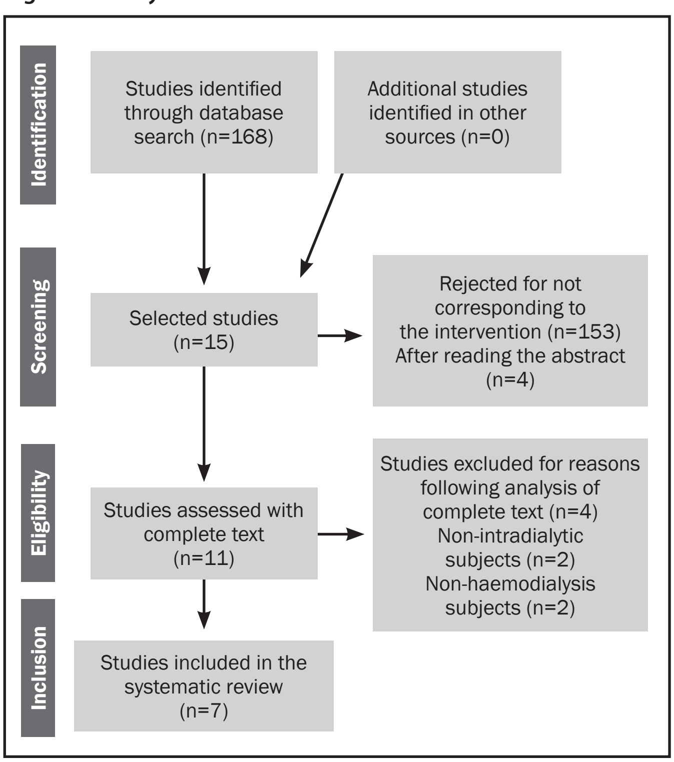
Reference	Ítems																TS	%	MQ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
Abreu *et al.*[20] 2017	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	14	87.5	VG
Anding *et al.*[6] 2015	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	14	87.5	VG
Chan *et al.*[15] 2016	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	15	93.8	E
Cho *et al.*[16] 2018	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	13	81.3	VG
Groussard *et al.*[17] 2015	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	14	87.5	VG
Liao *et al.*[18] 2016	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	14	87.5	VG
Wu *et al.*[19] 2014	1	1	1	1	1	0	1	1	1	1	0	0	0	1	0	1	11	68.8	G
T	7	7	7	10	5	7	7	7	7	7	5	4	2	7	6	6			

T: total items completed; TS: total items completed by study.
1: Criteria fulfilled; 0: Criteria not fulfilled.
MQ: Methodological quality (poor ≤8 points; acceptable 9-10 points; good 11-12 points; very good 13 -14 points; excellent ≥15).

Table 3. Articles found in the different databases.

Search term	No. articles after applying filters	No. articles after reading title	No. articles after reading abstract	Articles selected
Chronickidneydisease AND hemodialysis AND physicalexercise	61	8	5	4
Chronickidneydisease AND hemodialysis AND physicalactivity	66	5	4	2
Chronickidneydisease AND hemodialysis AND physical training	41	2	1	1

Figure 1. Study selection.



quality, 1 "good", and 1 study achieved "excellent" (Table 2). None of the studies were excluded for not reaching the minimum quality threshold.

Results

Study selection

The search threw up 168 articles, after applying the corresponding filters (Table 3). After reading the title and the summary, 15 articles were chosen, of which 2 were excluded as they were studies without intervention, and 2 for not fulfilling the corresponding data. The complete texts of the 11 remaining publications were assessed in adherence to the inclusion criteria, based on which 2 studies were eliminated for not performing iHD iPE and 2 for performing another type of dialysis. This way, 7 articles were obtained for inclusion in this systematic review (Figure 1).

Results measured

Table 4 includes information about the study source data (including authors and year of publication), study type, dialysis, stage of the CKD, type and performance protocol of the iHD iPE. Tables 5a, 5b and 5c display information about the assessment tests, results and conclusions of the health markers analysed in CKD patients in HD.

Discussion

The studies included in this work are controlled trials that are considered suitable for examining whether there is a cause-effect relationship between performing iPE and possible benefits on CKD patients during HD. The most relevant results of this systematic review reveal that iPE programmes significantly improve aerobic resistance, strength and physical function[6,15-19]. Furthermore, these programmes improve HRQOL significantly in the physical, social and psychological sub-scales[6,15,16,19,20] and even in quality of sleep (QS)[16]. iPE also had a positive influence on some biological markers linked to: OS, inflammatory status, lipid profile, blood pressure and endothelial regenerative capacity[17,18,20]. To provide

Table 4. Summary of the general study characteristics included in the review that research the impact of physical exercise on patients with chronic kidney disease in haemodialysis.

Author	Demographic	Study type	Dialysis	Chronic kidney disease study	Type of intradialytic exercise	Performance protocol
Abreu *et al.*[20] 2017	n= 44 >18 years CG: n=19 (61.5%♀, aged 42.5±13.5 years and time of dialysis=70.1±49.9 months). iPEG: n=25 (54.5% ♀, aged 45.7±15.2 years and time of dialysis=71.2±45.5 months) iPEG adherence 78.1%	Randomised control Patients with co-morbidities that impeded the practice of iPE were excluded	3 sessions* week. 3-4 hours Blood flow: 250 mL/min and dialysed 500 mL/min	Stage IV Maintenance dialysis > 6 months	Strength Exercise LL 3 months, 3 times/week (36 sessions), 30 minutes in the 2nd half hour of dialysis	3 * 10 repetitions in 4 different exercises with anklets and elastic bands (Theraband®) on LL. Load: Theraband:1.6/10kg Mvts ankle: 1/12 kg Intensity: 60% of 1RM
Anding *et al.*[6] 2015	n=46 22 ♀ and 24 % 63.2± 16.3 years 3 groups depending on adherence to the iPE sessions High HA > 80% Medium MA 60-80% Low LA < 60% iPEG adherence 78.1%	Controlled - Non randomised monocentric Patients with co-morbidities that impeded the practice of iPE were excluded	4-5 hours 3 times/week.	Stage IV. Maintenance dialysis > 3 months	Strength UL/LL and resistance 30 minutes * session and 2* week = 60 minutes week during the first 2 hours of dialysis 1 year (104 sessions).	Strength: 8 muscle groups. 2* series of 1 minute and 1 minute rest. Customised load calculated by the repetition rate (R) UL weights of 0.5-4 kg LL elastic bands of different resistances. Resistance: stationary cycling on supine cycloergometer (MOTOmed2) work on customised pulsations calculated using the Karvonen method.
Chan *et al.*[15] 2016	n=22 >40 years (59% ♂, 71 ± 11 years) iPE adherence 71.2% ± 23.3%	Controlled crossover non randomised trial Patients with co-morbidities that impeded the practice of iPE were excluded	3 hours 3 times/week.	Stage IV. Maintenance dialysis > 3 months	iHD progressive strength training 3 times/week. 30 minutes during the 1st half of HD. 12 weeks 36 sessions	2 * Strength exercises on UL biceps, deltoids and triceps. Pre-dialysis vascular access arm, intradialysis non-vascular access arm 3 * Strength exercises on LL quadriceps and hamstrings Load: between 2.5-59 kg Mode: Unilateral and bilateral
Cho *et al.*[16] 2018	n=57 26♂ and 31 ♀ Not hospitalised in the past 3 months. 4 groups: CG control n=13 AW aerobic iPE n=15 RE iPE strength n=14 CE iPE n=15 aerobic + strength iPE adherence 81%	Randomised control Patients with co-morbidities that impeded the practice of iPE were excluded	3 times/week	Stage IV. Maintenance haemodialysis ≥ 6 months	- AW - RE - CE 5 min warm-up + 30 min main part + 5-minute cool-down Performed in the first 2 hours of dialysis. 12 weeks 3 times/week. 36 sessions	AW: stationary cycling on supine cycloergometer (SP2100R) with an intensity of 60-70% of maximum capacity. 11-13 Borg Scale 15 points. RE: supine or seated position with elastic resistance bands (Theraband®) and soft weights on LL (quadriceps, vastus lateralis, adductor and femoral biceps) and UL (biceps brachii, triceps and deltoids) 3 series * 10-15 repetitions. Pre-dialysis vascular access arm, intradialysis non-vascular access arm CE: AW + RE

(continúa)

Author	Demographic	Study type	Dialysis	Chronic kidney disease study	Type of intradialytic exercise	Performance protocol
Groussard *et al.*[17] 2015	n=20 15♂ and 5 ♀ Age 20-85 years CG n=10 iPEG n=10 iPE adherence 80%	Randomised control Patients with co-morbidities that impeded the practice of iPE were excluded	3 times/week	Stage IV. Maintenance haemodialysis > 2 years	AW 3 days/week. 5 min warm-up + 30 min main part + 5 min cool-down Performed in the first 2 hours of dialysis. 3 months (12 weeks) 3 times/week. 36 sessions	AW: stationary cycling on supine cycloergometer (Oxycycle) with an intensity of 55-60% of maximum capacity and frequency of 50 rpm.
Liao *et al.*[18] 2016	n=40 23♀ and 17♂ Age 62± 8 years CG n=20 iPEG n=20 iPE adherence not specified	Randomised control Patients with co-morbidities that impeded the practice of iPE were excluded	3 times/ week 4 hours/ Session	Stage IV. Maintenance haemodialysis > 6 months	AW 3 days/week. 5 min warm-up + 20 min main part + 5 min cool-down Performed in the first 2 hours of dialysis. 3 months (12 weeks) 3 times/week. 36 sessions	AW: stationary cycling on a supine cycloergometer. With an intensity of 12-15 on the Borg Scale
Wu *et al.*[19] 2014	n=65 55♂ and 10♀ CG n= 33 44 (41-50) years iPEG n= 32 45 (37-48) years iPE adherence 84%	Randomised control Patients with co-morbidities that impeded the practice of iPE were excluded	3 times/ week 4 hours/ Session Blood flow: 250mL/ min and dialysed 500 mL/ min	Stage IV. Maintenance dialysis > 3 months.	AW 5 min warm-up 10-15 min main part during HD 3 times/ week. 12 weeks 36 sessions	AW: Stationary cycling on a supine cycloergometer with an intensity of 12-16 on the Borg scale associated to energy between 70-100 kcal and an increased heart rate of 20 beats/min.

CG: control group; iPEG: physical exercise group; iPE: physical exercise; ♀ female; ♂: male; iHD: intradialytic; HA: high adherence; MA: medium adherence; LA: low adherence; AW: aerobic; RE: strength CE: aerobic + strength; mL: millilitres; min: minutes; *: multiplication symbol

a clearer analysis, the variables included in this systematic review were grouped as follows.

Intradialytic physical exercise

Before applying an iHD iPE programme, it is vital to establish the time of performance, duration, intensity and iPE modality. In this respect, iHD iPE was performed in the first half[15] or within the first two hours[6,16-18,20] of the HD, mainly due to the hypothetical risks of iPE, given that it could exacerbate haemodynamic instability and/or the appearance of muscle cramps during the final stages of an HD session[7]. iPE usually triggers an increase in blood pressure, as well as posterior hypotension, which is the greatest concern, as presumably this could increase the risk of adverse ischaemic episodes, in particular during the final stage of CKD when the total volume of blood is reduced by ultrafiltration with the iHD iPE[21,22]. Only Chan *et al.*[15] reported a single adverse effect on one patient, with dizziness associated to hypotension in 1 of the 401 sessions carried out, entailing a risk of 0.25%. Liao *et al.*[18] reported modulations in systolic, diastolic blood pressure and in heart rate after 3 months of iHD aerobic cycling training, during the prior basal period iPE[18], which could reduce the symptoms associated with hypotension from the HD. At the time the iPE of the studies analysed was performed, it was probably based on a study carried out by Moore *et al.*[23], which revealed that moderate intensity iPE was well tolerated during the first and second hour of treatment, but not during the third hour due to the hypotension associated with the drop in blood pressure, systolic volume and cardiac output. Conversely, a recent study by Jeong *et al.*[24] found no differences in the iHD haemodynamic parameters between the first or third hour of HD, which would indicate the safety of iHD iPE even when performed during the last hours of HD. Therefore, the patient could be given the opportunity to choose the time to perform iPE, stimulating adherence to the iPE programme.

The deteriorated state of health of patients with CKD undergoing HD does not allow for iPE programmes with overly long sessions, therefore 30 minutes has been established as the most appropriate length for the main part of the session[6,15-17,20], though Liau *et al.*[18] and Wu *et al.*[19] performed shorter sessions. Some studies also included a previous

Table 5a. Summary of the assessment tests, results and conclusions of the physical function and capacity markers of the studies included in the review that research the impact of physical exercise on patients with chronic kidney disease in haemodialysis.

Author	Demographic	Assessment	Results	Conclusions
Anding *et al.*[6] 2015	n=46 22 ♀ and 24 ♂ 63.2± 16.3 years 3 groups depending on adherence to the iPE sessions High HA > 80% Medium MA 60-80% Low LA < 60% Average iPEG adherence 78.1%	Strength: 8 muscle groups Maximum strength tests (maximum no. of exercise repetitions). Resistance: average power (w) Physical function: - 6 min walking test - timed up and go test - sit to stand test (STS60)	Strength ↑* HA (120%) and MA (40-50%) LL: extension of leg, adductor, abductor and abdomen. UL: biceps and triceps. Resistance: ↑* HA (55%) and MA (45%) Physical function ↑* 11-31% n=46 •6 min walking test ↑• timed up and go test ↑* •sit to stand test (STS60)↑*	The iPE strength and resistance programme significantly improved resistance, strength and physical function. Furthermore, it can be integrated into a routine for patients with CKD in HD with high adherence.
Chan *et al.*[15] 2016	n=22 >40 years (59% ♂, 71 ± 11 years) iPE adherence 71.2%± 23.3%	Strength (balance machine) on UL and LL Aerobic 6 min walking test	Strength ↑* LL ↑UL 6 min walking test ↑	Progressive iHD resistance training significantly improved physical health measurements, significantly increasing strength in the LL and UL. Improvements were also observed in the AW component.
Cho *et al.*[16] 2018	n=57 26♂ and 31 ♀ Not hospitalised in the past 3 months. 4 groups: CG control n=13 AW aerobic iPE n=15 RE iPE strength n=14 CE iPE n=15 aerobic + strength iPE adherence 81%	DPA EMR No. AE*week TAE*day (minutes) No. SE*week MSE*day (minutes) % MVPA PAEE (kcal/day)	DPA EMR ↑* AW and CE /↑* CE vs. CG No. AE ↑* CE TAET ≈ Nº SE ↓* AW, RE and CE MSE ↓* AW, RE and CE MVPA ↑* CE PAEE ≈	iHD iPE, particularly CE, is clinically beneficial to improving DPA and reducing sedentary behaviour in patients with CKD in HD.
Groussard *et al.*[17] 2015	n=20 15♂ and 5 ♀ Age 20-85 years CG n=10 iPEG n=10 iPE adherence 80%	VO_2 peak Peak Power 6 min walking test	VO_2 peak ≈ GC y GEFi Peak Power ≈ GC y GEFi 6 min walking test ↑* GEFi ≈ GC	An iHD AW programme is beneficial to physical aptitude by increasing the distance covered during the 6 min walking test, considering the relatively short duration of only 3 months with 36 sessions.
Liao *et al.*[18] 2016	n=40 23♀ and 17♂ Edad 62±8 años GC n=20 GEFi n=20 iPE adherence not specified	6 min walking test	6 min walking test ↑*GEFi	iHD AW iPE cycling at a moderate intensity improves the aerobic physical condition of CKD patients in HD.
Wu *et al.*[19] 2014	n=65 55♂ and 10♀ CG n= 33 44 (41-50) years iPEG n=32 45 (37-48) years iPE adherence 84%	Physical Condition 6 min walking test time taken to walk up and down 22 steps sit-to-stand test grip strength test	Physical Condition ≠* iPEG vs CG 6 min walking test ↑*iPEG time taken to walk up down and 22 steps ↑*iPEG sit-to-stand test↑*iPEG grip strength test ↑*iPEG	Customised iHD iPE significantly improved the physical capacity of CKD patients in a short period of time, and therefore could be used as a simple therapeutic focus with no adverse effects

CG: control group; iPEG: physical exercise group; iPE: physical exercise; ♀: female; ♂: male; HA: high adherence; MA: medium adherence; LA: low adherence; AW: aerobic; RE: strength CE: aerobic + strength; DPA: daily physical activity; LL: lower limbs; UL: upper limbs; EMR: equivalent metabolic rate; No.: number; AE: active episodes; TAE: time of active episodes; SE: sedentary episodes; MSE: mean sedentary episodes; MVPA: moderate/vigorous physical activity; PAEE: iPE energy expenditure; VO2: oxygen consumption; CKD: chronic kidney disease; HD: haemodialysis; iHD: intradialytic.

5-minute warm-up[16-19], and further 5 minutes of cool-down after the main part of the iPE[16-18].

Customising the intensities is considered essential, not only to adapt to physical capacities, but also to align with the CKD evolution of each patient and for other factors associated with the clinical process of HD5. Both aerobic work (AW) and strength work (St) were performed at moderate intensity between 55-70% of the maximum of each patient[16,17,20], and/or an intensity ranging from 11 to 16 points on Borg's perceived

Table 5b. Summary of the assessment, results and conclusions of the quality-of-life markers of the studies included in the review that research the impact of physical exercise on patients with chronic kidney disease in haemodialysis.

Author	Demographic	Assessment	Results	Conclusions
Abreu *et al.*[20] 2017	n= 44 >18 years CG: n=19 (61.5% ♀, aged 42.5±13.5 years and time of dialysis=70.1±49.9 months). iPEG: n=25 (54.5% ♀ of 45.7±15.2 years and time of dialysis=71.2±45.5 months) iPEG adherence 78.1%	QoL test SF-36 Physical function Physical limitations role Body pain Vitality General health Mental health Mental limitations role Social function	QoL ≠* iPEG vs CG Physical function ≈ Physical role↑* Body pain ≈ Vitality ≈ General health↑* Mental health ↑* Mental Role ≈ Social function ≈	iPE strength in LL for 3 months contributed to the improvement of QoL in patients with CKD in HD
Anding *et al.*[6] 2015	n=46 22 ♀ and 24 ♂ 63.2± 16.3 years 3 groups depending on adherence to the iPE sessions High HA > 80% Medium MA 60-80% Low LA < 60% Average iPEG adherence 78.1%	QoL test SF-36 Physical function Physical limitations role Body pain Vitality General health Mental health Mental limitations role Social function	↑ iPEG QoL SF36 Physical function ↑* Physical limitations role ↑* Body pain ≈ Vitality ≈ General health ≈ Mental health ≈ Mental limitations role ↑* Social function ≈	Improvement of QoL in iPEG assessed using the SF-36 test and significant improvement in the sub-scales of physical function, function of physical/emotional limitations.
Chan *et al.*[15] 2016	n= 22 >40 years (59% , 71 ± 11 years) iPE adherence 71.2%± 23.3%	QoL test SF-36 Adverse effects (structured medical questionnaire)	↑ QoL SF-36 -↑* 3 sub-scales: physical, social and emotional -↓ 1 sub-scale: depression Of 401 total sessions (n=22) 1 patient suffered dizziness: Risk 0.25% equivalent to 1/401	Progressive iHD resistance training improved QoL. Furthermore, it can be worked into a routine for patients with CKD in HD with a high adherence and with no adverse effects
Cho *et al.*[16] 2018	n=57 26♂ and 31 ♀ Not hospitalised in the past 3 months. 4 groups: CG control n=13 AW aerobic iPE n=15 RE iPE strength n=14 CE iPE n=15 aerobic + strength iPE adherence 81%	QS % MI % FI % SFI= MI+FI TST WASO % SE	QS % MI ↓* AW, RE and CE % FI ↓* CG SFI ↓ AW and RE TST ≈ WASO ≈ % SE ≈	iHD iPE, particularly CE, is clinically beneficial to improving SQ in patients with CKD in HD.
Wu *et al.*[19] 2014	n=65 55♂ and 10♀ CG n=33 44 (41-50) years iPEG n=32 45 (37-48) years iPE adherence 84%	QoL KDQOL-SFTM SF-36	QoL ≠* iPEG vs CG KDQOL-SFTM ↑*iPEG all the items except for: pain, sexual function, work status and CKD load SF-36 ↑*iPEG physical function; limitations of physical function; general health; energy/fatigue; sleep; quality of social interaction; list of symptoms/problems	Customised iHD iPE significantly improved the QoL of CKD patients in a short period of time, and therefore could be used as a simple therapeutic focus with no adverse effects

CG: control group; iPEG: physical exercise group; iPE: physical exercise; ♀: female; ♂: male; HA: high adherence; MA: medium adherence; LA: low adherence; AW: aerobic; RE: strength CE: aerobic + strength; QoL: quality of life; SF-36: short form health test 36 items; QS: quality of sleep; MI: movement index; FI: sleep fragmentation index; SFI: average sleep fragmentation index; TST: total sleep time; WASO: wake after sleep onset; SE: sleep efficiency; KDQOL-SFTM: kidney disease quality of life questionnaire; CKD: chronic kidney disease; HD: haemodialysis; iHD: intradialytic; LL: lower limbs.

exertion scale[16,18,19]. Furthermore, for the St iPE, intensity can also be optimised based on the repetition rate[6] and for AW iPE optimum heart rate could be used following the Karvonen method[6], or limit the increase to 20 beats between the basal situation and that of the iPE[19]. With regards to the exercise programmes performed, work was performed with AW resistance[17-19], St[15,20,] and/or both simultaneously, in so-called combined exercise[6,16]. AW component iPE performed during HD consisted in stationary cycling on a supine-position cycloergometer[6,16-19]. St exercises with customised loads and with weights[6,15,20] or elastic resistance bands[6,16,20], were performed using the upper limb muscles (UL), such as

Table 5c. Summary of the biological markers assessment, results and conclusions of the studies included in the review that research the impact of physical exercise on patients with chronic kidney disease in haemodialysis.

Autor	Población	Evaluación	Resultados	Conclusiones
Abreu *et al.*[20] 2017	n= 44 >18 years CG: n=19 (61.5% ♀, aged 42.5±13.5 years and time of dialysis=70.1±49.9 months). iPEG: n=25 (54.5% ♀, aged 45.7±15.2 years and time of dialysis=71.2±45.5 months) iPEG adherence 78.1%	GPx hs-CRP Nrf2 NF-κβ [Nitrite] (μm)	GPx ↑* iPEG hs-CRP ↓iPEG Nrf2 ↑* iPEG NF-κβ ≈ iPEG and ≈ CG [Nitrite] (μm) ↓* iPEG	Strength iPE over 3 months exercise induced the expression of Nrf2 and GPx, maintained nitrite levels
Groussard *et al.*[17] 2015	n=20 15♂ and 5 ♀ Age 20-85 years CG n=10 iPEG n=10 iPE adherence 80%	Lipid profile Cholesterol HDL LDL TG Pro/antioxidant activity Ox-LDL GSH/GSSG GPx SOD F2IsoP	Lipid profile Cholesterol ↑CG ↓iPEG HDL ≈ CG and iPEG LDL ≈ CG ↓iPEG TG ≈ CG ↓* iPEG Pro/antioxidant activity Ox-LDL ≈ GG and iPEG GSH/GSSG ≈ CG and iPEG GPx ≈ CG and iPEG SOD ≈ CG and iPEG F2IsoP ↑*CG ≈ iPEG	An iHD AW cycling training programme has beneficial effects on the lipid profile (lowering plasma TG) and avoiding the increase of basal oxidation (without worsening the F2IsoP, which is the most reliable and specific marker of lipid peroxidation), considering the relatively short duration of just 3 months with 36 sessions on patients with CKD in HD.
Liao *et al.*[18] 2016	n=40 23 ♀ and 17♂ Age 62±8 years CG n=20 iPEG n=20 iPE adherence not specified	Blood pressure Systolic Diastolic Heart Rate Biochemistry iPTH Ca2+ tHcy hs-CRP IL-6 Albumin Creatine ALT Cholesterol Hematocrit Kt/V nPCR BMI weight Endothelial Progenitor Cells CD133+ CD34+ KDR+	Blood pressure Systolic Diastolic Heart Rate } ↑*iPEG Biochemistry ↓* hs-CRP ↓* IL-6 ↑*Albumin ↑*BMI } GEFi Endothelial Progenitor Cells CD133+ CD34+ KDR+ ↑*iPEG	iPE of iHD AW cycling at a moderate intensity improves: the nutritional state and cardiovascular resistance of CKD patients in HD, reduces the cardiovascular risk, inflammatory responses, which could contribute to these beneficial effects of exercise.

CG: control group; PEG: physical exercise group; PE: Physical exercise; ♀: female; ♂ male; GPx: glutathione peroxidase; hs-PCR: high-sensitivity C reactive protein; Nrf2: nuclear factor erythroid 2 linked to factor 2; NF-κβ: nuclear factor kappa-light-chain enhancer of B cells; HDL: high density lipoproteins; LDL: low density lipoproteins; TG: triglycerides; Ox-LDL: oxidised low density lipoproteins; GSH/GSSG: oxidised glutathione/reduced SOD: superoxide dismutase; F2IsoP: 15-F2-isoprostanes; iPTH = intact parathyroid hormone; tHcy=total homocysteine; CPR: C-reactive protein; IL-6: interleukin 6. ALT: alanine aminotransferase; Kt/V: dialysis measure; nPCR: normalised protein catabolic rate; BMI: Body mass index; CKD; chronic kidney disease; HD: haemodialysis; iHD: intradialytic.

the biceps, deltoids, triceps[6,15,16] and the lower limbs (LL), working the quadriceps, hamstrings, abdomen and adductor muscles[6,15,16,20]. In arm St work of the arteriovenous fistula (AVF), the patients received highly conservative recommendations[7], constituting an obstacle to performing St iPE[8]. However, there is no clinical evidence to suggest that limitations should be imposed to St work once the AVF has been correctly healed and when St work progression is gradual[25]. St iHD iPE is performed on the arm without vein access, whilst the exercises on the arm with AVF were performed just before the HD[15,16]. It is important to highlight that no adverse events occurred linked to the AVF with St routines[6,15,16].

Effects on function and physical capacity

Patients with CKD in HD have considerably reduced tolerance to exercise, in functional capacity, in AW and in St. They also suffer from greater muscle mass loss, which along with anaemia, constitute key factors in the reduction of functional and physical capacity[26]. However, practising iPE can help compensate this physical deterioration. In this respect, performing AW iPE in monotherapy[17-19], allows for significant improvement in AW assessment tests. 6 min walking test[17-19]; timed up and go test[19]; sit to stand test[19]; 22 steps; sit-to-stand test[19] and even a St test using a manual dynamometer, the grip strength test[19]. In the study by Groussard *et al.*[17], which significantly improved the distance covered (6 min walking test) in the iPE group by 23.4%, there was no effect on VO_2 maximum. This is perhaps because the changes caused by training at VO_2 maximum are positively linked to the duration of the iPE. More important changes have been described in VO_2 maximum, in patients that performed combined iPE (AW + St) for 6 or more months extra-dialytic[27]. Gains in St after exclusive St training were significant in the UL and the LL[6,15]. However, the patients with better adherence to the iPE programme obtained greater increases (120%) than patients with lower adherence (40-50%)[6]. The same occurred with significant improvements in AW resistance, with gains of 55% for patients with high adherence and 45% for average adherence[6]. This would indicate that adherence to iPE plays a key role in improving physical function and capacity of CKD in HD.

Studies that performed combined iPE[6,16] revealed significant improvements in St and AW capacity[6] and in daily physical activity[16]. The study by Cho *et al.*[16], revealed significant increases in equivalent metabolic rate (EMR) in the AW iPE and combined iPE between the basal situation and following 36 sessions. Significant increases were also demonstrated between the combined iPE group and the control group at the end of the study. Therefore, an increase of the EMRs is directly linked to the significant increase of active episodes of time spent performing moderate combined iPE[16]. These health-related outcomes linked to physical function and daily physical activity suggest that combined iHD iPE is the most suitable type during HD to contribute to delaying the progression of CKD[5]. Logically, following an iHD iPE programme (AW, St or combined) reduces sedentary episodes[16].

Effects on health-related quality of life

Determining health-related quality of life (HRQOL) that establishes multidimensional health outcomes[28], may contribute to establishing, perfecting and assessing iHD iPE programmes.

The most used tool by the studies analysed in this work was the SF-36 questionnaire (Short Form-36 Health Survey)[6,15,19,20], which refers to what the patients think about their own health, how they feel and if they are able to perform routine activities[29]. Generally speaking, iHD iPE programmes contributed to improving the HRQOL assessed using the SF-36, and results were significant in the physical[6,15,19,20], mental[6,20], social[15,19], emotional[15], general health[19,20] and QS[19] sub-scales. Wu *et al.*[19] assessed HRQOL using the KDQOL-SFTM (Kidney Disease Quality of Life Short Form), which includes the SF-12 as the generic core of HRQOL plus the load of kidney disease[28], with HRQOL significantly improving in practically all the generic and specific dimensions of the KDQOL-SFTM.

HRQOL in CKD patients is also related to alterations of QS and/or uraemic restless leg syndrome[30]. Cho *et al.*[16] described improvements in QS after 12 weeks of iHD iPE, demonstrating in particular a significant decrease of the movement index for the iPE group (AW, St and combined) and also a significant reduction in the sleep fragmentation index compared to the control group. These results were similar to those reported previously by Afshar *et al.*[31]. Furthermore, an increase in opioid levels (β-endorphins) from performing iPE, appears to be one of the mechanisms that attenuates restless leg syndrome[32] and would lead to improved QS. In addition, the improvements that iPE has on emotional factors[15], depression[15], increased energy consumption assessed in the EMRs[16] and in physical capacities[6,15-19], could lead to improvements in QS, which would stimulate good HRQOL in CKD patients.

Effects on biological markers

The possibility of using biomarkers and tools to monitor iHD iPE programmes could allow us to assess the effectiveness of iPE and the progression of the CKD in real time[5]. Some biomarkers have already been used to control iHD iPE studies[17,18,20].

OS and inflammation play a key role in the development and progression of CKD, and in addition, its complications - such as endothelial dysfunction and bone mineral disease - are critical factors that contribute to the morbimortality of patients in HD[33]. Moreover, physical inactivity is an important factor that contributes to chronic inflammation and to the alteration of the pro/antioxidant balance[25]. OS is caused by a deficiency in endogenous antioxidant capacity and the increased production of reactive oxygen species (ROS) activating various transcription factors, including the nuclear factor κB (NF-κB), which regulates the expression of genes responsible for activating the synthesis of inflammatory cytokines like the interleukin-6 (IL-6), interleukin-8 (IL-8), and the monocyte chemotactic-1 (MCP-1)[34]. However, Nrf2 is recognised as a transcription factor responsible for suppressing the pro-inflammatory signalling channels and activating antioxidant mechanisms mediated by NF-κB[35]. In the study by Abreu *et al.*[20], after 12 weeks of St iPE, the expression of Nrf2 and of glutathione peroxidase (GPx) were significantly induced. Therefore, the increase of the Nrf2 expression could a therapeutic strategy to reduce OS and inflammation in patients with CKD associated NF-κB. Although this study[20] is the only one to assess Nrf2 in humans during iPE in HD, there is evidence in murine models with CKD that prove that iPE can increase the expression of the Nrf2 gene[35,36]. The GPx neutralises OS and reduces the ROS[37], the significant increase of this GPx enzyme would stimulate the defence of the organism in CKD patients against the damaging effect of the OS and the ROS. The inflammatory states also revealed a tendency to reduce, which is reflected in the decrease of high-sensitivity C reactive protein (hs-CRP), which is a risk factor associated with cardiovascular disease in CKD patients in HD[31]. Together, these findings could position 12-week St iHD iPE as a modulating therapy of IS and of inflammation in patients with CKD.

Triglyceridemia is the most common blood lipids anomaly in patients with CKD and is considered a cardiovascular disease risk factor[5.] Groussard *et al.*[17] observed a significant reduction in the triglyceride plasma concentration (-23%), indicating an improvement in the lipid profile, after 36 AW iPE sessions. Furthermore, it prevents the increase of OS as it keeps isoprostane F2α (F2α-IsoP) levels under control, which is the most reliable and specific marker of lipid peroxidation in the iPE group. In turn, in the control group F2α-IsoP uncreased significantly. Therefore, AW iPE comprising stationary cycling iHD, could represent a useful strategy against hypertriglyceridemia and an increase in OS.

Endothelial progenitor cells (EPC) mobilised from the bone marrow, work as an endogenous agent in repairing the vascular endothelial system, contributing to angiogenesis and combating atherosclerosis. During CKD, EPC function reduces and deteriorates, which contributes to an increased risk of cardiovascular disease in patients with HD[38]. iHD stationary cycling AW iPE[18] significantly increased the number of EPC, monitored by CD133, CD34 and KDR in patients with CKD in HD. Furthermore, inflammation of endothelial cells causes EPC dysfunction. Therefore, the anti-inflammatory effect of iPE can contribute to increasing the number and improvement of EPC function. The anti-inflammatory effect of AW iPE was proven with the significant reductions of IL-6 and hs-CRP. Furthermore, these authors18 revealed a high correlation (r=0.721 p<0.001) between the EPC and the significant improvement of AW capacity in the 6 min walking test.

Therefore, these results, assessed using biomarkers, reveal that moderate intensity AW and/or St HD iPE performed over 3 months, is able to reduce the risk of mortality due to the multiple co-morbidities of CKD patients, especially cardiovascular risks, by reducing OS (stimulating NrF2 and GPx; modulation of F2α-IsoP), inflammation (reduction of IL-6 and hs-CRP), regulation of the lipid profile (reduction of plasma triglycerides) and stimulation of the EPC.

Limitations and strengths

The main limitations are linked to the low number of studies researched on this issue and with the relatively small number of participants. We should highlight that the two studies were not randomised and one of them used a crossover design. They were performed on demographics with different levels of physical activity and research protocols, which increases heterogeneity between the studies. However, all the subjects were at the same stage of the illness IV, with 3 or more months of maintenance HD. Furthermore, a strength of this systematic review would be the quality control via PRISMA and Mc Master.

Conclusion

Performing iHD iPE with AW, St and combined work programmes, stimulates health outcomes related to physical capacity and function; HRQOL and biological markers. Performing iPE leads to increased aerobic resistance, UL and LL muscle strength, reduces sedentary behaviour, and has a direct beneficial effect on the HRQOL of CKD patients, giving them emotional, social and psychological improvements. Furthermore, iHD iPE is able to control the OS stimulating NrF2 and GPx and the modulation of F2α-IsoP, inflammation caused by the reduction of IL-6 and hs-CRP, the regulation of the lipid profile and a reduction of plasma triglycerides and the stimulation of the EPC. Along with these outcomes, they allow for reduced mortality risks associated with the multiple co-morbidities of CKD patients, particularly cardiovascular.

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Conflict of interest

The authors claim to have no conflict of interest whatsoever.

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Hospital-associated functional decline and possible interventions based on physical activity, a review of the literature

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Summary

Hospital functional impairment is defined as the loss of the ability to perform at least one of the basic activities of daily living with respect to the baseline situation of the person (2 weeks before the onset of acute illness). Its prevalence has been increasing due to the demographic transition of the last few years, which has caused aging to become a challenge with great impact on the health of people, their families and the health system. One of the main consequences of the increase in hospitalizations in the elderly is hospital functional impairment. This condition has multiple consequences in the short, medium and long term, which include increased hospital stay, increased costs of care, increased morbidity and mortality, among others. One of the stages of hospital functional impairment, which corresponds to the functional decline during hospitalization, is modifiable; hence the importance of identification and timely management to intervene at risk patients. Among the interventions that are proposed to deal with this condition are specialized geriatric care, comprehensive management with a multidisciplinary team, nutritional support and physical activity. The latter has been shown to have beneficial effects on physical, cognitive and neuropsychiatric symptoms in the elderly; Therefore, it has been included in multiple hospital protocols as the main non-pharmacological intervention to reduce dependence and impact on functional hospital deterioration.
The objective of this literature review is to describe the definition, epidemiology, risk factors, complications, factors associated with functional recovery and intervention programs described for the treatment. Additionally, describe the interventions that include physical activity in elderly patients hospitalized for acute pathologies and possible functional outcomes in this population.

Key words:
Functional decline. Dependence. Physical activity. Hospitalization.

Deterioro funcional hospitalario y posibles intervenciones desde la actividad física, una revisión de la literatura

Resumen

El deterioro funcional hospitalario (DHF) se define como la pérdida de la capacidad de realizar al menos una de las actividades básicas de la vida diaria respecto a la situación basal de la persona (2 semanas antes del inicio de la enfermedad aguda). Su prevalencia va en aumento por la transición demográfica de los últimos años que ha generado que el envejecimiento se convierta en un reto con gran impacto en la salud de las personas, sus familias y el sistema sanitario. Una consecuencia importante en la hospitalización de los ancianos es el deterioro funcional hospitalario. Esta condición tiene múltiples consecuencias a corto, mediano y largo plazo dentro de las que se incluyen: aumento de la estancia hospitalaria, aumento de los costos en la atención, aumento de la morbimortalidad, entre otros. Una de las etapas del DFH, que corresponde a la declinación funcional durante la hospitalización, es modificable; de allí la importancia de la identificación y manejo oportuno para intervenir a los pacientes en riesgo. Dentro de las intervenciones que se plantean para lidiar con el DFH se encuentra la atención geriátrica especializada, el manejo integral con un equipo multidisciplinario, el soporte nutricional y la actividad física. Está última, ha demostrado tener efectos beneficiosos sobre la función física, cognitiva y síntomas neuropsiquiátricos en el adulto mayor; por lo que se ha incluido en múltiples protocolos hospitalarios como principal intervención no farmacológica para disminuir la dependencia e impactar en el deterioro funcional hospitalario.
El objetivo de esta revisión de literatura es describir la definición, epidemiología, factores de riesgo, complicaciones, factores asociados a la recuperación funcional y programas de intervención descritos para el tratamiento del DFH. Adicionalmente describir las intervenciones que incluyan actividad física en los pacientes adultos mayores hospitalizados por patologías agudas y los posibles resultados funcionales en esta población.

Palabras clave:
Deterioro funcional. Dependencia. Actividad física. Hospitalización.

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Introduction

The demographic transition that has been taking place in recent decades has meant that aging has become a global challenge with major implications for the health of people and their families, and health systems[1].

The World Health Organization (WHO) states that most of the population has a life expectancy of over 60 for the first time in history[2]. In addition, the aging pattern is much faster than in the past[2]; and these demographic alterations have led to changes in health conditions which have become prevalent, affecting public health[3].

It is estimated that about 10% of the elderly require hospitalisation for acute medical conditions at least once a year[4]. One of the most frequent consequences of this hospitalisation in this population group is hospital-associated functional decline (HFD)[4,5]. HFD has short-, medium- and long-term consequences, and some of these can be severe, leading to a significant consumption of social and health resources[6].

Physical activity is known to be a fundamental non-pharmacological strategy for healthy aging[7]. It has been shown to have beneficial effects on physical and cognitive functions, and the control of neuropsychiatric symptoms in the elderly[8]. For this reason, it has been included in many health maintenance programmes for such patients and in geriatric rehabilitation plans as an important therapeutic intervention to prevent frailty and dependence[4,9], conditions which have an impact on the physical and cognitive functions[9].

This literature review aims to define HFD, describe its epidemiology and the risk factors and complications involved, and report on intervention programmes involving physical activity for elderly patients hospitalised for acute medical conditions.

Methodology

This paper is based on a review of the available literature on hospital-associated functional decline and physical activity, and is presented as a narrative review.

Definition

Hospital-associated functional decline (HFD) has been defined on many occasions in terms of loss of function or dependency, decline in the basic activities of daily living (ADLs) and instrumental activities of daily living (IADLs), state of decline and functional impairment[6]. This paper will use the definition most widely accepted and used in recent years. HFD is understood as the loss of the ability to perform at least one of the basic activities of daily living compared to the person's baseline situation (2 weeks before the onset of an acute medical condition)[10]. This deterioration is more related to certain characteristics of the elderly person than the severity of the acute condition itself[11-12]. The literature describes two stages of functional decline: a non-modifiable one corresponding to the acute onset of the condition until admission to hospital and then functional decline once hospitalised[3,4]. This second stage is very important because it can be changed when detected and treated early; hence the importance of hospital protocols for early intervention for patients at risk.

Epidemiology

The prevalence of HFD is estimated at between 35 and 70% among inpatients over 60, with an incidence on discharge of between 35 and 50%[4],. The literature shows that the prevalence of HFD on discharge is directly proportional to age. It is estimated that it stands at 46% in the over-70s and 88% in the over-90s[4]. Studies with a follow-up after 3 months show the persistence of decline in one or more ADLs in 19% of the population and in 28% after one year[4,5], this being associated with increased mortality[13,14].

Risk factors and identification of patients

HFD is a multifactorial condition more related to the characteristics of the individual and those of hospitalisation than with the severity and characteristics of the acute condition suffered by the patient[4,11,12].

Age

The older the patient, the greater the risk of HFD. This has been demonstrated in several studies in which prevalences of up to 23% at the age of 70 and rising to up to 50% in over-85s have been described[5,15,16].

Changes with aging

With aging, the expected physiological changes include musculoskeletal changes, loss of muscle mass (sarcopenia), fatty infiltration and decreased bone mineral density, leading to decreased strength, aerobic capacity, frailty and more frequent falls[4,17]. At metabolic level, visceral fat and fatty infiltration of tissues increase, beta-cell mass decreases and the production of adipokines and inflammatory factors augment, leading to proinflammatory states, insulin resistance and a higher prevalence of acute conditions or decompensation of chronic conditions[18]. At cardiac level, the number of cardiomyocytes decreases, and cardiac hypertrophy and vascular stiffness appear, producing greater endothelial dysfunction, vasomotor instability and pulmonary ventilation impairment[4,18.] Neurosensory changes include reduced brain mass and increased cerebrospinal fluid, resulting in a slower processing speed, less focusing of neuronal activity, decreased working memory and, perhaps among the most important consequences, reduced motor skill[18].

Baseline situation

The risk factors associated with the individual also include the baseline situation of the patient (2 weeks before the onset of the acute medical condition). Some studies have documented that elderly patients in a good baseline situation are 2.5 times more likely to recover their baseline state, while those moderately dependent for ADLs (defined as a score lower than 60 on the Barthel scale) are at greater risk of HFD and of it persisting longer beyond discharge[4,19-21].

Delirium

Delirium is very frequent among elderly inpatients[5], with a prevalence of 14 to 24%[22]. Although the mechanism which links them is not known, this is presumed to be due to the increased frequency of falls, incontinence, immobility due to restraints, adverse drug reactions, pressure sores and greater time in hospital[5,23,24].

Cognitive impairment

Cognitive decline has been identified in several studies as a risk factor for worse outcomes following hospital discharge[25,26]. Sands *et al.* demonstrated a relationship between cognitive function and functional evolution during hospitalisation[26]. This implies that it is important to carry out an early assessment of the cognitive function of elderly patients admitted to hospital for acute medical conditions.

Depressive symptoms

The prevalence of depressive symptoms in elderly inpatients ranges from 10 to 25% depending on the diagnostic criteria used[27] and such symptoms are related to a three-times greater risk of HFD[28,29].

Polypharmacy

The greater the quantity of medications used, the greater the risk of incorrect prescription and adverse drug reactions[30]. Benzodiazepines and neuroleptics are among the medications which most affect mobility and balance[31]. Elderly patients are more sensitive to the effects of these medications and are slower to eliminate them due to changes in pharmacodynamics and pharmacokinetics resulting from the kidney disorders associated with aging, leading to more complications, such as delirium, falls and fractures[5,32]. Drug reactions are involved in the development of 20 to 25% of HFD[6,33].

Immobility

During hospitalisation, elderly patients have low levels of activity and mobility and a relationship between time in bed and drop in Barthel scale score has been described[34]. Studies estimate that elderly patients are immobile for 73 to 83% of their time in hospital[35]. Immobility is of the utmost importance in the first 48 hours of bed rest, which is when it has the greatest impact on reducing functional reserve and aerobic capacity[4]. It is one of the most relevant risk factors because it is susceptible to modification[5].

Environment and hospital routines

Hospital care usually focuses on the diagnosis and treatment of acute medical conditions and often leaves aside cognitive, social, family and functional considerations in the elderly[36]. Many practices contribute to the low mobility of patients, such as the prolonged use of catheters, physical restraints, excessive fear of their falling, acts which disrupt their sleep and the overuse of psychotropic drugs. Such measures probably have no major impact on young people but do on the elderly[5,6]. Physical barriers also pose a problem for mobility. These include raised beds, low chairs, non-adapted bathrooms, poor lighting and obstacles that increase the risk of falls[5,6].

Identifying patients at risk

The timely detection of patients at risk would facilitate the early initiation of specific interventions to prevent dependency and the need for residential care, and reduce morbimortality and health costs[4,9,37]. Patients at risk need to be detected in the first 48 hours following admission in order to reduce the associated complications[4]. Easy-to-apply screening scales exist to identify patients at risk, including, for example, the tools *Hospital Admission Risk Profile* (HARP), *Identification of Seniors at Risk of Functional Decline* (SHERPA), *Identification of Seniors at Risk* (ISAR) and the social-familial GIJÓN scale[5,38].

Complications

Hospital-associated functional decline has multiple consequences for the health in the short, medium and long terms. These include longer times in hospital, greater use of physical resources, higher health costs, higher readmission rates, loss of autonomy, greater functional dependency, more need for residential care and increased mortality[3-6,17,19,39]. Furthermore, a relationship between not recovering functionally following discharge and increased mortality has been described[5,6,40-42].

Factors associated with functional recovery

The factors associated with functional recovery include the early detection of risk factors which benefit from early intervention, the baseline situation at the time of admission (good previous functional reserve) and the potential for recovery[4-6,43,44].

Interventions

Specialised geriatric care and a multidisciplinary team

A type of intervention which has shown some of the best results with elderly inpatients is comprehensive geriatric care[5,6]. This includes multidisciplinary care and a suitable environment for the population, monitoring their entire functional development. It involves geriatric units specialised in the hospital setting with detection and treatment protocols for geriatric syndromes, a multidisciplinary team and early planning for discharge[38,45,46].

Nutritional support

The backing of clinical nutrition is very important for elderly patients. Protein intake is important for maintaining muscle mass and potentially increasing muscle strength[4-6]. The recommendations indicate a protein intake of at least 1.2 g/kg/day for over-65s, combined with physical activity, in order to maintain and restore lean mass[47].

Physical activity

Physical activity is one of the most relevant non-pharmacological strategies for healthy aging. There are many definitions covering it, so we must start by describing them and differentiating concepts.

WHO defines physical activity as any bodily movement produced by the skeletal muscles that requires energy expenditure[48]. AMEDCO (Sports Medicine Association of Colombia) describes it as any voluntary bodily movement requiring muscle contraction and higher-than-baseline energy expenditure, understood as a complex, voluntary, autonomous human behaviour involving components of a biological, psychological and socio-cultural nature[49]. Physical activity should be distinguished from the activities necessary to stay alive and those aimed at improving the health and lifestyle[50]. The American College of Sports Medicine (ACSM) says that physical activity means moving voluntarily and increasing the metabolism as a result of muscle activity[51].

According to WHO, exercise is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that its objective is to improve or maintain one or more components of physical fitness[2,52-54].

The beneficial effects of physical activity on the health are associated with the modification of biological and psychosocial variables which protect against cardiovascular disease, increase the neurotrophic capacity of the brain, support the growth and maintenance of neural circuits, improve cerebral perfusion and circulation, and increase and maintain muscle mass, among other things[8].

Physical activity is one of the factors that conditions body activity and favours multiple changes in body composition over the long term, depending on the amount of energy expended and the frequency, intensity and duration of exercise carried out[55]. The benefits of structured physical exercise for the elderly include: decreased incidence of cardiovascular disease; the maintenance of adequate nutritional and metabolic balance; the postponement of insulin resistance associated with aging, reduced bone mineral loss by boosting osteoblastic hormonal activity and bone remodelling; reduced risk of fracture; reduced risk of falls; strengthening of the muscles; improved balance, coordination and agility; the preservation of cognitive function; decreased prevalence of depression; and enhanced social integration[8,56,57].

A sedentary lifestyle is the main cause of low levels of physical activity and was defined by WHO in 2002 as "little agitation or movement"[58]. In energy terms, a person is considered sedentary when they do not increase on the energy they spend at rest (BMR) by more than 10% in their daily activities[59].

Studies conducted by WHO and PAHO show that three quarters of the Latin American population have a sedentary lifestyle, with women and the poor leading the trend. The level of physical activity of the elderly population is low compared to studies in some Latin American countries, which highlight lower participation as the population ages[60].

Prolonged inactivity entails a marked and progressive reduction of muscle mass, flexibility and balance[61]. Inactive behaviour is very common among elderly inpatients. The effects include a loss of muscle mass and aerobic capacity, and increased neuropsychiatric symptoms[62]. In elderly inpatients, physical inactivity is associated with the time patients are alone in their room. They are more immobile in the afternoon, accompanied by neuropsychiatric symptoms[62].

In the hospital environment, multiple factors are described which prevent inpatients from carrying out physical activity; many of these are modifiable. They include, in addition to the symptoms of the condition itself, the use of medical devices (urinary catheters, prolonged use of venous catheters, fear of falling, etc.)[63].

As for the standardised creation of physical activity programmes, a major hindrance is the heterogeneity in the way that the mobility of hospitalised adults is measured and defined. In practice, it has been difficult to identify the subgroups of patients who benefit the most from interventions, define the appropriate dose and pinpoint the best time to implement the programmes[64, 65].

Exercise programmes described in the literature

It has been reported that physical training, especially of the lower body, can help preserve and improve functional capacity in the elderly[66]. There is evidence that the muscles of older people respond well to intense physical training[66]. Programmes of this kind were first described in 2007 in a Cochrane systematic review with physical activity rehabilitation interventions, walks 3 times a day, changes of position and physical therapy, showing a better functional outcome when physical activity was included compared to conventional hospital care[67].

Subsequently, physical activity programmes tailormade for the patient have been described, showing uncertain results; not so when more specific subpopulations or groups of medical conditions have been evaluated[63].

In another meta-analysis of inpatient rehabilitation programmes for the geriatric population which included 17 clinical experiments that evaluated the effect of rehabilitation (including physiotherapy, occupational therapy or both) compared to conventional care, the results in terms of functional improvement were satisfactory, with a significant decrease in mortality and the need for residential care[67].

In order to prevent functional decline, physical activity programmes should be initiated within 24 hours of hospital admission68 and include walking at least twice a day for 20 minutes, and the exercise should be graded, while the optimal dose for prescription is unknown[68].

As for the duration of interventions, the most recent studies suggest that programmes should be implemented for at least 3 months to improve physical performance in older adults[69]. Therefore, it is proposed that interventions to prevent physical inactivity should probably be more progressive and adapted to the patient, and not just limited to their time in hospital[62,69]. While the patient is in hospital, it is proposed that the therapy sessions be customised in order to have impact on the times of the day in which greater immobility is displayed (in the afternoon)[61]. One of the most important strategies for effective physical activity programmes is encouragement of the participation of medical staff and family in the comprehensive care of the patient[61,66].

Conclusion

HFD is a very common condition among the elderly population of multifactorial origin with multiple associated complications. It is important to identify patients at risk early in order to initiate interventions to promote the autonomy and functional recovery of this population group. Numerous interventions are described in the literature and one of the most important of these is physical activity; however, although its potential benefits when it comes to preventing frailty and dependency, both conditions which affect physical and cognitive functions, are known, there are no methodological models for prescribing exercise for older people in our hospital environment.

Conflict of interest

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

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XVIII CONGRESO INTERNACIONAL DE LA SOCIEDAD ESPAÑOLA DE MEDICINA DEL DEPORTE

Universidad, Ciencia y Medicina al servicio del Deporte

Nueva fecha

25-27 de noviembre de 2021

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26-28 de noviembre de 2020

UCAM

Universidad Católica San Antonio de Murcia

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(Murcia) - España

XVIII Congreso Internacional de la Sociedad Española de Medicina del Deporte

Fecha
25-27 de Noviembre de 2021

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- Aplicación de la variabilidad de la frecuencia cardiaca al entrenamiento deportivo.
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- Respuestas fisiológicas y patológicas de la frecuencia cardiaca y de la tensión arterial en la ergometría.
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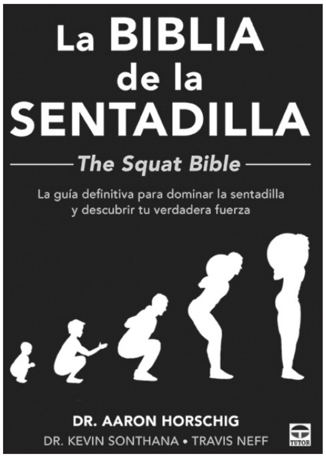

LA GUÍA DEFINITIVA PARA DOMINAR LA SENTADILLA

Por: Aaron Horschig
Edita: Ediciones Tutor. Editorial El Drac.
Impresores 20. P.E. Prado del Espino. 28660 Boadilla del Monte. Madrid
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Aaron Horschig doctor en fisioterapia y entrenador de fuerza y acondicionamiento, dedica su trabajo a ayudar a los deportistas a encontrar procedimientos no solo para reducir los dolores y molestias relacionados con el entrenamiento, sino para que descubran su verdadero potencial. Como fundador de *SquatUniversity.com*, el Dr. Horschig ha adaptado sus técnicas para mejorar el rendimiento deportivo en general.

En La biblia de la sentadilla: la guía definitiva para dominar la sentadilla y descubrir tu verdadera fuerza, Aaron Horschig te ayudará a desentrañar tu destino deportivo proporcionándote valiosas ideas sobre cómo: entrenar de un modo más seguro, tratar adecuadamente los dolores y las molestias, perfeccionar tus técnicas para la sentadilla, y aprovechar al máximo tu fuerza y tu potencial.

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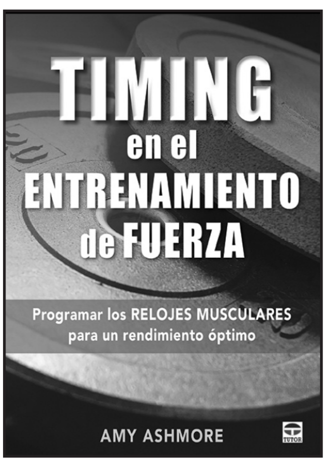
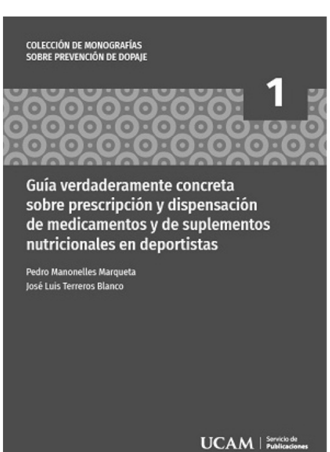


NUEVO ENFOQUE PARA MEJORAR EL RENDIMIENTO

Por: Amy Ashmore
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
ISBN: 978-84-16676-92-7. Nº páginas: 272. Formato: 17 x 24 cm
Precio sin IVA: 28,80 € – Precio con IVA: 29,95 €

Desde la aparición del entrenamiento periodizado, los científicos del deporte saben que el timing, o la elección del momento oportuno para entrenar, es una de las variables de programación más decisiva para optimizar el rendimiento. Las investigaciones más recientes, al descubrir la existencia de relojes dentro de cada uno de los más de 600 músculos esqueléticos del cuerpo, han llevado la aplicación del timing a los programas de entrenamiento en una nueva dirección. Este libro examina cómo estos relojes internos utilizan señales facilitadas por la programación del entrenamiento para regular los procesos fisiológicos necesarios que mejoran el rendimiento.

Este no es otro libro sobre periodización, sino que te enseña a manipular los relojes musculares para entrenar y rendir al máximo todos los días; llega incluso a determinar qué hora del día le conviene más a tu cuerpo. Aprenderás a entrenar a tus músculos para "pensar", proporcionándoles señales de tiempo que les dirán cuándo activar acciones fisiológicas clave que influyen en todo el organismo. A continuación, aprenderás la forma de transmitir señales a esos relojes con métodos de entrenamiento como el emparejamiento biomecánico de los ejercicios, el complex training y el entrenamiento concurrente.



COLECCIÓN DE MONOGRAFÍAS SOBRE PREVENCIÓN DE DOPAJE

Por: Pedro Manonelles Marqueta, José Luis Terreros Blanco
Edita: UCAM Servicio de Publicaciones
ISBN: 978-84-16045-07-5. Nº páginas: 71. Formato: 16,5 x 24 cm
Este libro se ofrece gratis para los médicos y farmacéuticos que lo soliciten a: presidencia@femede.es

La Universidad Católica San Antonio de Murcia (UCAM) ha editado la "Guía verdaderamente concreta sobre prescripción y dispensación de medicamentos y de suplementos nutricionales en deportistas", elaborada por la Cátedra Internacional de Medicina del Deporte de la UCAM y cuyos autores son Pedro Manonelles y José Luis Terreros.

La mayor parte de sustancias prohibidas por dopaje son medicamentos que, en caso de ser detectados en un control de dopaje, pueden suponer una importante sanción para el deportista. No obstante, se pueden prescribir medicaciones prohibidas siguiendo un procedimiento administrativo denominado Autorización para uso terapéutico, procedimiento que se indica en la guía.

La UCAM que trabaja intensamente para prevenir el dopaje ha considerado que es importante que los médicos y farmacéuticos conozcan cómo se puede prescribir y dispensar medicación sin que exista riesgo de dopaje para el paciente-deportista.

2021		
Congreso Mundial de Psicología del Deporte	1-5 Julio Taipei (Taiwan)	web: https://www.issponline.org/index.php/events/next-world-congress
26th Annual Congress of the European College of Sport Science	7-10 Julio Glasgow (Reino Unido)	E-mail: office@sport-science.org
22nd International Congress of Nutrition (ICN)	14-19 Septiembre Tokyo (Japón)	web: http://icn2021.org/
European Federation of Sports Medicine Associations (EFSMA) Conference 2021	28-30 Octubre Budapest (Hungría)	web: http://efsma.eu/
Congreso Mundial de Podología	Barcelona	web: www.fip-ifp.org
XVIII Congreso Internacional SEMED-FEMEDE	25-27 Noviembre Murcia	web: www.femede.es
2022		
8th IWG World Conference on Women and Sport	5-8 Mayo Auckland (N. Zelanda)	web: http://iwgwomenandsport.org/world-conference/
XXXVII Congreso Mundial de Medicina del Deporte FIMS	Septiembre Guadalajara (México)	web: www.femmede.com.mx

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

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

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

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

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

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

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

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

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

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

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

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

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www.femede.es

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de medicina del deporte
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La dirección de Archivos de Medicina el Deporte desea agradecer a todos su desinteresada colaboración.

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