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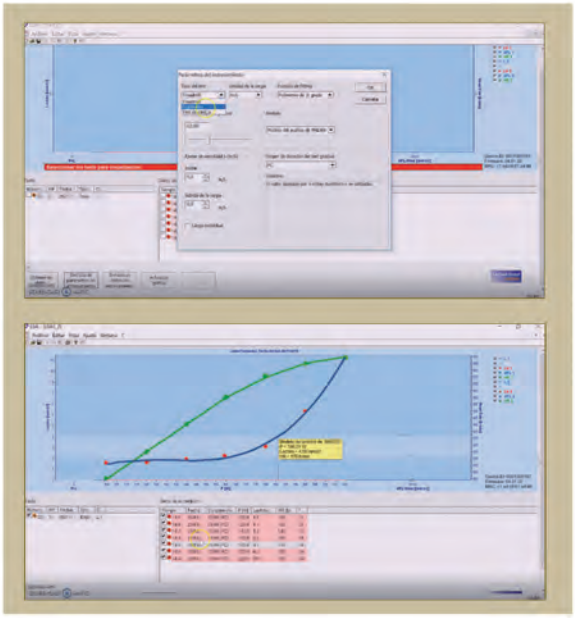

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Summary / Sumario

The traditional periodization in individual sports: providing effective responses to both new and old problems

Periodización tradicional: dando soluciones a los viejos y nuevos problemas

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Performance in individual events require an unique combination of different multi-factorial (psychological, physical, technical) capacities. To target these characteristics and elicit specific adaptations, training must be focused on the desired elements of performance[1]. Moreover, performance is multidimensional, making the quantification of the load a complex issue. The desirable prediction of performance of any athlete is extremely difficult in the upcoming months which preceding a major international competition. The periodization of training based on individual responses to optimize the training process can be conceptualized as a logical sequential of manipulating fitness and recovery phases, following principles of specificity, overload and recovery to achieve high levels of sports performance at the most important competitions.

The inception of this concept in the XX century is dated around 1952-1956. The USSR team achieved the second position in the Olympics because the athletes had not achieved their best performances at the time of the Olympics. Then, a young researcher was asked to find how to peak performance at the right time: Lev Matveev (1924-2006) [transcription in English from the original in Russian] wrote his doctoral dissertation on the problem. The theoretical basis of training was not novel, Matveev based his ideas about periodization on the Theory of Lauri Pihkala (coach of Paavo Nurmi), Hans Selye (General Adaptation Syndrome [GAS]), Pavlov (stimulus-response, conditioned reflexes), and Yakolev (supercompensation). His dissertation substantially modified the philosophy of training, its organization and science, and became on the basis for the international success of the Eastern Block. Matveev's theory was applied on soviet athletes for the first time at the 1960 Olympic Games and USSR was the winner on the medal table. A common criticism of this success has been due to the likely (and in many cases confirmed) use of androgens, however, it is worth noting that androgen use was not confined to the GDR and the USSR, in fact, far from it, as androgen use was common in many countries during this period. Thus, the idea that their success was solely due to drug use is at best an oversimplification.

In the USA, J. Garhammer published one of the first papers dealing with periodization specifically for strength training in athletes, particularly for strength power events. The classical model was also developed and evolved by recognizable swimming coaches as James Counsilman (USA) and Forbes Carlile (AUS).

However, his colleagues at the time often questioned the basis of Matveev's work. If only elite athletes are recruited for analyzing the validity of the traditional model, the usage of parametric statistics is more than doubtful. Those athletes are at the very end of a normal distribution curve, so they do not follow a normal distribution for a correct experimental design[2]. Although Matveyev originally dealt with elite and high-level athletes, an advantage of Matveyev's conceptual paradigm was that it could be applied to athletes of any level in contrast with the criticism of other soviet sport scientific (e.g. Vladimir Zatziorsky).

The known "traditional periodization" has not been indifferent to controversial positioning of different theories which are reflected in the scientific literature. Two important issues have been discussed in the literature. Firstly, traditional periodization has been criticised by authors from the Eastern countries. Several sports scientists and coaches, including Bondarchuk, Verkoshansky and Issurin noted potential problems with the traditional periodization paradigm. A contemporary of Matveyev, Yury Verkoshanky was a sport scientist, working primarily with track and field, who developed the Conjugated Successive System of Training as an alternative to traditional periodization models. Issurin, contemporary with both Matveyev and Verkoshanky also noted potential problems with the traditional concept and developed the Block Periodization model. Verkhoshansky also criticized the technique used to manage periodization [training units] as rudimentary, "… knowing the typical microcycles, which are formed like children's construction

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blocks, the following larger part (mesocycles) that in turn configure the large microcycles…"[3]. Issurin[4] mentioned the need to change the old theory of training and accept a new implementation of the modern demands for competitive athletes. The same author highlighted a few weak points in the traditional periodization as frequent performance peaks within the same competition year, and a deep and specialised focus on the effects of training in a relatively short time. It was due to a change in the international rules for amateur athletes in 1981, allowing athletes to accept money for competition, precipitated considerable discussion and debate as to whether an athlete should be in good shape over a relatively long time or an excellent shape for a single major event. Because of this change many athletes, particularly in track and field, started to modify their training according to "market" rules[2]. Rather than trying to peak when it counted, athletes had to perform over relatively long-terms, often to make a decent living[2]. This alteration in rules and changes in the competition calendar of many sports began to alter training considerations and methods.

Besides, the criticism of the periodization in the last years[5] supports the idea about how periodization dictates should be understood as hypothetical and tradition-driven assumptions rather than evidence-led constructs. Kiely[5] questioned the classical periodization paradigm used in different articles selected, asserting that Selye's Theory of the GAS as a generic predictable biological response should be formulated towards neurobiological aspects of human performance. Cunanan *et al.*[6] argued that GAS has proven to be an instructive framework for understanding the training needed to induce functional adaptations. From our point of view, a periodized program may be advantageous given the need to plan training around practice and competitions throughout the season.

In addition, Kiely[5] also criticized the concept of periodization because he considered that it was not "flexible" enough to meet the athlete's needs. Conversely, Cunnagan *et al.*[6] affirm that this type of criticism usually stems from the often erroneously stated and very typical confusion of periodization with programming. The terms periodization and programming has been wrongly interchangeable by the researchers. The periodization is conceptualized as the macro-management of the training process concerning the annual plan. Whereas periodization (long-term global organisation of training) and programming (short-term prescription of training sessions and sets) are different.

The sports scientists have evolved numerous and different periodization approaches including traditional, blocks, and other variations such as flexible (day-by-day), reverse, each offer a differing rationale and template for the sub-division of the program into sequential elements.

However, a recent systematic review of González-Ravé *et al.*[7] aimed to identify the main characteristics of endurance training for highly-trained swimmers. The results showed as the traditional version of periodization[8-10] was the model conducted in the majority of studies. The traditional model has been the staple of many swimming coach education programs for several decades and enjoys substantial popularity in high performance swimming in many countries, although the fact that other periodization models have not been examined in the literature according to the inclusion criteria of this study does not necessarily imply that they would not be effective in elite swimmers.

Designing training programs is challenging to induce optimal training adaptations and maximize performance for athletes. Despite traditional training periodization provides coaches and athletes basic guidelines for structuring and planning an effective training for two-three peaks of performance. This periodization has resulted successful at present in individual sports as shown Solli *et al.*[11] or Arroyo *et al.*[12]. A major limitation of this approach is its inability to elicit multiple peaks for repeated competitions over the competitive season as required the contemporary elite sport.

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Índice

Bone mineral density in well-trained females with different hormonal profiles

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Summary

Objective: The association between sex hormones and bone mineral density (BMD) has been studied in sedentary women, whereas only few studies have evaluated trained females. Therefore, the aim of this study was to assess the influence of sex hormones on BMD in well-trained females with different hormonal profiles: eumenorrheic females, oral contraceptive (OC) users and postmenopausal women. The secondary purpose was to determine if maximal oxygen consumption ($\dot{V}O_{2max}$) or maximal back squat strength (1RM) could be good predictors of BMD in this population.
Methods: Sixty-eight eumenorrheic, forty-one monophasic-OC users and sixteen postmenopausal well-trained females participated in this study. A Dual-energy X-ray Absorptiometry scan (DXA), a basal blood sample and a maximal back squat and/or a maximal treadmill test were performed. In order to measure all volunteers under similar hormonal conditions (low sex hormone levels), all tests were carried out during the early follicular phase for the eumenorrheic females and in the withdrawal phase for the OC group.
Results: One way ANCOVA reported lower values of BMD in postmenopausal (1.13±0.07g/cm^2) than in eumenorrheic (1.19±0.08 g/cm^2) (p=0.003) and OC users (1.17±0.07 g/cm^2) (p=0.030). Pearson´s correlation showed a positive relationship between BMD and 1RM (p<0.001), but not with $\dot{V}O_{2max}$.
Conclusions: Lower BMD has been reported in postmenopausal women compared to both, eumenorrheic females and OC users. BMD loss after menopause seems to be not fully compensated by exercise, but this could effectively mitigate it. Moreover, 1RM back squat reported a slight association to BMD. Hence, strength training may be the best choice to prevent BMD loss.

Key words:
17β-estradiol. Progesterone. Oral contraception. Exercise. Postmenopause. Eumenorrheic.

Densidad mineral ósea en mujeres entrenadas con diferente perfil hormonal

Resumen

Objetivo: La asociación entre hormonas sexuales y densidad mineral ósea (DMO) ha sido bastante estudiada en mujeres sedentarias, pero no en mujeres entrenadas. Por tanto, el objetivo de este estudio fue analizar la influencia de las hormonas sexuales en la DMO de deportistas con diferentes perfiles hormonales: mujeres eumenorreicas, usuarias de la píldora anticonceptiva y mujeres postmenopáusicas. El segundo objetivo fue analizar si el consumo máximo de oxígeno ($\dot{V}O_{2max}$) o la sentadilla trasera (1RM) serían buenos predictores de DMO en dicha población.
Metodología: Sesenta y seis mujeres eumenorreicas, cuarenta y una usuaria de píldora monofásica y dieciséis mujeres postmenopáusicas bien entrenadas participaron en el estudio. Una densitometría ósea (DXA), una analítica basal y una prueba de esfuerzo y/o de 1RM en sentadilla trasera fueron llevados a cabo. Con el objetivo de que todas las voluntarias fueran medidas bajo las mismas condiciones (bajos niveles de hormonas sexuales), todas las pruebas fueron realizadas en la fase folicular temprana para las mujeres eumenorreicas y en la fase no hormonal para las usuarias de píldora.
Resultados: ANCOVA de una vía mostró valores de DMO más bajos en mujeres postmenopáusicas (1,13±0,07g/cm^2) comparado con las eumenorreicas (1,19±0,08 g/cm^2) (p=0,003) y las usuarias de píldora (1,17±0,07 g/cm^2) (p=0,030). La correlación de Pearson mostró una relación positiva entre DMO y sentadilla (p<0,001), pero no mostró asociación con el $\dot{V}O_{2max}$.
Conclusión: Las mujeres postmenopáusicas presentan valores de DMO más bajo que las mujeres eumenorreicas y las usuarias de píldora. El descenso de DMO tras la menopausia parece no ser completamente compensado por la práctica de actividad física, aunque ésta puede atenuar ese descenso. Además, la sentadilla mostró una ligera asociación positiva con la DMO, por lo que el entrenamiento de fuerza podría ser la mejor opción para prevenir el descenso de DMO.

Palabras clave:
17β-estradiol. Progesterona. Píldora anticonceptiva. Ejercicio. Postmenopausia. Eumenorrea.

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Introduction

Osteoporosis is a skeletal disease represented by low bone mineral density (BMD) due to an imbalance between rates of bone formation and bone resorption. BMD homeostasis depends on two bone cells: osteoblasts (which stimulate bone formation) and osteoclasts (which stimulate bone resorption)[1]. Osteoclasts also produce a glycoprotein called sclerostin, which inhibits bone formation[2-4]. The activity of these two cells is affected by many factors such as pregnancies, tobacco, calcium intake, 17β-estradiol (E2) levels, age, oral contraceptive (OC) use and physical activity[5].

Sex hormones, specifically E2, play a key role in bone growth. These sex hormones are essential for the maintenance of bone tissue, since E2 decrease osteoclasts formation and generation as well as stimulate their apoptosis[6-9]. In short, E2 suppress bone resorption and the production of sclerostin by inhibiting the osteoclasts activity. Moving on to the osteoblasts, in the last years some studies have proved the positive effect E2 has over these cells. It seems that these sex hormones stimulate osteoblasts activity, encouraging bone formation[10-12]. Although the role of the progesterone on BMD metabolism is still unclear[13], it seems to have, together with E2, complementary bone action such as preserving peak bone mass and preventing pre- and perimenopausal bone loss[14]. Despite osteoporosis can also occur in young individuals, is most common in elderly population[5], mainly due to the loss of the ovarian function and the decrease in sex hormones[1]. The drop in E2 produces an imbalance in bone formation and resorption, accelerating bone loss during the first years of the menopause[15].

Furthermore, the use of OC pills has been widespread among females in the last few years, inducing a reduction of endogenous hormones production in this population. Depending on the dosages of exogenous sex hormones (ethinyl estradiol and progestin) presented in the contraceptive formulations, bone tissue metabolism might be affected[16]. Studies related to OC and BMD are still inconclusive possibly because of the differences in studies design, formulations and time of use of OC, different methods for measuring BMD and population characteristics[16].

Exercise is advocated to be one of the best tools to increase bone mass and prevent its loss in elderly[17,18]. Physical and functional performance has been positive correlated with BMD as well as with the maximal oxygen consumption ($\dot{V}O_{2max}$) and strength[19-23], hence BMD may be associated with these two performance variables. Hence, it seems that increasing bone mass before the postmenopause it´s a good way to prevent osteoporosis in elderly females[24]. In fact, an increase of 10% of bone tissue during the adulthood may reduce fracture risk in half in the future[25].

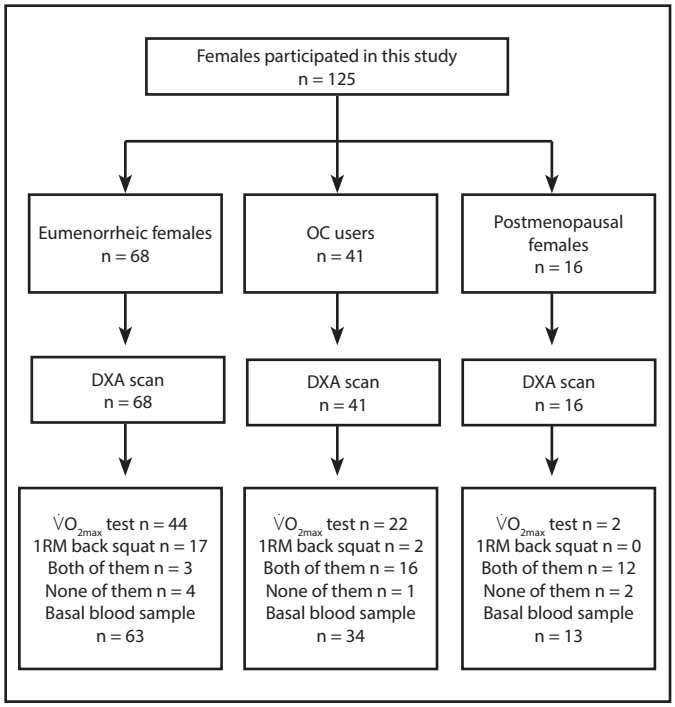
Taking into account all the data aforementioned, we hypothesized that, in active population, OC users may have lower values of BMD regarding eumenorrheic females whereas postmenopausal athletes might have similar values of BMD to eumenorrheic. Thus, the aim of this study was to analyse the influence of sex hormone concentration on BMD in female athletes, comparing three different hormonal profiles: eumenorrheic, monophasic OC users and postmenopausal female athletes. Furthermore, a secondary objective of the present study was to determine if $\dot{V}O_{2max}$ and maximal squat strength are good predictors of BMD in this population.

Material and method

Participants

Sixty-eight eumenorrheic females (26-32 days cycles length), forty-one low dose monophasic OC users (4.13±3.83 years intaking them) and sixteen postmenopausal females (at least one year without menstruation) participated in this study. Volunteers characteristics are shown in Table 1 and the flow chart for participation is shown in Figure 1. At the start of the data collection, all participants conducted a questionnaire gathering information about training status, health conditions, dietary supplements consumption and type of OC pills when appropriate. Brands and formulation of OC pills used were: Ceciliana (n=3): ethinyl estradiol 0.03 mg and dienogest 2 mg; Drosure (n=2): ethinyl estradiol 0.03 mg and drospirenone 3 mg; Yasmin (n=9): ethinyl estradiol 0.03 mg and drospirenone 3 mg; Loette (n=4): ethinyl estradiol 0.02 mg and levonorgestrel 0.1 mg; Levobel (n=2); ethinyl estradiol 0.02 and levonorgestrel 0.1; Diane (n=4): ethinyl estradiol 0.035 mg and cyproterone 2 mg; Edelsin (n=1): ethinyl estradiol 0.035 and Norgestimate 0.25 mg; Drosbelalleflex (n=2): ethinyl estradiol 0.02 mg and Drospirenone 3 mg; Melodene (n=2): ethinyl estradiol 0.015 mg and gestodene 0.06 mg; Linelle (n=3): ethinyl estradiol 0.02 mg and levonorgestrel 0.1 mg; Stada (n=1): ethinyl estradiol 0.02 mg and drospirenone 3 mg; Sibilla (n=3): ethinyl estradiol 0.03 mg and dienogest 2 mg. Thereby, exogenous sex hormones concentration mean for the OC group was 0.03±0.01 mg/day of ethinyl estradiol and 1.79±1.28 mg/day of progestin. All of them were well-trained in endurance and/or in strength training (1.31±0.41 hours per session, 3.9±1.1 sessions per week with 7.65±5.15 years of

Figure 1. Flow chart with the sample we had for each test.



OC: oral contraceptive; DXA: Dual-energy X-ray Absorptiometry scan; $\dot{V}O_{2max}$: maximal oxygen consumption; 1RM back squat: back squat maximal strength.

Table 1. Characteristics of the study population.

	Eumenorrheic		OC users		Postmenopausal		
	Mean±SD	n	Mean±SD	n	Mean±SD	n	*p*
Age (yr)	32.90±10.22	68	26.48±4.74	48	51.71±3.69	16	0.000[Ψ]
Height (cm)	163.76±5.96	68	163.01±5.94	48	160.97±5.31	16	0.233
Weight (kg)	59.25±9.54	68	58.23±5.95	48	56.08±8.32	16	0.386
BMI (kg/m^2)	22.09±3.25	68	21.92±2	48	21.7±3.33	16	0.866
$\dot{V}O_{2max}$ (ml/kg/min)	49.69±4.18	47	48.80±5.73	38	46.01±98	14	0.076
1RM back squat (kg)	74.55±16.73	20	66.83±15.24	18	50.33±4.19	13	0.000[β]
FSH (mUI/mL)	8.03±3.65	63	5.24±4.53	34	76.73±47.69	13	0.000[β]
LH (mUI/mL)	6.22±2.58	63	3.44±3.17	34	41.74±21.14	13	0.000[β]
E2 (pg/mL)	48.59±34.55	63	26.47±27.45	34	19.97±26.13	13	0.001[¥]
Progesterone (ng/mL)	0.46±0.72	63	0.28±0.17	34	0.21±0.17	13	0.169

BMI: body mass index; $\dot{V}O_{2max}$: maximal oxygen consumption; 1RM: maximal back squat strength; FSH: follicle-stimulating hormone; LH: luteinizing hormone; E2: 17 β-estradiol.
[Ψ]Significant differences between all groups (p<0.001).
[β]Significant differences in postmenopausal regarding eumenorrheic females and OC users (p<0.001).
[¥]Significant differences between eumenorrheic females and OC users (p<0.05).

experience for eumenorrheic females; 1.39±2.08 hours per session, 3.68±1.15 sessions per week with 6.57±4.48 years of experience for the OC group; 1.17±0.31 hours per session, 3.9±1.16 sessions per week with 7.9±3.31 years of experience for postmenopausal women). Females with metabolic pathologies, hormonal disorders, smoking habits, intaking supplementation or with injuries/surgeries in the last 6 months were excluded from this study. To be included in the study participants were required to be healthy adult females, without iron deficiency anemia (serum ferritin <20 µg/l, hemoglobin <115 µg/l and transferrin saturation <16%), non-pregnant or oophorectomized, not to consume medication that alters vascular function (e.g., tricyclic antidepressants, α-blockers, β-blockers, etc.) and they had to perform endurance and 7or strength training between 3 and 12 hours per week. All participants were informed about the procedures and risks involved and an informed consent was obtained from each participant. The experimental protocol was approved by the ethical Committee of the Universidad Politécnica de Madrid and it is in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki)[26] (Figure 1).

Procedures

Volunteers first came to the laboratory to perform a Dual-energy X-ray Absorptiometry scan (DXA) to evaluate body composition, and a basal blood sample to discard possible diseases. After 60-90 min of ad-libitum meal, volunteers performed a 1RM back squat test (20 eumenorrheic females, 18 OC users and 12 postmenopausal) or a maximal treadmill test (47 eumenorrheic females, 38 OC users and 14 postmenopausal) to determine their 1RM back squat and their maximal $\dot{V}O_2$. Some volunteers performed both tests, conducting them in different menstrual cycles. In order to measure all groups under similar hormonal environment (low sex hormone levels), all these tests were carried out during the early follicular phase (between the 2nd and 5th day of the menstrual cycle, being the onset of the cycle the first day of menstrual bleeding) for the eumenorrheic females and in the withdrawal phase (between de 3rd and the 7th day of the placebo week) for the OC group.

Dual-energy X-ray Absorptiometry scan

A DXA scan (Version 6.10.029GE Encore 2002, GE Lunar Prodigy; GE Healthcare, Madison, WI, USA) was done between 8-10 am in fasting state to obtain the whole BMD. The scan was calibrated per two days using the phantom supplied by the manufacturer. All volunteers performed the test in underwear, with their body and hands in a supine position and their feet joined by a tape. During the measurements, moving and talking were forbidden. DXA scan was always carried out by the same researcher.

Maximal treadmill test

After a warm-up of 3 min walking on the treadmill at 6 km/h, the maximal running test started at 8km/h increasing its speed 0.2 km/h each 12 seconds until exhaustion. The test was carried out with a computerized treadmill (H/P/COSMOS 3PW 4.0; H/P/COSMOS Sports & Medical, Nussdorf-Traunstein, Germany). $\dot{V}O_2$ was measured with the gas analyser Jaeger Oxycon Pro (Erich Jaeger; Viasys Healthcare, Hoechberg, Germany).

1RM back squat test

The 1RM in the back squat exercise was determined by using the Powerlift App[27]. Participants performed a 5-min cycle-ergometer warm-up and some mobility and dynamic stretching exercises. Then, volunteers performed 4 sets of 1 rep with submaximal loads proportionally increased between 70% and 90% of participants' maximum reported. A box was set just under participants tights in order to fix the point where tights were parallel to floor.

Sex hormones analysis

Basal blood samples were taken between 8-10 am in fasting state to ensure that females were healthy and without hormonal disorders. Samples were obtained by venipuncture into a vacutainer containing clot activator. Following the inversion and clotting, the blood was

centrifuged (Biosan LMC-300 version V.5AD) for 10 min at 3000 rpm and transferred into Eppendorf tubes and stored frozen at -80°C until further analysis. Then, the serum samples were delivered to the clinical laboratory to determine sex hormones and verify menstrual cycle phase. Luteinizing hormone (LH), follicle-stimulating hormone (FSH), E2 and progesterone were measured via ADIVA Centaur® solid-phase competitive chemiluminescent enzymatic immunoassay (Siemens city, Germany). Coefficients of variation reported by the laboratory were 7.74 for FSH, 10.77 for LH, 7.84 for E2 and 14.11 for progesterone.

Statistical analysis

All data are reported as means ± SD. One way ANCOVA was performed for comparisons among groups and age was used as a covariable. Scheffé test was applied to examine the pairwise comparison of each significant fixed factor. Pearson's correlation was performed to verify the association between BMD and $\dot{V}O_{2max}$, 1RM back squat and sex hormones concentrations. All tests were conducted with a 5% significance level. All data were initially tested for normality with the Kolmogorov-Smirnov test. Statistical analyses were performed using SPSS software for windows, version 20.1 (IBM corp., Armonk, NY, USA).

Secondly, Cohen effects sizes (ES) were calculated to verify the magnitude of the mean differences between menstrual phases. The ES were interpreted based on the following criteria: <0.2 = trivial, 0.2 to 0.6 = small effect, 0.6 to 1.2 = moderate effect, 1.2 to 2.0 = large effect, and >2.0 = very large[28]. The 90% confidence interval (CI) was also calculated. Magnitude Based Inferences were carried out to determine the beneficial, trivial or harmful effect, of the menstrual cycle phases. When a clear interpretation was possible, a qualitative inference was given as follows: 0.5% to 5%, very unlikely; 5% to 25%, unlikely; 25% to 75%, possibly; 75% to 95%, likely; 95% to 99.5%, very likely; and >99.5%, most likely[29].

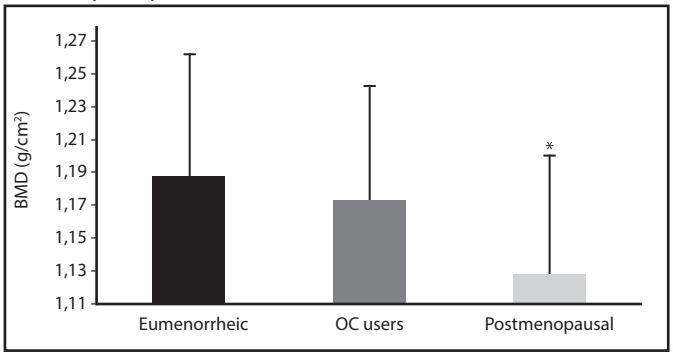
Results

The one-way ANCOVA showed, as expected, significant differences between groups in age ($F_{2,122}$=55.202) and weight ($F_{2,121}$=4.339), having the postmenopausal females lower values in comparison with the eumenorrheic group (p=0.013) and OC users (p = 0.023). Nonetheless, no significant differences were reported for $\dot{V}O_{2max}$ ($F_{2,95}$=1.742) and 1RM back squat ($F_{2,46}$=2.706) among groups. In accordance with sex hormones, significant differences were found for FSH ($F_{2,106}$=62.064) and LH ($F_{2,106}$=82.820), where postmenopausal females presented higher values than eumenorrheic and OC users (p<0.001 for all comparisons). Moreover, E2 levels ($F_{2,104}$=7.344) in eumenorrheic were significantly higher than in OC users (p=0.006); whereas, not significant differences were reported for progesterone ($F_{2,106}$=1.705) among groups (Table 1).

Significant differences were observed for BMD ($F_{2,121}$=5.708; p=0.004) among different hormonal profiles (Figure 2). Scheffé test reported lower values of BMD in postmenopausal females in relation to the eumenorrheic (p=0.003) and to the OC (p=0.030) group. Effect sizes and magnitude-based inferences for BMD among groups are shown in Table 2. A small and unclear effect for eumenorrheic and OC users was found; whereas a large and likely effect was reported when comparing postmenopausal females with eumenorrheic and OC users.

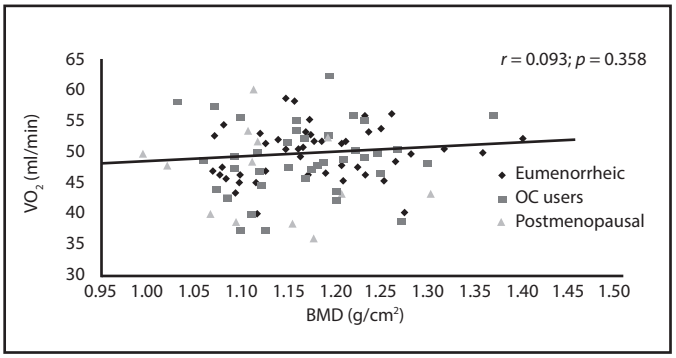
Pearson´s correlation did not show significant association between BMD and $\dot{V}O_{2max}$ (Figure 3), whereas a positive relationship between BMD and 1RM was found (r=0.446; p=0.001) (Figure 4). Regarding sex hormones,

Figure 2. BMD comparisons among different hormonal profiles: eumenorrheic (n=68), OC users (n=41) and postmenopausal females (n=16).



* Significant differences regarding eumenorrheic females (p<0.05).

Figure 3. Relationship between BMD and $\dot{V}O_{2max}$ in well-trained females (n=99).



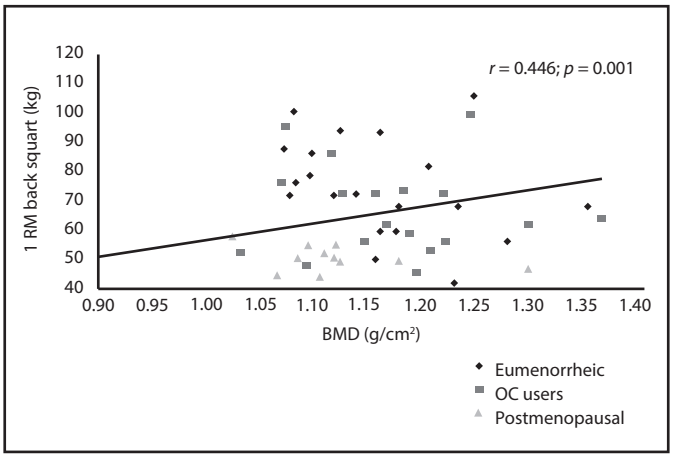
BMD: bone mineral density; $\dot{V}O_{2max}$: maximal oxygen consumption.

Table 2. Pairwise comparison for BMD. Results expressed as effect size and magnitude based inference.

Variable	Pairwise comparisons	ES (90% CI)	Chances of being negative/trivial/ positive	Qualitative inference
BMD (g/cm²)	OC users *vs* Eumenorrheic	-0.22 (-2.29, 1.85)	31.4/17.9/50.8	Unclear
	Postmenopausal *vs* Eumenorrheic	-1.27 (-2.75, 0.21)	2.6/3.2/94.2	Likely
	Postmenopausal *vs* OC users	-1.19 (-2.90, 0.53)	4.4/4.8/90.8	Likely

BMD: bone mineral density

Figure 4. Relationship between BMD and maximal back squat strength in well-trained females (n=50).



BMD: bone mineral density; 1RM: 1RM back squat.

no significant association was found when correlating BMD with LH (r=-0.186; p=0.052), E2 (r=0.063; p=0.518) and progesterone (r=0.054; p=0.574). The FSH hormone reported a light negative correlation with BMD (r=-0.240; p=0.012).

Discussion

The aim of this study was to compare three different hormonal profiles (eumenorrheic, OC users and postmenopausal) to observe the influence of sex hormones on BMD in well-trained females. The main finding was that postmenopausal females have lower values of BMD compared with the eumenorrheic women and there is a light association between maximal back squat strength values and BMD.

Regarding BMD differences when comparing eumenorrheic and postmenopausal females, our results are in accordance with previous literature which reported a decrease in BMD because of the fall of plasmatic E2 in the elderly[30-32]. However, it is worth mentioning that previous studies carried out with sedentary healthy females[33-35] showed decreases of BMD higher than those seen in our female athletes. In this line, the World Health Organization (WHO) showed that BMD loss in lumbar spine and femur in women, ranged from 10% to 20% in elderly[33]. These percentages were similar to the ones reported by Martin *et al*.[34]. Additionally, another research studying the whole body revealed a 20% reduction in bone mass at the age of 60 years old compared with the group between 20-40 years old[35]. In contrast, our results showed a difference of 5% on BMD comparing eumenorrheic with postmenopausal women. These differences between our results and previous studies might be explained by the positive effect that exercise exerts on bone mass, since exercise is well known as a good method for preserving bone tissue[36-38].

According to young females the positive effect of OC use pointed out by some previous studies[30,39-41] has not been confirmed in the present investigation, since no differences were found between eumenorrheic and OC users. Our findings, however, are in accordance with others new findings that reported no differences in BMD with the use of OC pills[16,42-48]. The dosages of sex hormone concentrations could explain this discrepancy. Currently, ethinyl estradiol and progestin levels in OC pills are lower than they used to be in the past (e.g. ethinyl estradiol concentration was 150 mg/day but today is 15 mg/day; progestin concentration was 9.85 mg/day but today is 0.35 mg/day)[49]. This could be determinant when comparing BMD, since sex hormones, specially ethinyl estradiol, play an important role in bone metabolism. On the one hand, ethinyl estradiol decrease osteoclasts formation and generation as well as stimulate their apoptosis[6-9]. Hence, ethinyl estradiol suppress bone resorption by inhibiting the osteoclasts activity. On the other hand, recent studies showed that ethinyl estradiol may stimulate osteoblasts activity, encouraging bone formation[10-12]. Moreover, the time of OC use should be considered, since the period reported in the studies is different: 6 months[16], 12 months[47], 24 months[43], 36 months[30] or even 7 years[46]. Finally the only study found with athletes (rowers) didn't study BMD but bone metabolism markers[50]. All metabolic markers studied, osteocalcin (bone formation) and type I carboxyterminal telopeptide (ICTP) (bone resorption), were lower in OC users compared with eumenorrheic females which could suggest that no differences in BMD may exist between groups.

Another objective of the present study was to determine if $\dot{V}O_{2max}$ and maximal back squat strength are good predictors of BMD in this population. Our results didn't show significant association between BMD and $\dot{V}O_{2max}$, whereas a positive correlation between BMD and 1RM was found. Although previous literature reported a strong positive correlation between BMD and maximal $\dot{V}O_{2max}$ in sedentary females[48,51-53], our data did not support these findings. These differences might be explained by the training status of the samples. Our volunteers were physically active so they all have high levels of $\dot{V}O_{2max}$ and BMD, whereas previous literature has been carried out with sedentary females[48,51-53]. This could have led to a spurious correlation, since so the women with higher levels of $\dot{V}O_{2max}$ might be those more active, and therefore with more frequent stimuli for BMD increase as well. So that, $\dot{V}O_{2max}$ could not be a good predictor of BMD when studying active population since training status could be a confounding variable. However, regarding 1RM back squat, a positive correlation with BMD was found. This result confirmed the strong association between BMD and muscle strength previously documented in female athletes[54-58] as well as the good predictor that muscle strength is for BMD recorded in advance with healthy females[20,21,59,60]. Thus, not only might strength levels be determinant for BMD in sedentary population but also in active people. This association could be explained by the fact that the greater the muscle mass, the higher the forces exerted by the tendons over the bones. So that, bones have to resist these mechanical forces, which makes them become stronger[61].

Finally, the association between sex hormones and BMD were not significant for any but for FSH, where a negative correlation was observed. On the basis of the hormones released by the anterior pituitary, negative correlations between LH and BMD as well as FSH and BMD were reported in previous studies carried out with healthy Chinese women[62,63], there foreign line with our results. The negative correlation found between FSH and BMD could be explained by the fact that this sex hormone could stimulate osteoclasts and induce immune cells to

excrete TNF-α promoting bone resorption[62]. Indeed, another study confirmed that FSH is related to bone turnover indicators[64] and the risk of osteoporosis[63]. Moving on to the ovarian sex hormones, the critical role of E2 in bone metabolism is consistent with several previous reports[6-12] as well as progesterone, which preserves peak bone mass and prevents bone loss[14]. Despite previous studies reported a positive association between E2 and BMD[65,66] as well as between progesterone and BMD[67] in sedentary females, our findings didn´t show these correlations. These discrepancies may be due to population characteristics, since previous researches were carried out with sedentary women, whereas the current study with female athletes. It is well known that exercise is one of the best ways for increasing bone mass and preventing it loss[17,18]. Thus, although sex hormones play a key role in bone metabolism, their influence becomes less crucial in trained females, since exercise is an important positive factor. Furthermore, a recent study carried out with healthy Chinese women, reported no association between E2 and BMD, suggesting that decreases in BMD in the elderly is associated with the increased of FSH and LH levels, rather than the decreased of E2[62].

The current study attempts to address a gap in the research through investigation of an important variable like BMD in well-trained females. The strengths of our study included the inclusion of different female hormonal profiles and the recruitment of a homogenous group of active and healthy women for all of them: eumenorrheic females, OC users and postmenopausal women. However, longitudinal studies with an intra-subject design should be carried out to explore the influence of the hormonal changes throughout life span. Finally, a limitation of this study could be not have taken into account the direct relation between FSH and E2, hence the increase in FSH after menopause is related to the absence of E2. Thus, it would have been interesting to evaluate how long have postmenopausal women been in menopause.

The present study showed lower BMD in postmenopausal than eumenorrheic in spite of the regular practice of exercise. Nonetheless, it´s worth mentioning that previous studies carried out with sedentary healthy females showed decreases of BMD higher than those seen in our well-trained postmenopausal females. Differences between study results might be explained by the positive effect that exercise could exert on bone mass. Therefore, the BMD loss after menopause seems to be not fully compensated by exercise, but this could effectively mitigate it during this stage. Interestingly, maximal oxygen consumption did not correlate to BMD in this population; while1RM back squat reported a slight association to BMD. Hence, strength training may be the best choice to prevent BMD loss.

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Conflict of interest

The authors do not declare a conflict of interest.

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Pain catastrophizing in Flamenco dance students at professional dance conservatories

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Summary

Introduction: Flamenco is marked by the deep emotional impression it creates and its percussive footwork steps, performed in traditional high-heeled shoes. It places high demands on the dancer which leads to risks of injury, pain and associated emotional repercussions. Catastrophizing is a key factor determining how the context is valued and pain is experienced. The objectives of this study were: firstly, to analyse the general incidence of catastrophizing among flamenco students and secondly, to determine the repercussion this has on catastrophizing in professional practice among dancers who perform on stage even though they are still students.

Material and method: The sample analyses 70 students from the *Conservatorios Profesionales de Danza de Andalucía* (Andalusian Professional Conservatoires for Dance) (17.67±5.65 years old); 44.29% (n=31) also danced professionally. The dancers completed the Pain Catastrophizing Scale (PCS).

Results: The results do not show significant differences in categories: rumination, magnification, nor in the overall catastrophizing of pain when comparing participants who were dance students with those who also danced professionally. However, in terms of helplessness, there is a significant difference between both groups, with those who danced both as students and professionals displaying higher levels of helplessness than those who were only students.

Conclusions: The artistic professional development on stage before spectators can trigger anxiety states that can have a directly proportional association to the levels of catastrophism. Perhaps being a student at the same time as dancing professionally signifies a greater physical and mental load which can lead to certain psychological processes.

Key words:
Psychological suffering. Injury. Movement. Dance.

Catastrofismo ante el dolor en estudiantes de baile flamenco de conservatorios profesionales de danza

Resumen

Introducción: El baile flamenco se caracteriza por una fuerte impronta emocional y sobre todo por el carácter percutivo de sus zapateados realizados con un calzado tradicional de tacón. Esta danza supone altas demandas de esfuerzo con sus consiguientes riesgos de lesión, dolor y efectos emocionales asociados. El catastrofismo juega un papel esencial en la valoración del contexto y la experiencia del dolor. Este estudio tuvo como objetivos; en primer lugar, analizar la incidencia general del catastrofismo en estudiantes de baile flamenco y; en segundo lugar, determinar la repercusión sobre el catastrofismo de la práctica profesional en aquellas bailaoras que aun siendo estudiantes actúan escénicamente.

Material y método: La muestra analizada consta de 70 alumnas de Conservatorios Profesionales de Danza de Andalucía (17.67±5.65 años); el 44.29% (n=31), también bailaban profesionalmente. Las bailaoras cumplimentaron la *Escala de Catastrofismo ante el Dolor* (ECD).

Resultados: Los resultados no muestran diferencias significativas en las categorías: rumiación, magnificación, ni en el global del catastrofismo ante el dolor al comparar participantes que sólo eran estudiantes de baile y las que además, tenían carácter profesional. En cambio, en la dimensión de desesperación sí se observa una tendencia significativa entre ambos grupos, estudiantes y profesionales, acentuada en este último grupo.

Conclusiones: El desarrollo profesional artístico en escena ante espectadores puede desencadenar estados de ansiedad que pueden llegar a tener una asociación directamente proporcional a los niveles de catastrofismo. Quizás, el hecho de ser estudiante y, a la vez, ejercer la profesión de bailaora suponga una mayor carga física y mental que puede desencadenar determinados procesos psicológicos.

Palabras clave:
Dolor psicológico. Lesión. Movimiento. Danza.

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Introduction

Flamenco dancing is characterised by strong emotional stamping and by the percussive nature of the footwork performed with traditional high-heeled shoes[1]. The performance of Flamenco requires dancers to exert high levels of effort similar to those observed at elite-level physical sport activities[2]. Therefore, as in the case of ballet[3], Flamenco dancers are considered to be elite athletes[4]. During a professional performance an average of four stamps on the floor per second are made, which can reach frequencies of up to twelve stamps per second[5]. This imposes high impact stress with its subsequent risks of injury, primarily centred on the feet, knees and back[5-7].

Injury is a traumatic event which, depending on its extent, can lead to a turning point in the life of anyone doing physical activity[8]. In the world of sport, there is a widespread view that relates pain with athletic performance and injury as a fundamental part of an athlete's life[9]. This is exactly the same with dancing[10]. Encarnación *et al.*[11] warn that in ballet, dancers tend to ignore an injury and to carry on dancing. In fact, these artists are taught from an early age that ballet is equivalent to pain, due to its complicated technique, this is particularly true for women as a result of the use of pointe shoes[12]. This attitude means that injuries are not always diagnosed and treated by a medical practitioner and, therefore, could become chronic through incorrect treatment. As a result, ballet dancers are no longer able to continue performing, suffering psychological changes such as state of mind, thoughts and conducts that make rehabilitation difficult.

Pain is the immediate and prolonged effect of an injury[8]. In a study conducted with 75 students of Flamenco, 74.7% acknowledged having felt pain when dancing Flamenco and 66.7% further stated that they had an injury[13]. Pain is described as a complex process in which biological and psychological factors are part of an emotional and sensorial experience at an individual level[9]. However, its relationship is not directly proportional to the severity of the injury, given that other factors may come into play such as age, level of education, race, socio-economic status, depression, resilience, pain catastrophizing and attitudes to treatment. For athletes, the fact that they have experienced pain during training is often considered with satisfaction, taking this as an indication of effort and that they have pushed their performance to its limits[9]. However, dancers are not always able to differentiate between the pain of their routine training and the pain of an actual injury[14].

In order to improve the results of the treatment and the extent of the pain, psychological intervention programs could be implemented which, irrespective of demographic factors (age, sex, place of residence), could be feasible even taking into account the psychosocial factors characteristic of dancers[15]. However, in order to obtain optimal results, it is first necessary to quantify the extent to which pain coping strategies are present in specific populations of patients.

Catastrophizing is a tendency to magnify the perception of pain with a negative mindset, during actual or anticipated pain experience[16]. Its role is essential with regard to the assessment of the context and the experience of pain. It is related to increased pain sensitivity, intensity and disability, leading to an emotional state associated with anxiety and depression[17]. A number of studies report that catastrophizing may change during psychological interventions through improvements in pain, psychological state and physical capacity[8].

When examining the psychosocial factors associated with dancing stress, it can be appreciated that it is essential to understand the main causes of stress and the the main ways in which dancers try to cope with these stressors[8]. For their physical wellbeing, Patterson *et al.*[19] indicate that stress in life and social support are exponential contributors. Different cultures also have an influence, given that dancers from different countries may experience different stressors and develop alternative ways of coping with pain.

Catastrophizing scores have been studied in different types of dancing, basically in ballet and contemporary dancers[9,11,12,14,18,20-25] and specifically in traditional Irish dancers[10,26]. In contrast, we are not aware of any studies made on Flamenco dancing. Despite the fact that there are studies that detail important cases of injuries and pain in Flamenco dancing[5,6,27-30] there are few studies that analyse the pain beyond the anatomical perspective. Lupiáñez[31] holds that Flamenco dancers have no mental training to cope with cognitive distortions that appear during performance. Moreover, it has been confirmed that Flamenco artists suffer from anxiety symptoms such as sweating during the shows. This leads to symptoms such as foot numbness or trembling knees, making it impossible to perform the footwork with the desired skill and technique[32].

Therefore, the study objectives are to analyse the level of catastrophizing of the official Flamenco women dance students and to determine whether or not there are any differences in the catastrophic thinking between professional and non-professional female dancers.

Material and method

Participants

The study sample comprised 70 female students of artistic studies at the Conservatorios Profesionales de Danza de Andalucía (Professional Dance Conservatories in Andalucia), in the specialty of Flamenco dancing. Within this group of students, 44.29% (n=31) also danced professionally. The age ranged from 12 to 30 years, with a mean age of 17.67 ± 5.65 years. On a weekly basis, they dedicated an average of 8.19 ± 3.30 hours to Flamenco dance practice.

Non-probability consecutive sampling was used to select participants, selecting all possible accessible subjects who met the inclusion criteria. These were: 1) Student of a professional dance conservatory, specialising in Flamenco dancing; 2) At least two years of experience in Flamenco dancing; and 3) Active and dedicating at least 6 hours a week to practising Flamenco dancing (rehearsals, classes / or shows). The exclusion criteria were: 1) No injury at the time of the study; and 2) No injury in the last 6 months prior to the study.

Prior to the investigation, approval was obtained from the ethics committee of the Universidad Católica San Antonio (Catholic University of St. Anthony), Murcia. In all cases, the study met the requirements of the Code of Ethics of the World Medical Association (Declaration of Helsinki) for trials with human subjects. Furthermore, all the subjects taking part in the trial, or legal guardians in the case of minors, signed an informed consent prior to the collection of data, explaining the study objectives, as well as the conditions in which the measurements would be taken and the confidential nature of the information obtained.

Instruments

The study used the *Pain Catastrophizing Scale* (PCS)[33], specifically its Spanish version *Escala de Catastrofismo ante el Dolor* (ECD)[8], a 13-item self-administered questionnaire to assess three factors: Rumination (I can't stop thinking about how much it hurts), Magnification (It's awful and I feel that it overwhelms me) and Helplessness (it's awful and I feel that it's stronger than me). The score for each item is from 0 (not at all) to 4 (all the time) obtaining a maximum score of 52 points: low scores indicate a low level of catastrophic thinking while high scores indicate a high level of catastrophic thinking. Overall, this scale has a strong internal consistency with a Cronbach's alpha of 0.82[16].

Procedure

This is a cross-sectional, descriptive study in which all the variables are assessed at the same time. A direct interview was made based on questions regarding socio-demographic details (age, sex) and related to dance practice (level of education, years of experience, hours of practice per week, student and professional - only student). Likewise, the Flamenco dancers completed the Spanish version of the PCS in the presence of the principal investigator, first giving them a brief justification of the investigation and expressing the strict confidentiality of the results obtained. The questionnaire was conducted in the course of the first quarter of 2020. All data were obtained in a single 20-minute session for each group of students, prior to commencing a dance class in their reference classroom.

Data analysis

A descriptive analysis was performed using the SPSS 16.0 statistical program, obtaining the characteristic parameters, mean and standard deviation, for the quantitative variables. To analyse the representativeness of the arithmetic means, the Pearson's coefficient of variation was used.

A Student's paired T test was used to compare two means for these same variables, in order to make a comparison between the means for the group of students and the group of professionals.

Results

When comparing the 3 dimensions of pain catastrophizing between participants who were only dance students and those who were students and professionals at the same time, no significant differences were found in the categories: rumination, magnification or in the overall pain catastrophizing score. However, with regard to the helplessness dimension, a significant trend was observed between the non-professional and professional groups, which was accentuated in this latter group (Table 1).

Complementary to Table 1, and following a separate analysis of each of the 13 items, statistically significant differences were found in 3 items:

- Rumination of the four items making up this category, for item 1. I worry about whether the pain will end (t=1.968; p=0.025) and for item 3. The pain is terrible and I think it's never going to get any better (t=-1.998; p=0.026).
- Magnification of the four items making up this category, for item 7. I am reminded of past painful experiences; where a significant tendency to accentuate these thoughts or feelings is recorded for the group of professional Flamenco dancers (t=-1.01, p<0.1).

Discusión

The aim of this study was to identify the pain catastrophizing level in Flamenco dance students, while also analysing the differences in each of the catastrophizing dimensions (rumination, magnification and

Table 1. Descriptive and comparative statistics of T-Student measurements

Variables	Sample (n=70)	Students (n=39)	Students professionals (n=31)	t value (p<0,05)	Confidence interval 95%
Rumination	1.85±1.06	1.87±1.08	1.83±1.05	t=0.135 p=0.893	-0.477; 0.546
Magnification	1.57±0.99	1.50±1.00	1.67±1.00	t=-0.712 p=0.479	-2.979; 0.979
Helplessness*	1.29±0.82	1.19±0.67	1.41±0.97	t=-1.1 p<0.1	-2.870; 2.376
Catastrophizing	19.89±10.54	19.10±9.28	20.87±12.04	t=-0.69 p=0.24	-6.850; 3.313

*slight or moderate significance level.

helplessness) for female students compared to those dancers who were performing on stage.

The results obtained do not support those reported by Cahalan *et al*.[10] in which, in a sample of elite Irish dancers, the factors significantly related to severe injuries (1 rehearsal or performance day lost due to injury and more than 21 days for recovery) were: female sex, subjective health and psychosocial complaints, as well as heightened catastrophizing. Along these lines, catastrophizing has already been shown to be a pain predictor for athletes and sedentary individuals alike, and to explain the differences in the perception of pain between men and women[34]. Likewise, in the study conducted by Etherton *et al*.[35] with a sample of university students subjected to an induced pain experience, they also found that the mean subjective pain was higher for women than for men. However, men exhibited greater cardiovascular reactivity in response to the painful task compared to women, while failing to fully recover to baseline levels.

Analysing the three categories: rumination, magnification and helplessness, there is a significant trend only in the last factor of helplessness (t=-1.1; $p<0.1$) (CI 95%: -2,870; 2,376). This is more evident in the professional group of Flamenco dancers. However if, moreover, the statistical results of the items of this category are observed: 1. I worry about whether the pain will end and 3. The pain is terrible and I think it's never going to get any better, there are a high level of significant differences between both groups (t=1.968; $p=0.025$) and (t=-1.998; $p=0.026$) respectively for each item. This fact relates to the Locus of control concept[35]: not knowing the origin of the cause of the event or not feeling in control of one's own fate can be related to episodes of depression. This component of the helplessness category, showing the incapacity of individuals in the face of painful situations, is clearly reflected in our study in which professional Flamenco dancers demonstrate a feeling of impotence compared to non-professional student dancers.

Moreover, within the magnification category, in relation to: the exaggeration of unpleasant painful situations and the expectations of negative consequences[8] there is item 7. I am reminded of past painful experiences; where the group of professional Flamenco dancers shows a significant tendency to accentuate these thoughts or feelings (t=-1.01, $p<0.1$). This tendency, although moderate, reflects a differentiating factor between Flamenco dancing as part of an educational curriculum, and exposure to another type of responsibility before an audience.

Perhaps being a student and, at the same time, working as a professional Flamenco dancer entails greater physical and mental stress that may trigger certain psychological processes such as increased anxiety and a greater concern and impression with regard to feelings of pain associated with their situation, in a similar way to the findings reported in studies that relate anxiety and catastrophizing in injured athletes[36,37]. However, in the work of Paparizos *et al*.[12] that relates catastrophizing and pain, by inducing pain in a group of female dancers who were divided into three levels (advanced, intermediate and beginners). The advanced dancers showed greater tolerance to pain than the beginners.

We found that, within the Flamenco dance technique, there may exist a somatization specificity between anxiety or stage fright and certain dimensions of pain catastrophizing. Studies of athletes have shown how there is a close correlation between competition anxiety and pain catastrophizing conditions[16]. This correlation in athletes leads us to detect quite a wide field of action for professional and non-professional Flamenco dancers alike directed at improving their performance from a physiological and psychological point of view. The demands of this discipline are well-known, as well as the high levels of aversive stimuli that generate stress and unworkable responses by the Flamenco dancers lacking mental training to cope with them[32]. Despite this, there are no studies to assess catastrophizing as an indicator associated with coping with the pain in a dance specialty such as Flamenco. We would therefore highlight the interest of our study in order to make it possible to continue to progress in this line of investigation.

It should be underscored that the rating of catastrophizing, as well as its three factors (rumination, magnification and helplessness) could prove extremely useful to the dancer population where pain, associated with normal practice or due to injury, is a daily element that has been empirically demonstrated[11]. Furthermore, the psychological models that explain pain from a cognitive perspective have shown that negative thinking may hinder rehabilitation due to the resulting emotional imbalance[38], lending support to the idea that.the control of catastrophizing in athletes may help to reduce negative outcomes. As is the case with athletes, Flamenco dancers with high catastrophizing levels may not be correctly using their attentional capacity due to intrusive pain-related thoughts, as indicated by Sullivan *et al*.[34]. In this regard, psychological training programs stand as an effective tool to reduce catastrophizing in sport, including psychological techniques such as full attention, relaxation, cognitive restructuring and visualization[39].

With regard to the limitations and future lines of investigation present in the study, it should be highlighted that the sample only considers women and it would therefore be necessary to replicate the study on samples of men and also on other dance specialties. It is considered necessary to develop future lines of study on the perception of pain and catastrophizing with professionals who have completed their academic stage of training. A further proposal is to analyse pain catastrophizing at different moments of the academic course (start, middle, end) and try to correlate this with the type and number of potentially stressful stimuli present at each moment in time (rehearsal times, exams, auditions, performances, role in the show). It would also be of interest to study the differences in pain catastrophizing, algias and sport injuries between dancers of different levels and sexes.

Conclusions

Due to the high physical demands of Flamenco dancing, those who practice this form of dancing have subjective perceptions of pain that are comparable to other sport and dancing activities. It was observed that those subjects studying Flamenco and also performing professio-

nally show greater negative perception in those aspects characterising catastrophic thinking such as rumination, magnification and particularly helplessness to cope with the pain, with a moderately significant trend. It therefore appears evident that stage performance in front of an audience may trigger states of anxiety that may have an association that is directly proportional to the catastrophizing levels.

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Conflict of interests

The authors have no conflict of interest at all.

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The human factor in alpine skiing and snowboarding accidents

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Summary

Introduction: Hundreds of millions of people practice winter sports worldwide. Alpine skiing and snowboarding are associated with a possible risk of injury. There are at least three important factors that can affect safety in wilderness activities (environmental factors, technical factors and human factors). Awareness of human factors would allow us to reduce the risk in winter sports.
Material and method: The objective of this study is to find out, through a self-explanatory cross-sectional personal survey, what and how human factors are involved in alpine skiing and snowboarding accidents.
Results: 219 surveys were carried out of a total of 3,911 patients attended at the different health care points. The highest percentage of respondents related their accident to distraction or complacency, both in 72.2% of the respondents. Other factors that were pointed out by more than 50% were; lack of knowledge (60.4%), lack of following the norms (58.5%), fatigue (57.5%), lack of situational awareness (57%) and stress with (53.8% of the respondents).
Conclusions: By identifying these most frequent human factors during downhill skiing and snowboarding, actions can be taken to prevent or contain human error.

Key words:
Skiing injuries. Snow sports. Human factors.

El factor humano en los accidentes de esquí alpino y snowboard

Resumen

Introducción: Cientos de millones de personas practican deportes de invierno en todo el mundo. A la práctica de esquí alpino y snowboard se le asocia un posible riesgo de lesión. Existen al menos tres factores importantes que pueden afectar a la seguridad en las actividades del medio natural (factores ambientales, factores técnicos y factores humanos). El conocimiento de los principales factores humanos nos permitiría reducir el riesgo en los deportes de invierno.
Material y método: El objetivo de este estudio es el conocer, por medio de una encuesta personal auto-cumplimentada explicativa transversal, cómo y qué factores humanos intervienen en los accidentes de esquí alpino y snowboard.
Resultados: Se realizaron 219 encuestas de un total 3911 pacientes atendidos en los distintos puntos de asistencia sanitaria. El mayor porcentaje de encuestados relacionaron su accidente con la distracción o el exceso de confianza, ambos en un 72,2% de los encuestados. Otros factores que fueron señalados por más del 50% de los encuestados fueron; la falta de conocimientos (un 60,4% de los encuestados), la falta de seguimiento de las normas (58,5%), la fatiga (57,5%), la falta de conciencia situacional (57%) y el estrés con (53,8%).
Conclusiones: Identificados estos factores humanos más frecuentes durante actividades de esquí alpino y snowboard se podrán realizar acciones para prevenir o contener el error humano.

Palabras clave:
Lesiones de esquí. Deportes de nieve. Factores humanos.

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Introduction

Hundreds of millions of people from all over the world practice winter sports[1]. Alpine skiing and snowboarding are considered to have beneficial health effects[2], although they are also associated with a potential risk of injury. The studies in our geographical areas point to an injury rate of 4.6 per 1000 skiers-day[3], with differences between alpine skiers (2 to 10 injured per 1000 skiers-day) and snowboarders (1 to 6 injured per 1000 snowboards-day)[4,5]. The high at-risk population which, for example, in Spain was 5,667,845 during the 2018-2019 season[6], converts these percentages into a high absolute number of injured persons per year. Moreover, the possibility of suffering a serious or fatal injury while skiing or snowboarding means that they are controversially considered to be high-risk sports[7].

There are at least three important factors that could affect the safety of activities in the natural environment[8], in which the aforementioned winter sports are included. These are: environmental factors, technical factors and human factors (HF). While attention is normally paid to the first two factors (e.g. visibility, ice on the piste, skiing level), HF tend to be overlooked even though studies show that they are the most common cause of accidents, while this risk factor is the easiest to prevent and mitigate[9].

Little has been written about the role of HR in the natural environment10 and there is no specific definition of HF in this scenario. It has been suggested that their definition should include what they are and what is intended to be achieved with them. This proposed definition could be that the analysis of HF is "the ongoing process to identify those actions and decisions which, during activities in the natural environment, may prevent or contain human error"[9].

HF can be divided into three categories: psychophysiological (tiredness, fatigue, etc.); cognitive (situational awareness, decision making, etc.); interpersonal relations (teamwork, leadership, communication). Although more than 300 HF have been described, the main accident-related ones are known as the "Dirty Dozen" and are described in Table 1[9]. These twelve factors, originally developed for aviation maintenance, are perfectly transferable to activities in the natural environment[11,12].

Human error will not be reduced simply by observing the interaction of the HF. However, once we understand and see how the presence of HF allows human errors to appear more frequently, we can then introduce protective recommendations in contexts such as alpine skiing and other accidents in the natural environment[13,14].

A knowledge of the principal human factors would allow us to reduce the risk in winter sports. The aim of this study is to determine what human factors intervene in alpine skiing and snowboarding accidents and how they do so.

Table 1. Main human factors related to accidents.

"The dirty dozen"	
Overconfidence	Distraction
Fatigue	Lack of knowledge
Stress	Lack of communication
Lack of situational awareness	Lack of teamwork
Psychological pressure	Lack of assertiveness
Failure to comply with norms	Lack of resources and material

Material and method

Self-administered cross-sectional explanatory personal questionnaire.

Study design

The study was conducted through the self-administration of a questionnaire by injured persons above the age of 16 years and who were treated at the medical centres of the ski resorts of Masella y Pas de La Casa–Grau Roig during the season 2017-2018. The study was approved and accepted by the local ethics committees and the managements of the ski resorts involved.

Questionnaire design

The first part of the questionnaire was non-standardised, including basic demographic data (age and sex) and details of the sport practised at the time of the accident. The second part comprised 12 questions on the circumstances of the accident that the respondent had just suffered. The wording in this second part aimed to get the injured person to assess the different personal circumstances prior to the accident. Each of these 12 questions sought to assess the 12 most common conditions or human factors (HF) respectively, based on current literature and termed the "Dirty dozen" (Table 1).

To ensure that each question clearly identified a different HF, these questions were prepared with the help of volunteers selected by the nominal group technique, including ski and snowboard instructors, ski resort users and patrollers-protective service workers. Once the questionnaire had been designed, a pre-test was conducted on a group of volunteers, also selected by the nominal group technique, representing groups from different social environments and levels of education, to ensure correct understanding of the questionnaire. Experts translated the questionnaire from Spanish into Catalan, English and French.

To collect the information, it was decided to use the quantitative technique with closed-ended questions given that it better met the goal of quantifying the phenomena to be studied. Each question had a score from 1 to 10, with 1 indicating that it was highly unlikely that the circumstance described was related to the accident, while 10 showed that the respondent considered that it was entirely the cause of the accident. Finally, in the analysis of the study, these quantitative data were converted into qualitative ordinals (Table 2) with a view to making sense of the quantitative data obtained and better interpreting the results.

Table 2. Equivalence of the quantitative data in ordinal qualitative data for the human factor variables

Ordinal categorical variable	Range
Not at all	(1)
Slightly	(2-3)
Sufficiently	(4-5)
Quite a lot	(6-7)
Considerably	(8-9)
Entirely	(10)

Sample size

Previously considering a non-finite population, a confidence level of 90% with a variability as adverse as possible, of 50%, a maximum admitted error of 6% and a potential loss percentage of 5%, we calculated that we would need an adjusted sample size of more than 198 questionnaires.

Study protocol

Simple random sampling was made, whereby the injured person was selected once he or she had met the inclusion criteria. These criteria were evaluated after the normal triage and consisted in: agreement by the injured person to complete the questionnaire; over 16 years of age; minor injury; experience controlled pain (<4 on the verbal numerical pain rating scale) so that the questionnaire could be completed comfortably without negatively affecting the prognosis. The office worker at the medical centre personally explained to each respondent that he/she should rate each of the conditions described in the questions with a score from 1 to 10, to indicate how they had contributed to the accident, with 1 being extremely unlikely and 10 most certainly,

Finally, descriptive and inferential statistical techniques were used to process the data obtained, using the SPSS version 16 for Windows statistical package. When seeking associations between variables, the age variable was divided into: young <30 years; senior 30 to 45 years; veterans >45 years. The variable for sport practised: ski or snowboard. The qualitative ordinal data on the influence of the human factor: "slightly or not at all" and "sufficiently or more". Pearson's χ^2 test was used to seek relationships between variables, given that the variables were qualitative. The statistical significance cutoff was set at p <0.10.

Results

219 questionnaires were completed from a total of 3,911 patients treated at the different healthcare points. 7 questionnaires were rejected (3%) as they were incomplete. The mean age of respondents was 29 (IQR 23-44), 59% were male. 68% were skiing while the remaining 32% were snowboarding at the time of the accident. The comparison of the epidemiological data according to the sport practised is attached in Table 3.

84.9% (180) of respondents indicated that one of the HF studied had moderately contributed (range ≥4) to the accident.

The highest percentage of respondents related their accident to distraction or overconfidence, both for 72.2% of respondents. Other factors indicated by more than 50% of respondents as having contributed to some extent to the accident were: lack of knowledge (60.4% of respondents), failure to abide by the norms (58.5%), fatigue (57.5%), lack of situational awareness (57%) and stress (53.8%).

The human factors that respondents considered to have entirely contributed to the accident were: overconfidence (9% of respondents), distraction (8.5%) and lack of knowledge (8%).

4.3% of respondents indicated that the misreading of the signs at the facilities could have moderately contributed to the accident and 13.2% of respondents indicated that it could have been lack of knowledge the material. More detailed information is provided in Table 4.

The human factors that were significantly related to age (p <0,10) were overconfidence (young 58.3%, senior 40%, veterans 36.4%), failure to abide by the norms (young 42.6%, senior 18.3%, veterans 27.3%), and lack of knowledge (young 56.5%, senior 35%, veterans 13.6%).

The human factors that were significantly related to the sport practised by respondents (p <0,10) were overconfidence (skiing 38.2% compared to snowboarding 70.6%), failure to abide by the norms (skiing 27.1%, compared to snowboarding 44.1%), and lack of knowledge (skiing 36.8% compared to snowboarding 51.5%) (Figure 1).

Discussion

This study uses a questionnaire to analyse how the most common human factors contribute to alpine skiing and snowboarding accidents. Although there are studies that analyse HF in different activities in the natural environment[9-13], to the best of our knowledge this is the first study to analyse HF solely in relation to ski resorts..

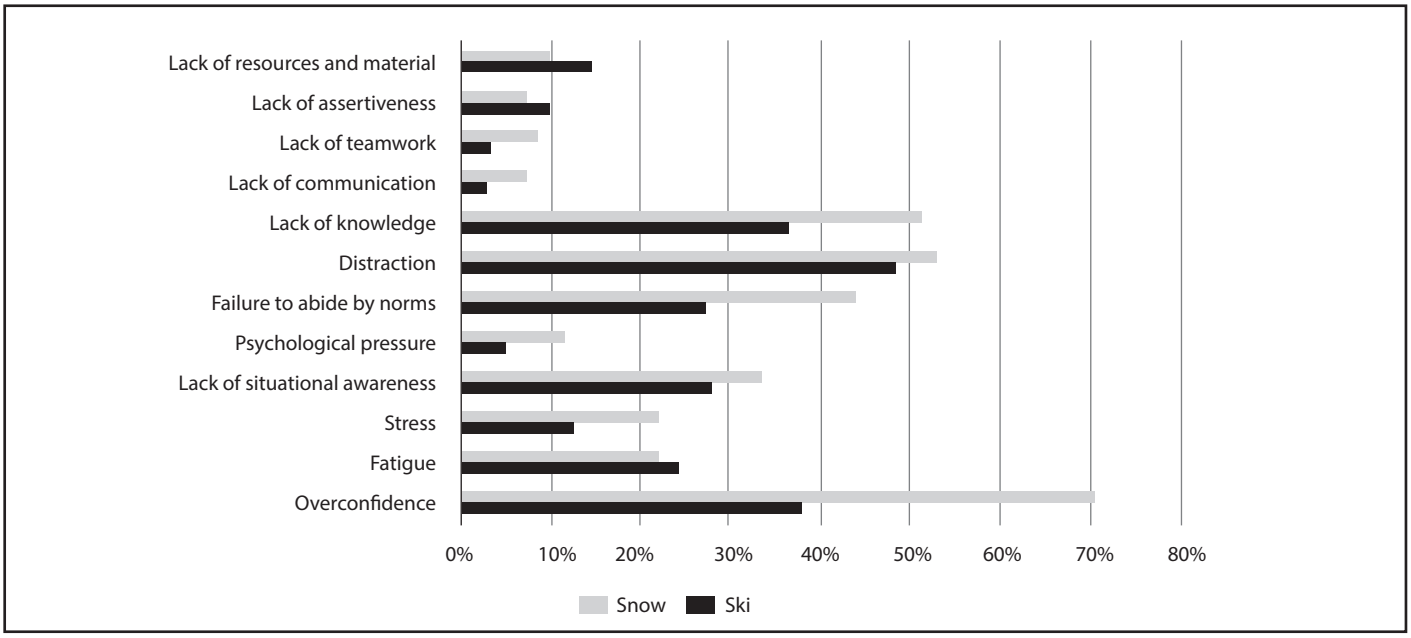
Table 3. Comparison of the epidemiological data according to the sport practised.

	Total		Men		Women		Age
	N	%	N	%	N	%	Mean (IQR)
Ski	144	67.9	75	60%	69	79.3	37 (24-48)
Snowboard	68	32.1	50	40%	18	20.7	25 (21-30)
Total	212	100%	125	100%	87	100%	29 (23-44)

Table 4. Percentages for the contribution of the different human factors to the accident according to the respondents.

	Not at all	Slightly	Sufficiently	Quite a lot	Considerably	Entirely
Overconfidence	27.8%	23.6%	15.6%	17.9%	6.1%	9.0%
Fatigue	42.5%	34.0%	12.3%	8.0%	2.8%	0.5%
Stress	46.2%	38.2%	5.7%	6.1%	2.4%	1.4%
Lack of awareness	42.5%	27.8%	11.8%	9.0%	4.2%	4.7%
Psychological pressure	63.7%	29.2%	2.4%	2.4%	1.9%	0.5%
Failure to abide by norms	41.5%	25.9%	12.3%	6.6%	8.5%	5.2%
Distraction	27.8%	22.2%	14.6%	17.9%	9.0%	8.5%
Lack of knowledge	39.6%	18.9%	17.5%	8.0%	8.0%	8.0%
Incorrect reading of the signage at the facilities	66.0%	29.7%	0.9%	1.4%	0.9%	0.9%
Lack of teamwork (disregard colleagues)	65.1%	29.7%	2.4%	1.4%	0.5%	0.9%
Lack of adaptation to difficulty (assertiveness)	58.0%	33.0%	4.2%	2.8%	0.9%	0.9%
Lack of resources	60.4%	26.4%	5.7%	3.8%	1.4%	2.4%

Figure 1. Comparison of percentages according to the activity in which the respondents considered that the different HF had sufficiently contributed to the accident.



Importance of the human factor in ski resort accidents

A study on the psychological aspects of mountain accidents confirmed that, in the case of alpine skiing, among the direct causes of accidents put forward by survivors were HF such as: skiing technique errors, over-fatigue and excessive speed. The contributing factors included: overconfidence, low technical level, poor concentration, as well as a combination of: favourable weather conditions, perception of little difficulty, recklessness and optimal piste conditions. The authors concluded that there are a combination of factors that lead to multiple mistakes[13]. This study, together with others, highlights the fact that the weighting of each of the human factors is complicated, although their importance in accidents is evident[13,15].

The results of the study indicate that 84.9% of respondents consider that at least one of the 12 HF analysed "sufficiently" contributed to the accident. Such a high percentage suggests that the human factor plays a key role in the cause of skiing and snowboarding accidents, even perhaps above the other environmental factors and material factors. The accident rate studies of other sports in the natural environment that have investigated the influence of HF, also point to this factor as an important cause of accidents. This is the case of BASE jumping, with

similar percentages (86%) to our study[16]. These results are also repeated in other studies such as those analysing air sports accidents (paragliding, hang gliding, etc.) where the influence of HF appears to be constantly between 55 to 85%[17-19].

Distraction and overconfidence, human factors most related to ski resort accidents

According to the respondents, the HF that most contributed to the accident were: distraction and overconfidence. These same HF are highlighted in the annual studies of the Swiss *Bureau de Preventions des Accidents*, where more than 76,000 alpine skiing accidents are analysed each year[20].

The study *Contributors to human error and how to lower rates of committing error* establishes that the three main contributors to human error are ineffective supervision, overconfidence and an environment that favours distractions, where factors such as fatigue and complacency are also considered[21].

With regard to road safety, a lack of attention while driving is recognised as one of the main contributing factors to road accidents, contributing to 80% of crashes and 65% of near-miss crashes[22]. Chamorro, in his study on the psychological aspects of mountain accidents, emphasises that 18.39% are caused by distraction, according to the injured persons interviewed[13]. In the context of Ski resorts, Sévigny in their work on "Les accidents en ski alpin dans la région des Laurentides", observed that distraction was associated with the accident, in 27% of cases they found that distraction disappeared as a cause of accidents when these occurred on the most difficult pistes, and no association between fatigue and distraction appears to exist[23].

Distraction is anything that takes our minds off a task when we need to attend to something specific, even if only for a very brief moment in time (e.g. when rearranging or adjusting material, eating or talking on the phone while moving). Given that our minds work faster than our hands, a distraction can very quickly steer us away from the task at hand. A distraction could involve a failure to complete all the necessary steps or to follow the established procedure (e.g. a correct ski turn). And if something has distracted us, once we resume the activity, we will not carry on where we left off (e.g. starting the execution of a turn too late). When the lack of attention is caused by internal factors such as thoughts and reflections, this is termed cognitive distraction or inattention. This could, for example, cause us to make less effort to check for other skiers at piste intersections or to reduce our peripheral vision that would have helped us to avoid possible collisions, etc.) Given that there is no clear conceptual delimitation between distraction and inattention[24], these concepts have been grouped together under the same HF: "distraction". It is easy to understand that we recognise, more or less explicitly, that distraction affects safety and puts it at risk when alpine skiing or snowboarding.

In general, individuals tend to underestimate the potential risk of distractions and, in turn, to overestimate their ability to do several things at the same time[25]. With regard to road safety, in order to reduce this error, the reinforcement of education and training, and awareness-raising campaigns are recommended[26]. Checklists ("everything ready before starting the descent...") are also good tools for combating these errors. In short, there is a need to be proactive in environments in which distractions are possible and focus on the task in hand, avoiding any other task. Studies demonstrate that effective task management can reduce the risk of human error by 81%[27].

Complacency or overconfidence, an insidious cause of error that generally occurs when a people perform a task repetitively and rely on pattern recognition. This causes us to take our minds off potentially dangerous situations and leads us to think that certain risk situations are not so, apparently because we are full of "false positives". Everything went fine before, so nothing bad is going to happen now... It is easy to become complacent when using the same terrain and routes, a characteristic situation when skiing and snowboarding at ski resorts. In our study, 72% of respondents related their accident with overconfidence. As Chamorro indicated in his study[13], when skiing at ski resorts, overconfidence is a more important factor than when skiing off-piste, according to the responses of the injured skiers interviewed.

Some studies indicate that, in certain sports, confidence has a protective effect, reducing the perception of risk[27,28]. But, at what point does this confidence shift from a protective to a negative effect? In the context of accidents at work, it occurs when complacency makes you feel that the task can be done with your eyes closed and it becomes second nature[29]. At the ski resort, this behaviour could lead you to increase your speed, not to value the condition of the snow, tunnel vision, be less vigilant.

This human factor can be mitigated by analysing each situation at all times and in its context (e.g. What are the piste conditions like at the moment?) Likewise, a "double safety check" could be essential.

Distraction, overconfidence and lack of knowledge: human factors that are the direct cause of ski resort accidents

Although distraction and overconfidence were not the only HF that were most frequently identified, together with a lack of knowledge, they stood out due to the fact that they were considered to have entirely contributed to the accident, thereby recognising these factors as a direct cause of accidents.

Lack of knowledge is a HF that is more prevalent in activities in which there is a high presence of automatic skills[25] such as alpine skiing and snowboarding, all the more so if these are practised in a ski resort environment. We must be aware of our limitations and be humble and not overestimate our skills, thereby avoiding falling prey to the Dunning-Kruger effect (cognitive bias by which people with low ability or knowledge overestimate their ability)[30]. Particularly when faced with a situation that we are not sure how to resolve". Education and training are the best safety tools for addressing this human factor, although as the study shows, it is not sufficient to have good knowledge.

Failure to comply with norms, fatigue, lack of situational awareness and stress, are contributing factors to accidents in ski resorts

Norms are those unwritten rules that are followed or tolerated by the majority of athletes. However, on occasions, there are persons who establish their own rules or criteria, and which are not always the most appropriate for the established safety. It is customary to hear the oft-repeated excuse that something "has always been done that way". This human factor can be mitigated by ensuring that everyone follows the same standards and takes nothing for granted. Ski resorts are governed by the Norms of Conduct of the International Ski Federation (ISF) for skiers and snowboarders[31].

The questionnaire identified with examples the failure to follow the norms, such as speeding or not wearing a helmet among others. This human factor constantly appears as a contributing factor in other accident studies, both with regard to road safety[32], sports activities[13], and ski resorts[28]. Excessive speed has been identified as a double contributing factor, given that speed is related to greater probability of being involved in an accident, but it also affects the severity of the accident suffered[33]. Excessive speed is also associated with other factors such as risk behaviour[2], overconfidence[27] and pressure of the environment[13].

Another example of a failure to follow the norms is to reject the use of a helmet. Although it has been hypothesized that the use of a helmet at ski resorts could be associated with greater risk behaviour[34] and increased injury to other parts of the body[35], a number of studies have demonstrated that this is not the case[36,37]. The use of helmets has increased over the last 20 years, and in the Alps 90% of adults and 100% children now wear helmets[37]. As has been demonstrated, compliance with this norm implicitly leads to fewer minor and major head injuries[38].

57.5% of the injured persons interviewed indicated that fatigue had contributed to the accident. Fatigue is a feeling of tiredness, reduced energy, and increased effort to perform tasks effectively and without errors. We would be facing a degradation of the human body-system, caused by prolonged, strenuous work that requires particular effort. This leads to a fall in concentration and the awareness level. It is estimated that fatigue contributes to 20-30% of traffic accidents (air, road, rail)[39]. In the context of sports accidents, this human factor has also been mentioned by injured persons in other studies, such as climbing, mountaineering, mountain skiing and alpine skiing. Alterations in dehydration biomarkers have been associated with fatigue, poor performance and a risk of injury[40]. With regard to alpine skiing, fatigue has been described as a direct cause of accidents[13].

This human factor can be mitigated with adequate rest, healthy eating and correct hydration. There is a need to be alert for the symptoms characteristic of fatigue, with regard to oneself and to colleagues alike. In the event of fatigue, tasks that are physically and psychologically demanding should be avoided[15].

More than half the injured persons interviewed indicated that the lack of situational awareness had contributed to the accident. This HF occurs when there is a lack of alertness and vigilance. In particular, when a task of activity is habitually performed, then a person tends to develop a lack of situational awareness[14]. There is an unconscious competence that makes us act on auto-pilot. This automaticity is a mechanism developed with experience and which can affect the awareness of the situation and provide good performance with a very low level of attention. When practising a demanding physical task such as alpine skiing or snowboarding, automaticity may positively affect situational awareness by reducing the demands for limited attentional resources[14]. However, on the other hand, the awareness of the situation may be negatively affected by the automaticity of the cognitive processes due to a reduction in the response capacity to new stimuli (e.g. skiing over uneven terrain). This human factor is closely related to complacency. The lack of communication, assertiveness and knowledge, as well as stress and fatigue all significantly contribute to the lack of situational awareness. The strategies to mitigate the lack of situational awareness are based on correct safety culture, checks and inspections. For example, at a ski resort, while going up in the chair lift, we should be deciding which pistes are the least crowded, which are affected by the sun and any noise by made skiers as they slide on their ski edges, indicating that the snow is frozen.

Stress is the final human factor indicated by the respondents as contributing to accidents. Stress is the subconscious response to extremely demanding situations, causing psychosomatic reactions or psychological disorders. This does not only relate to the working environment, but also to our personal lives[15]. Stress can lead to errors when it is excessive as it acts as a distraction and reduces concentration levels when performing complex tasks such as a day skiing. The relationship between the stress response and the greater incidence of injuries and accidents in the sports context has been extensively discussed by different authors[41,42], establishing the existence of physiological causes (over-working of different systems of the body), behavioural causes (relaxation in preventive measures) and psychological causes (inadequate attentional focus)[43]. This human factor is mitigated by maintaining awareness of it, with a suitable warm-up and inspection of one's personal equipment. If we feel stressed, it is important to take short breaks, encourage good communication with colleagues and avoid the idea of non-stop skiing (or without a break) to make the most of the price of the ski pass or of your only free day, particularly for those who do not ski on a regular basis. The same actions that helped to mitigate fatigue: healthy eating and correct hydration, doing moderate physical exercise, keeping regular sleep and rest patterns, will all help to reduce stress levels[15].

Conclusions

As shown by our results and those of other earlier studies[13], there are certain human factors that can be identified in alpine ski and snowboard accidents. Distraction and overconfidence are the human factors most related to ski resort accidents, according to the victims. These HF,

together with other contributing factors discussed herein, must be the target of possible preventive actions. In this way, not only will attention be paid to environmental and technical aspects, but also to those actions and decisions which, during activities in the natural environment, can prevent or contain human error. To facilitate these preventive actions and decision making, which may be difficult to make on an ongoing basis (for example during a complete skiing day at a winter ski resort) it has been demonstrated that it could be effective to be aware of, and to abide by some basic norms of conduct[44]. This type of training, based on decision making and following basic prevention norms, is already being used by other institutions such as the Safety Committee of FEDME (Spanish Federation of Mountain and Climbing Sports)[45], with great acceptance. At the ski resorts, this type of information, used during learning and in prevention campaigns, based on basic concepts and focused on those HF that have proven to be the greatest contributors, would be extremely useful for the prevention of accidents.

Limitations

One of the limitations of this study is the understanding of some of the concepts included in the questionnaire. Although we did try to minimise this through the pre-test during the questionnaire design and with the explanations by the office workers. Another limitation is the possible bias produced by the self-selection of the subjects prepared to respond to the questionnaire. Furthermore, we do not have the figure for the questionnaires rejected by injured persons.

A further limitation is whether or not amateurs are able to reliably identify the causes attributable to their accident, given that they are not aware of (or cannot identify) many of the risk factors involved. Certainly, they can make an approximation through a directed survey, as in this study.

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Conflict of interests

The authors have no conflict of interest at all.

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Comparison of the anthropometric profiles of elite youth rugby union players

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Summary

Background: Anthropometric evaluation of athletes is necessary to optimize talent identification and player development. The aim was to describe the anthropometric characteristics of national under-18 and under-20 rugby team by field positions in two season.
Material and method: 152 players of under-18 and under-20 rugby teams were to measured mass, stature, skinfolds, percentage body fat, skeletal muscle mass, bone mineral and somatype between 2015-2016 and 2016-2017 season. Mean and standard deviation were calculated for each national team, groups and positional. The Mann-Whitney U test were performed to investigate differences between national team and by groups. The Kruskal-Wallis test was performed to investigate differences between positional.
Results: The foward units were heavier, taller and had a larger percentage body fat and skeletal muscle mass than back units ($p < 0.05$). The props had a larger percentage body fat ($p < 0.05$) and the seconds row were taller ($p < 0.05$).
Conclusions: The elite players of under-20 in Spain are heavier and have a larger percentage body fat and skeletal muscle mass than elite players of under-18. The foward units are heavier, taller and have a larger percentage body fat, skeletal muscle mass and bone mineral tan back units. The props are heavier positional and have larger percentage body fat. The seconds row are taller positional.

Key words:
Anthropometric. Rugby. Body composition. Somatotype.

Perfil antropométrico comparativo entre jugadores juveniles de rugby de élite

Resumen

Introducción: La evaluación antropométrica de los deportistas es necesaria para optimizar la identificación y el desarrollo de los jugadores. Nuestro objetivo es describir las características antropométricas por posición en los jugadores de las selecciones de rugby XV Sub18 y Sub20 durante dos temporadas.
Material y método: A 152 jugadores de las selecciones de rugby XV Sub18 y Sub20 de España se les midió la estatura, masa corporal, pliegues cutáneos, porcentaje de tejido graso, masa muscular esquelética (MME), masa mineral ósea (MMO) y somatotipo durante las temporadas 2015-2016 y 2016-2017. Se calculó el promedio y la desviación estándar para cada selección, grupo y posición. Se realizó el análisis de U de Mann-Whitney para comparar entre selecciones y por grupos. Para comparar entre posiciones se utilizó la prueba de Kruskal-Wallis.
Resultados: Los jugadores agrupados como delanteros presentan mayor masa corporal, estatura, porcentaje de tejido graso, MME y MMO que los tres cuartos ($p < 0,05$). Los jugadores que ocupan la posición de piliers presentan mayor porcentaje de tejido graso ($p < 0,05$) y los que ocupan la posición de segunda línea son los de mayor estatura ($p < 0,05$).
Conclusiones: Los jugadores de élite en España Sub20 presentan mayor masa corporal, porcentaje de tejido graso y MME que los jugadores élite de España Sub18. Los jugadores agrupados como delanteros de nivel élite en España Sub18 y Sub20 presentan mayor masa corporal, estatura, porcentaje de tejido graso, MME y MMO que los jugadores agrupados como tres cuartos. La posición con mayor masa corporal y porcentaje de tejido graso es la de piliers en los jugadores de élite de España en las categorías Sub18 y Sub20. Los jugadores de nivel élite que ocupan la posición de segundas líneas son los de mayor estatura en España en las categorías Sub18 y Sub20.

Palabras clave:
Antropometría. Rugby. Composición corporal. Somatotipo.

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Introduction

Fifteen-a-side rugby union is a contact sport played on a field between two teams. The nature of the modern game means that all the players need to be able to make intermittent high-intensity efforts during a match which involve sprinting, tackling and competing in rucks, mauls and scrums. Within each team, there are two distinct groups of players (forwards and backs), and each player is given a number which represents their precise position within each group[1]. In each group, the players perform tasks specific to their position during a match. The forwards wear the numbers[1-8], and the backs wear the numbers[9-15]. The forwards are frequently involved in physical clashes with the members of the opposing team, securing possession of the ball in scrums, line-outs, rucks (contact situation in open play in which the ball is on the ground, and one or more players from each team close around it while remaining on their feet) and mauls (contact situation in open play that occurs when the ball carrier is held by an opponent and one or more of the ball carrier's team mates bind onto him/her)[2-4]. They need to be able to pass the ball in limited areas of the field when attacking. While the backs need to secure possession of the ball in tackles and rucks, their main role is to evade defenders while carrying it in wide open spaces on the field[2-4]. Based on this overview of the game, the forwards are slower and stronger than the backs, and the backs are faster and more agile[5,6]. The completely different roles played by the forwards and the backs would suggest the need for specific anthropometric profiles in order to develop effective and safe skills during games[7].

The morphology of rugby players has changed over the last century. In the last 25 years, their mean body mass has increased at a rate three to four times greater than in the previous 75 years[8], with taller backs and heavier forwards[9]. In rugby, high body mass is usually a predictor of success8. During the static phases focussing on ball retention, high body mass (regardless of composition) is an advantage because it represents an external load that the other team has to try to move in scrums. During the dynamic phases of a game, however, the determining factor of play is the ability to accelerate and decelerate, along with a player's power to body mass ratio (which is always influenced by body composition)[10]. High relative fat mass is associated with high energy expenditure[1,11], which leads to a greater risk of traumas and overuse injuries when the physical characteristics of the athlete are not optimal for the role their position dictates[12]. In conclusion, high body mass *per se* is an advantage in the static phases of the game, which are more common at low competitive levels. However, a specific relationship between lean body mass and fat mass is needed in most of the dynamic actions which characterise modern rugby and, consequently, is also required to achieve optimum performance[13,14]. An anthropometric assessment of players by gender, position and age may provide an evaluation that could improve talent identification, training methodologies, injury-prevention strategies and monitoring of changes in body composition over the season[1,15].

Body composition data are limited for fifteen-a-side rugby[4], few studies existing to date which provide anthropometric data for younger players by position. Due to the different physical demands that players in different positions face[1,2], a comparative anthropometric study of Spanish youth-level rugby players by position is needed, this being the first study to provide such data.

We aim to describe the anthropometric characteristics of the Spain U18 and U20 international rugby squads by position over two seasons.

Materials and methods

The players in the Spain men's international rugby squads in the U18 and U20 categories were studied in the 2015-2016 and 2016-2017 seasons. Assessment was carried out at each squad's training camp each season. All the participants and/or their legal guardians were informed about the purpose of the study and gave their written consent to participate. The study complied with the Declaration of Helsinki for research involving human subjects and was approved by the Ethics Committee at the Clinical Hospital of the Complutense University of Madrid.

Subjects

A total of 152 different players were studied in the 2015/2016/2017 seasons, conducting a total of 166 assessments, 14 players repeating in the two squads in the seasons studied. Sixty-six belonged to the U18 category and one hundred to the U20 category. The players were divided into two groups: forwards and backs. They were also subdivided into 9 subgroups according to their positions on the field: props, hookers, second row, back row, scrum-halves, fly-halves, centres, wings and full-backs.

Anthropometry

Body mass and height were measured on the first day of the training camp before breakfast, with the players only wearing shorts. Body mass was measured with a digital scale (Seca 877, Seca, Leicester, UK) and height with a wall-mountable height rod (Seca 206, Seca, Leicester, UK). The skinfolds, circumferences and diameters of all the players were measured by the same researcher. A total of eight folds (biceps, triceps, subscapular, suprailiac, supraspinal, abdominal, front thigh and medial calf) were measured three times with a manual caliper (Innovare 4 Cescorf, Porto Alegre, Br). In the same session, three bone diameters (medial epicondyle of the humerus to the lateral epicondyle, radial styloid process to the ulnar styloid process and medial condyle of the femur to the lateral condyle) were measured with a pachymeter (Cescorf, Porto Alegre, Br) and 4 muscle circumferences (arm relaxed, arm flexed, mid-thigh and calf) with a tape measure (Cescorf, Porto Alegre, Br).

The mean was calculated for each fold (after eliminating any possible outliers in the event of a difference greater than 1 mm). The sum of 8 folds was obtained. Body mass index (BMI), body fat percentage

(Carter equation[16]), skeletal muscle mass (Lee equation[17]) and bone mineral mass (Rocha equation[18]) were also calculated. Somatotyping was performed using the Heath-Carter method[19].

Statistics

The mean and standard deviation, with a confidence interval of 95%, were calculated for each squad, group (forwards and backs) and position (props, hookers, second row, back row, scrum-halves, fly-halves, centres, wings and full-backs). The methodology proposed by Heath-Carter was used for somatotyping, using the somatotype dispersion index (SDI), the mean somatotype dispersion distance (SDD) and the somatotype attitudinal mean (SAM)[19]. Prior to analysis of the data, the Kolmogorov-Smirnov test was used to evaluate normal distribution; non-parametric statistics was used to analyse data without normal distribution. The Mann–Whitney U test was applied to compare by squad and by group. The Kruskal-Wallis test was used to compare by position. Comparison with other studies was performed with the independent samples *t* test and the somatotypes were compared with SDD. Data analysis was performed using SPSS for Windows version 20.

Results

Table 1 shows the descriptive values of anthropometric measurements obtained by category (U18 and U20), Table 2 the values obtained by field position (forwards and backs), and Tables 3 and 4 the values obtained for each field position by team category.

Comparison between categories (U18 and U20)

Height: Comparing each squad by group (Table 3) shows that there is no significant difference in height between the forwards in the two squads, the U18 forwards measuring 1.83±0.07 m and the U20 players measuring 1.84±0.06 m. The same occurs with the backs (Table 4), where the height in the U18 squad is 1.79±0.06 m, while in the U20 squad it is 1.79±0.05 m. However, when the forwards are compared with the backs (Table 2), differences are observed (p <0.005).

Body mass: In relation to body mass and BMI, there are significant differences between the forwards in the two squads, the U18 players giving lower figures of 93.2±10.0 kg and 27.8±2.9 kg/m^2, and the U20 players higher figures of 102.3±14.4 kg and 30.1±4.4 kg/m^2 (p <0.05). No significant differences are observed between the backs in the two squads. Comparing the forwards and the backs, the weight and BMI of the forwards are greater, with 98.9±13.6 kg and 29.2±4.0 kg/m^2, while those of the backs are lower, with respective values of 79.5±7.5 kg and 24.7±1.9 kg/m^2 (p <0.05).

Body fat percentage: There are differences in body fat percentage, sum of the 8 folds and skeletal muscle mass between the forwards in the two squads and between the backs in the two squads, the values for U20 players being higher (p <0.05). Comparing forwards with backs, higher values are observed in the forwards (p <0.05).

Somatotype: Regarding somatotypes, it is observed that that of the forwards is heterogeneous, with an SDI of more than 2, while that of the

Table 1. Anthropometric values by team category.

	U18 squad (n=66)	U20 squad (n=100)	p
Weight	86.6 ±11.7	93.2±16.2	0.016*
Height	1.81±0.07	1.82±0.06	0.305
BMI	26.25±3.1	28.02±4.3	0.012*
BF	10.43±3.6	12.62±4.8	0.01*

BMI: Body mass index; BF: Body fat; p: U Mann-Whitney p-value; *statistically significant difference: p<0.05.

Table 2. Comparison of anthropometric variables by group of players.

		Forwards (n: 95)	Backs (n: 71)	*P*
Weight	95% CI	98.9±13.6	79.5±7.5	0.000**
		96.16-101.71	77.75-81.30	
Height	95% CI	1.83±0.06	1.79±0.06	0.000**
		1.82-1.85	1.77-1.80	
BMI	95% CI	29.2±4.0	24.7±1.9	0.000**
		28.44-30.10	24.25-25.18	
% body fat	95% CI	13.6±4.8	9.1±2.1	0.000**
		12.68-14.65	8.68-9.69	
Σ 8 folds	95% CI	135.7±57.6	80.9±27.1	0.000**
		124.03-147.51	74.54-87.38	
SMM	95% CI	33.8±3.1	30.4±2.7	0.000**
		33.22-34.50	29.78-31.08	
BMM	95% CI	13.6±1.3	12.4±1.1	0.000**
		13.38-13.93	12.17-12.71	
Somatotype				
Endomorphic	95% CI	4.4±1.8	2.6±0.9	0.000**
		4.03-4.81	2.42-2.87	
Mesomorphic	95% CI	4.7±1.1	4.1±0.9	0.000**
		4.52-4.99	3.90-4.35	
Ectomorphic	95% CI	0.9±0.7	1.7±0.5	0.000**
		0.83-1.12	1.56-1.84	
SDI		2.19*	1.69	
SDD		4.43*		
SAM		2		

BMI: Body mass index; BF: Body fat; Σ8 folds: Sum of 8 folds; SMM: Skeletal muscle mass; BMM: Bone mineral mass; SDI: Somatotype dispersion index; SDD: Mean somatotype dispersion distance; SAM: Somatotype attitudinal mean; CI: confidence interval 95%; p: Mann-Whitney test *p*-value. The asterisks indicate statistically significant differences: *p<0.05; **p<0.01, respectively.

Table 3. Comparison of anthropometric variables in forwards by squad.

	Forwards U18 (n:36)	Forwards U20 (n:59)	*p*
Weight	93.2±10.0	102.3±14.4	0.002**
Height	1.83±0.07	1.84±0.06	0.1
BMI	27.8±2.9	30.1±4.4	0.009**
% body fat	12.0±3.7	14.6±5.1	0.007**
∑ 8 folds	114.8±45.5	148.5±60.7	0.003**
SMM	32.6±2.8	34.5±3.0	0.004**
BMM	13.5±0.2	13.7±0.17	0.32
Somatotype			
Endomorphic	3.8±1.5	4.7±2.0	0.02*
Mesomorphic	5.3±1.3	6.0±1.2	0.07
Ectomorphic	1.1±0.7	0.8±0.6	0.13
SDI	2.33*	2.02*	
SDD	2.21*		
SAM	1.18		

BMI: Body mass index; BF: Body fat; Σ8 folds: Sum of 8 folds; SMM: Skeletal muscle mass; BMM: Bone mineral mass; SDI: Somatotype dispersion index; SDD: Mean somatotype dispersion distance; SAM: Somatotype attitudinal mean; *p*: Mann-Whitney test *p*-value; The asterisks indicate statistically significant differences: **p*<0.05; ***p*<0.01, respectively.

Table 4. Comparison of anthropometric variables in backs by squad.

	Backs U18 (n:30)	Backs U20 (n:41)	p
Weight	78.7±8.2	80.0±6.9	0.177
Height	1.79±0.06	1.79±0.05	0.7
BMI	24.3±2.2	24.9±1.7	0.08
% body fat	8.5±2.2	9.6±1.9	0.005**
∑ 8 folds	70.1±27.7	88.8±23.9	0.001**
SMM	30.4±3.0	30.3±2.5	0.954
BMM	12.6±0.2	12.3±0.15	0.34
Somatotype			
Endomorphic	2.4±1.0	2.8±0.8	0.0001**
Mesomorphic	4.0±0.9	4.1±0.9	0.609
Ectomorphic	1.8±0.6	1.6±0.5	0.141
SDI	1.68	1.61	
SDD	3.11*		
SAM	0.43		

BMI: Body mass index; BF: Body fat; Σ8 folds: Sum of 8 folds; SMM: Skeletal muscle mass; BMM: Bone mineral mass; SDI: Somatotype dispersion index; SDD: Mean somatotype dispersion distance; SAM: Somatotype attitudinal mean; *p*: Mann-Whitney test *p*-value; The asterisks indicate statistically significant differences: **p*<0.05; ***p*<0.01, respectively.

Table 5. Comparison of anthropometric variables by position of players.

	Prop N:31	Hooker N:12	Second row N:23	Back row N:29	Scrum-half N:12	Fly-half N:11	Centre N:19	Wing N:21	Full-back N:8
U18	9	8	11	8	5	6	8	7	4
U20	22	4	12	21	7	5	13	12	4
Weight (kg)	112.5±11.2$^{*\$\ddagger\#\&\mu\yen}$ (CI:108.4-116.7)	88.1±4.3$^{\wedge\dagger}$ (CI:85.3-90.8)	96.8±10.8$^{\#\&\mu\yen}$ (CI:92.1-101.5)	90.5±7.2$^{\wedge\ddagger\mu}$ (CI:87.7-93.2)	71.4±5.8$^{\wedge*\dagger\$}$ (CI:67.7-75.1)	78.9±4.1$^{\wedge\dagger\$}$ (CI:76.1-81.7)	84.1±7.8$^{\wedge\dagger}$ (CI:80.5-87.7)	79.5±6.8$^{\wedge\dagger\$}$ (CI:76.2-82.7)	80.3±3.7$^{\wedge\dagger}$ (CI:77.2-83.4)
Height (m)	1.82±0.06†‡ (CI:1.79-1.84)	1.77±0.04† (CI:1.74-1.79)	1.90±0.05$^{\wedge*\ddagger\#\&\mu}$ (CI:1.87-1.92)	1.83±0.05‡ (CI:1.81-1.85)	1.72±0.03$^{\wedge\dagger\$\&\mu\yen}$ (CI:1.69-1.74)	1,77±0,04† (CI:1.73-1.80)	1.82±0.04†‡ (CI:1.80-1.84)	1.81±0.05†‡ (CI:1.78-1.83)	1.81±0.06‡ (CI:1.75-1.86)
BF (%)	19.0±3.9$^{\dagger\$\ddagger\#\&\mu\yen}$ (CI:17.6-20.5)	11.5±2.0 (CI:10.2-12.8)	11.2±2.7$^{\wedge}$ (CI:10.0-12.4)	10.6±2.2$^{\wedge}$ (CI:9.7-11.5)	9.2±2.2$^{\wedge}$ (CI:7.7-10.6)	8.8±2,7$^{\wedge}$ (CI:6.9-10.6)	9.5±2.1$^{\wedge}$ (CI:8.5-10.4)	8.7±1.6$^{\wedge}$ (CI:7.9-9.5)	9.8±2.2$^{\wedge}$ (CI:8.0-11.7)

BF: Body fat; CI: Confidence interval 95%; ^: Different to prop; *: Different to hooker; †: Different to second row; $: Different to back row; ‡: Different to scrum-half; #: Different to fly-half; &: Different to centre; µ: Different to wing; ¥: Different to full-back.

backs is homogeneous, with an SDI below 2. The mean somatotype is different between forwards and backs (SDD> 2), between the forwards in the two squads (SDD> 2) and between the backs (SDD> 2). Endomorphism is significantly different between the forwards in the two squads and between the backs in the two squads (p <0.05). However, there are no significant differences when the two squads are compared by groups in terms of mesomorphism and ectomorphism. Significant differences are noted when forwards are compared with backs, endomorphism and mesomorphism being higher in the forwards, and ectomorphism being higher in the backs (Figure 1).

Position: The comparison by position is shown in Table 5. The body mass of the props is greater compared to other positions, with the sole exception of the second row, with whom no significant difference is observed. As for height, players in the second row are taller than those in other positions, save the third row and the full-backs, with whom no significant difference is observed. The body fat percentage is seen

Table 6. Comparison of somatotype by position of players.

	Prop N:31	Hooker N:12	Second row N:23	Back row N:29	Scrum-half N:12	Fly-half N:11	Centre N:19	Wing N:21	Full-back N:8
U18	9	8	11	8	5	6	8	7	4
U20 22	4	12	21	7	5	13	12	4	
Somatotype									
Endomorphic	6.6±1.3$^{\dagger\$\ddagger\#\&\mu\yen}$ (CI:6.1-7.1)	3.7±0.8$^{\mu}$ (CI:3.2-4.3)	3.3±1.0$^{\wedge}$ (CI:2.8-3.7)	3.2±0.9$^{\wedge}$ (CI:2.9-3.5)	2.8±0.9$^{\wedge}$ (CI:2.3-3.4)	2.5±1.2$^{\wedge}$ (CI:1.6-3.4)	2.7±0.8$^{\wedge}$ (CI:2.3-3.1)	2.3±0.7$^{\wedge *}$ (CI:1.9-2.6)	2.9±1.0$^{\wedge}$ (CI:2.0-3.7)
Mesomorphic	6.9±0.9$^{\dagger\$\ddagger\&\mu\yen}$ (CI:6.6-7.3)	5.8±0.8 (CI:5.3-6.3)	4.7±1.1$^{\wedge}$ (CI:4.2-5.2)	5.2±0.8$^{\wedge}$ (CI:4.9-5.6)	4.9±0.8$^{\wedge}$ (CI:4.4-5.5)	5.3±0.6$^{\wedge}$ (CI:4.9-5.7)	4.7±1.0$^{\wedge}$ (CI:4.3-5.2)	4.4±1.1$^{\wedge}$ (CI:3.8-5.0)	4.5±0.7$^{\wedge}$ (CI:3.9-5.1)
Ectomorphic	0.2±0.3$^{\dagger\$\ddagger\#\&\mu\yen}$ (CI:0.1-0.3)	0.8±0.4$^{\&\mu}$ (CI:0.5-1.1)	1.5±0.5$^{\wedge}$ (CI:1.3-1.7)	1.3±0.4$^{\wedge}$ (CI:1.1-1.5)	1.6±0.4$^{\wedge}$ (CI:1.3-1.9)	1.4±0.4$^{\wedge}$ (CI:1.1-1.8)	1.6±0.6$^{\wedge *}$ (CI:1.3-1.9)	1.9±0.5$^{\wedge *}$ (CI:1.6-2.1)	1.8±0.8$^{\wedge}$ (CI:1.0-2.5)

CI: Confidence interval 95%; ^: Different to prop; *: Different to hooker; †: Different to second row; $: Different to back row; ‡: Different to scrum-half; #: Different to fly-half; &: Different to centre; µ: Different to wing; ¥: Different to full-back.

Figure 1. Somatochart by group of players.

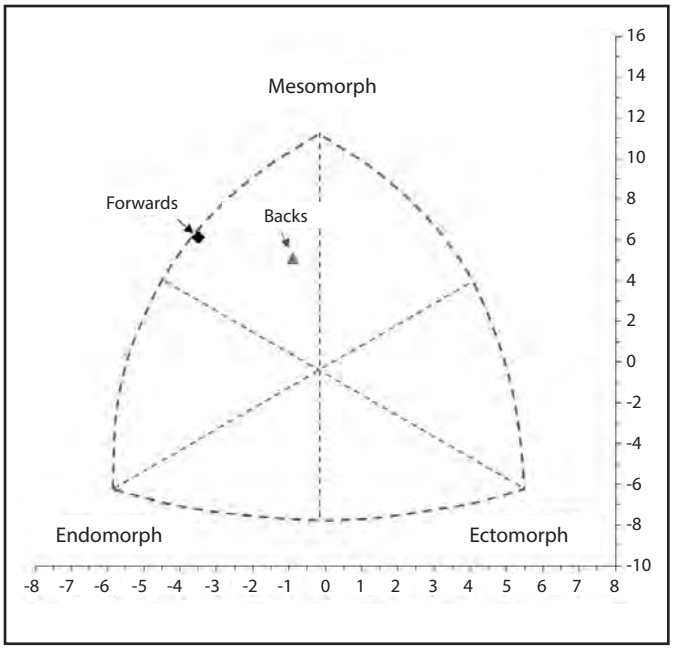
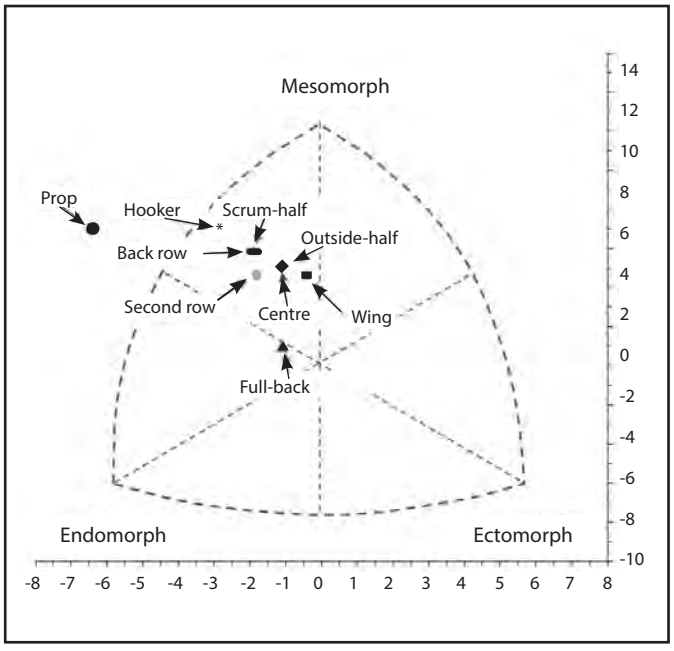


Figure 2. Somatochart by position of players.



to be higher in the props when compared with other positions, with the exception of the hookers, with whom no significant difference is observed. The somatotype by position is shown in Table 6 and Figure 2.

Discussion

This is the first study focussing on the anthropometric profile of the U18 and U20 international fifteen-a-side rugby squads in Spain. The information obtained in this study is limited by only centring on the elite fifteen-a-side rugby population aged from 17 to 20. However, because they are the first data obtained, they will reveal physical aspects of rugby players in this age group in Spain which could help improve talent identification, training methodologies, injury-prevention strategies and the monitoring of variations in body composition during the season[1,15].

This study shows that the U18 and U20 international rugby squads are of similar height, which is consistent with other research which observed no significant differences between the U18 and U20 categories in rugby[20-22]. However, body mass is greater in the U20 squad, a result which coincides with studies at rugby academies in the United Kingdom, where they observed greater body mass in under-20s compared

to under-18s[20-22]. The body fat percentage and the sum of folds are also higher in the U20 squad, but this differs from other studies that have shown that the sum of folds is similar at these ages[20-22]. That the U18 and U20 players are of similar height can be explained by the fact that only minimal changes in height are expected after the age of 18, and most of the players will have almost reached adult height by this point in their lives. By contrast, body mass would be expected to continue to rise with the intensification of the demands of competition and training (intensification of strength training programmes)[4]. The higher body fat percentage and sum of folds in the U20 squad is striking. This can be explained by the desire to increase body mass because this has been shown to increase linear momentum in tackling and physical collision[4]. A study focusing on rugby league also suggests that increasing the folds can protect players against the high number of collisions experienced in the sport[23]. Although an association between a low body fat percentage and enhanced performance has been demonstrated[4, 24,25], this can be explained by decreased acceleration on vertical and horizontal planes when the body fat percentage rises.

The difference in body mass, height, body fat percentage, sum of folds, skeletal muscle mass and somatotype between forwards and backs observed in this study is consistent with others, in both teenage[7,.26-28] and adult[4,29] rugby players. The data on the mean body mass of U18 players given in the few studies published to date are not uniform. The mean results from this study are similar to those observed in U18 players in South Africa[30], which gave 94.2±8.5 kg for forwards and 77.8±8.8 kg for backs ($p = 0.66$), but greater than the study conducted with players of a similar age in Ireland ($p < 0.05$), in which the forwards weighed 83.6±10.5 kg and the backs 73.6±6.6 kg[7].

The height of the U18 forwards observed in this study is similar ($p = 0.48$) to the heights seen in other studies focusing on players of a similar age, with forwards measuring 1.82±0.07 m and backs 1.78±0.05 m[7]. The comparison of the body fat percentage in the U18 forwards and backs is smaller ($p < 0.05$) than what can be observed in other studies of players of the same age, which show 18% and 14%, respectively[7,30]. Somatotyping the forwards and backs in the U18 squad, differences (SDD>2) can be observed when compared with the results of a study conducted with players in New Zealand[28]. In the forwards, mesomorphism is predominant over endomorphism, and both are predominant over ectomorphism, with slightly lower mesomorphism values than the aforementioned study of players of a similar age, which cited 5.6, and slightly higher endomorphism values than the same study, which found 3.428. Meanwhile, in the backs, mesomorphism is predominant over both endomorphism and ectomorphism, but the values are lower in mesomorphism and ectomorphism compared to the aforementioned study of players of a similar age, which indicated 5.5 and 2.3, while endomorphism gave a slightly higher figure than the New Zealand study, which cites 2.228. In the U20 forwards and backs, a greater body mass is observed ($p < 0.05$) compared with studies of players of a similar age[26,27] but a lower body mass when compared with top-flight adult players, which stands at 108±8kg in forwards and 94±8kg in backs[4]. The U20 forwards and backs in this study are taller ($p < 0.05$) than those of a similar age in other studies, in which the forwards measured 1.80±0.04 and the backs 1.77±0.03 m[26], but of a similar height to the adult players measured in a study in Spain, in which the forwards stood at 1.82±0.07 m and the backs at 1.79±0.09 m[31]. Meanwhile, the body fat percentage found in the U20 forwards and backs is similar to that of adult international players[4] but lower than that found in adult players in Spain[31]. Somatotyping the forwards and backs in the U20 squad, differences (SDD>2) can be observed when compared with the results of a previous study conducted with players of the same age[28]. Mesomorphism is predominant in the forwards, the results being similar to another study with players of the same age, which gave 5.9, but the present study shows greater endomorphism than that same study, which indicated 3.628. Although mesomorphism predominates in the somatotype values of the U20 backs, it is lower than the value of 5.4 observed in players of a similar age, while endomorphism is higher than the study in New Zealand, which stood at 2.428. The differences observed between forwards and backs can be explained by the roles of each group in the game. The forwards are frequently involved in physical confrontation, which includes actions such as tackling, competing in scrums and rucking, and body mass and height are factors positively correlated with success during play[32]. The backs need to gain ground carrying the ball and score points by running through open space, and are typically involved in actions such as repeated high-speed sprints and shows of skill[33].

In this study, the players are categorised into 9 positions. Comparisons show that the body mass of props is greater than that of other positions, with a mean which is higher ($p < 0.05$) than a study of Argentinean adults, which showed a body mass of 105±10 kg[34], but similar ($p = 0.22$) to that of Italian adult internationals, which stood at 116±6 kg[29]. The greater body mass of props is understandable because they are the driving force in scrums and are constantly involved in rucks, mauls and tackles. The second-row forwards are taller, being similar in height ($p = 0.5$) to the adult players who competed in a national tournament in Argentina, who measured 1.89 ± 0.04 m[34], and slightly shorter ($p < 0.05$) than the subjects in a study of adult international players, who were 1.97 ± 0.02 m[29]. The second-row forwards are usually the tallest players because they are the ones who jump the most at lineouts and try to gain possession of the ball at kick-off. The props show the highest body fat percentage, similar ($p = 0.35$) to the 20±3% observed in adult internationals[29]. This higher body fat percentage can be explained by the demands of the position, and the objective is to absorb impact in collisions and tackles. In terms of somatotype, the props show greater endomorphism, although the somatotype is different from that observed in adult players (SDD> 2), with greater endomorphism ($p < 0.05$) than that observed in other studies with adults: 4.9±1.134. The props also show greater mesomorphism, although the values are lower ($p < 0.05$) than those obtained in a study with adult players, which indi-

cated 8.1±0.234. These results reflect the specific requirements of the position: high bone and muscle mass for scrums[35].

Study and analysis in recent years has shown that the anthropometric profile is a key determinant for success in high-level rugby36. Therefore, the information obtained in this study needs to be added to the tactical, physical and psychological characteristics related to the specific demands of the game.

Conclusions

The elite rugby players in the Spain U20 squad have a greater body mass, body fat percentage and skeletal muscle mass than their U18 counterparts.

The elite rugby players in the Spain U18 and U20 squads are of similar height.

The elite forwards in the Spain U18 and U20 rugby squads have a greater body mass, height, body fat percentage, skeletal muscle mass and bone mineral mass than the players in the backs group.

The props are the position with the greatest body mass and body fat percentage in the Spain U18 and U20 elite rugby categories.

The second-row forwards are the position with the tallest players in the Spain U18 and U20 elite rugby categories.

The data obtained will help us create normative values for talent identification, training guidelines, dietary interventions and the control of performance improvements.

Study limitations

Other factors can also influence body composition besides training and competitive games, such as diet and activity outside competitive games and training. Although the players followed similar dietary and training guidelines, it would be impossible to control these variables, and we do not know what influence they may have on body composition and the differences between categories.

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Conflict of Interests

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

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Relationship between the anthropometric profile and physical fitness of surfers and their dynamic postural balance

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Summary

Introduction: Surfing is a discipline that has considerably increased the number of followers who practice this sport. Research has focused on describing the main variables associated with performance, but not the relationships that may exist between them.
Objective: To establish the relationship of dynamic postural balance with respect to the anthropometric profile and physical aptitude in surfers.
Material and method: This research is an observational and cross-sectional study of a descriptive-correlational type. The sample included 30 surfers (8 women and 22 men). The variables of the anthropometric profile studied were body mass, bipedal height, body mass index (BMI), sum of folds, body composition and somatotype. Furthermore, physical aptitude was assessed by indirect tests. The data of the anthropometric profile and physical aptitude were correlated with the results of the dynamic postural balance test *(Y balance test).*
Results: For the anterior direction of the *Y balance test,* the variables that were significant were gender, body weight, bipedal height, sum of folds, adipose mass and Sargent's jump height ($R^2 = 0.55$). The posteromedial direction of the *Y balance test* yielded a significant model that indicates that gender, sum of folds and adipose mass are the variables that jointly predict dynamic postural balance ($R^2 = 0.30$). For the posterolateral direction, the model indicates that the BMI, sum of folds, adipose mass, mesomorphism, ectomorphism and performance in the sit and reach test are the variables that influence the performance of the *Y balance test* ($R^2 = 0.55$).
Conclusion: Predictive models were established to determine anthropometric and physical condition variables that would be decisive for the performance of a surfer's postural balance.

Key words:
Postural balance.
Anthropometric profile.
Physical aptitude. Surfing.

Relación entre el perfil antropométrico y aptitud física con el equilibrio postural dinámico en surfistas

Resumen

Introducción: El surf es una disciplina que ha aumentado considerablemente la cantidad de adeptos que practican este deporte. Las investigaciones se han orientado en describir las principales variables asociadas al rendimiento, pero no las relaciones que pueden existir entre ellas.
Objetivo: Establecer la relación del equilibrio postural dinámico con respecto al perfil antropométrico y aptitud física en surfistas.
Material y método: Esta investigación es un estudio de diseño observacional y transversal, de tipo descriptivo-correlacional. La muestra incluyo 30 surfistas (8 mujeres y 22 hombres). Las variables del perfil antropométrico estudiadas fueron: masa corporal, estatura bípeda, índice de masa corporal (IMC), suma de pliegues, composición corporal y somatotipo. Además, se evaluó la aptitud física mediante pruebas indirectas. Los datos del perfil antropométrico y aptitud física se correlacionaron con los resultados de la prueba de equilibrio postural dinámico *(Y balance test).*
Resultados: Para la dirección anterior del *Y balance test*, las variables que resultaron significativas fueron género, peso corporal, estatura bípeda, suma de pliegues, masa adiposa y altura del salto de Sargent ($R^2 = 0,55$). La dirección posteromedial del *Y balance test* arrojó un modelo significativo que indica que el género, suma de pliegues y masa adiposa son las variables que predicen conjuntamente el equilibrio postural dinámico ($R^2 = 0,30$). Para la dirección posterolateral el modelo señala que el IMC, suma de pliegues, masa adiposa, mesomorfismo, ectomorfismo y rendimiento en la prueba sit and reach son las variables que influyen en rendimiento de la prueba *Y balance test* ($R^2 = 0,55$).
Conclusión: Se establecieron modelos predictivos para determinar variables antropométricas y de la aptitud física que serían determinantes para el desempeño del equilibrio postural de un surfista.

Palabras clave:
Equilibrio postural.
Perfil antropométrico.
Aptitud física. Surf.

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Introduction

Surfing as a discipline has grown exponentially over the last few years, to such an extent that it has been included in the upcoming Olympic games[1]. Surfing is a dynamic sport performed in a highly unstable and changing environment, meaning that balance is an essential characteristic for these athletes[2]. In this respect, it has been surmised that postural balance is directly related to the improved performance and competition level of surfers[2].

Maintaining correct postural balance is a psychomotor challenge that includes a series of sensorimotor processes to reach optimal performance[3]. Postural balance or equilibrium is defined as a complex motor skill resulting from the interaction of a number of sensorimotor processes, directed at controlling the body in space[3,4]. This ranges from anticipatory and compensatory strategies up to the input of information from the visual, vestibular and somatosensory systems for integration into the central nervous system[3,5].

One of the most widely recognised methods for assessing dynamic postural balance is the *Star Excursion Balance Test* (SEBT) or its modified version, the *Y Balance Test*[6]. The SEBT protocol evaluates eight directions while the Y balance test only evaluates three directions: anterior, posteromedial and posterolateral[6]. These directions have been shown to be the most sensitive in detecting postural balance alterations and the risk or injury[7]. Despite the fact that surfing is a dynamic activity, investigations habitually report static postural balance evaluations through force plates[2,8]. For this reason, suggestions were made to conduct dynamic evaluations in order to strengthen the scientific knowledge of this sport[9].

For its part, the anthropometric profile may have an impact on the performance of athletes. Specifically, for surfers, it has been reported that the presence of less adipose tissue can predict greater athletic performance[10]. It has also been reported that elite surfers present a balanced mesomorph somatotype, which reveals a characteristic body shape by type of athlete[8,10]. With regard to the physical capabilities necessary for good performance in surf, it has been reported that high cardiorespiratory fitness, high muscular strength and considerable anaerobic strength and power would be essential for optimal performance[9]. However, to date, there has been no investigation that relates the aforementioned variables for surfers with postural balance. Therefore, the aim of this study is to determine predictive models that could explain the postural balance of surfers based on anthropometric profile and physical fitness variables.

Material and method

This investigation is a cross-sectional, descriptive, correlational, observational study. Non-probability convenience sampling was used to select participants, who all signed an informed consent approved by the Ethics Committee of the Universidad Santo Tomás, Chile (61.19).

Participants

The sample included 30 surfers (22 men and 8 women) from the commune of Pichilemu (Chile), aged between 16 and 35 years and who had been surfing for at least 2 years. The following exclusion criteria were considered: a) Musculoskeletal injuries in the last 3 months; b) Surgery in the last 6 months on the upper or lower body; c) Vestibular disorders; d) Discomfort of any type when making the evaluations (for example: pain).

Anthropometric profile

The different evaluations made to determine the anthropometric profile were in accordance with the *International Society for the Advancement of Kinanthropometry* (ISAK)[11]. Standing stature was measured using a stadiometer (Seca® Hamburg, Germany, accurate to 0.1cm) and body weight with a digital scale (Seca® Hamburg, Germany, accurate to 0.1 kg). These measurements gave the body mass index (BMI), dividing the body weight (kg) by the square of the stature (m^2). An anthropometer (Rosscraft, Canada; accurate to 0.1mm) was used to measure the following breadths: biacromial; transverse chest, anteroposterior thorax, biliocristal, biepicondylar (humerus and Femur). 10 girths were measured with a tape measure (Sanny®, Brazil; accurate to 0.1mm) which corresponded to: Head, arm relaxed, arm flexed and tensed, maximum forearm, mesosternum thorax, minimum waist, maximum hip, maximum thigh, medial muscle and maximum calf. Six skinfolds were measured with a calliper (Harpenden®, England; accurate to 0.2 mm) corresponding to triceps, subscapular, supraspinale, abdominal, medial thigh and ending with maximum calf). The above measurements served to calculate the pentacompartimental body composition, which establishes five components (epithelial mass, adipose mass, muscle mass, bone mass and residual mass)[12]. The somatotype (body shape and composition) was also determined using the equations established by Heath & Carter (1990) based on three parameters which differ one from the other, either endomorph (a predominance of adiposity); mesomorph (high level of muscularity) and ectomorph (slender body)[13].

Physical fitness

Prior to the evaluations, the participants were subjected to a general warm-up: joint mobility, 10 minute jog and sprinting with changes in speed. The participants subsequently took the physical fitness tests. Hamstrings - lower back flexibility was measured with the *Sit and Reach Test*[14]. Each participant sat on the floor with feet slightly apart and the soles of the feet placed flat against a measuring box, with the knees stretched out. From this position they were asked to reach forward as far as possible with their hands on the measuring box. Once in that position, the best distance was recorded (cm).

The CORE abdominal strength was measured with the prone bridge test[15]. This test consisted in lying in a prone position, propped on the forearms, with the pelvis in a straight line with the rest of the body and

with both feet hip-width apart. The surfer was asked to hold the position for as long as possible[15].

The Sargent or vertical Jump test was used to measure the explosive power of the lower limbs in accordance with the protocol established by Harman, Rosenstein, Frykmam, Rosenstein & Kraemer (1991)[16]. The vertical jump test measures the difference between the height of the athlete with the hand stretched upwards (feet on the floor) and the height reached with that hand with a jump. 3 jumps were performed, taking the best measurement and with a 45 second rest between each attempt[17].

Agility was measured with the modified Illinois test[18]. The test starts with the participant lying in a prone position with arms at his/her side. At the command of a whistle, the participant must get up and run to the first cone in the circuit, then through a slalom course of four cones in the centre and back again, past the penultimate cone, and then complete the circuit[19]. Each participant must complete the circuit in the shortest possible time.

The medicine ball throw test was used to determine the explosive force of the upper body[20]. A line was marked on the floor, where the athlete had to stand. Behind the line marking the starting point, with the feet at an equal distance and slightly apart, the ball was taken with both hands behind the head and the participant was asked to throw the medicine ball as far as possible[20]. The test used a medicine ball (3 kg for men; 2 kg for women), chalk and a tape measure (Sanny®, Brazil; accurate to 0.1mm) to measure the distance (cm) reached by the ball[20].

Finally, to determine the maximum oxygen consumption ($\dot{V}O_{2max}$) the *Shuttle Run*[21] test was used. Two lines were marked out, 20 metres apart, and participants were asked to run back and forth, making a change in direction at the rate indicated by a buzzer, with the frequency progressively increasing[21]. The test had a slow starting speed of 8 km/h, which was gradually increased up to a final speed of 18 km/h[21]. During the test the subjects themselves are responsible for determining their own pace so that, when the signal is heard, the participant must be 1 to 2 metres from the end line. At each end, the line must be touched with the foot and the test ends when the subject either withdraws voluntarily from the test and/or when the participant can no longer keep up the pace imposed by the buzzer[21,22]. The $\dot{V}O_{2max}$ was estimated by the equations proposed by Leger *et al*. (1988)[22]:

For subjects under 18 years of age:

$$\dot{V}O_{2max} = 31.025+(3.238\times FSR)-(3.248\times Age)+(0.1536\times FSR\times Age)$$

For subjects over 18 years of age:

$$\dot{V}O_{2max} = (6\times FSR)-27.4\ \dot{V}O_{2max}=(6\times FSR)-27.4$$

$\dot{V}O_{2max}$: $mL.kg^{-1}.min^{-1}$

FSR: Final speed reached in the last stage completed ($km.h^{-1}$)

Age: Years.

Dynamic postural balance

Dynamic postural balance was evaluated using the *Y Balance Test* considering 3 directions: anterior, posteromedial and posterolateral. Each participant started the evaluation standing upright with their hands on their hips. When instructed to do so, the participant reached as far as possible with the lower limb. The dominant lower limb was evaluated which, for the purpose of this test, was the limb that supports the body weight6. Participants had three attempts in each direction, recording the best of the three[6,23]. The attempt was considered valid when the support foot did not leave the floor and the participant was able to return to the initial position without losing balance after doing the reach. A tape measure in centimetres (Sanny®, Brazil, accurate to 0.1mm) was used to measure the distances achieved in all 3 directions. The final reach value of the lower limb was expressed as a percentage, normalizing the results to segment length with the following calculation:

$$\%\ Y\ Balance\ Test = \frac{(\text{distance reached (cm)})}{(\text{segment length (cm)})} \times 100$$

The segment length was measured considering the distance between the anterior superior iliac spine up to the medial malleolus of the ankle[23].

Statistical analysis

The SPSS 23.0 (SPSS 23.0 for Windows, SPSS Inc., IL, USA) software was used for the data analysis. The mean and standard deviation were calculated to describe the characteristics of the sample: anthropometric profile (anthropometric measures, body composition and somatotype), physical fitness and dynamic postural balance. The Shapiro-Wilk was applied to assess the distribution of the data and, subsequently, a multiple linear regression model was applied (confidence interval of 95%) to determine the impact of the anthropometric profile and physical fitness on the 3 directions of the dynamic balance test. The collinearity of the variables present in the analysis was verified using values with a tolerance of less than 0.10 and, for values above 10.0, a variance inflation factor (VIF) to confirm the non-existence of multicollinearity. The level of significance for all the statistical tests was < 0.05.

Results

The 30 surfers evaluated (8 women and 22 men) had a mean age of 26.0 years, body weight of 70.5 kg, standing stature of 169.4 and BMI of 24.4 kg/m^2. The sample, based on the body composition, obtained 23.5% adipose mass and 47.7% muscle mass. The somatotype classification places the participants as Meso-endomorphs (3.1 - 5.7 - 1.7). Table 1 shows the anthropometric characteristics of the surfers assessed, distributed according to gender. The descriptive results of the physical fitness and postural balance of the surfers evaluated are provided in Tables 2 and 3 respectively.

Multiple linear regression analysis

The significant variables in the models are shown in Table 3. For the anterior direction of the *Y balance test*, the significant variables were

Table 1. Anthropometric measurements, body composition and somatotype of the surfers (mean and standard deviation).

	Men (n=8)	Women (n=22)
Age (years)	25.6 (3.5)	26.1 (5.3)
Body weight (kg)	59.4 (6.6)	74.5 (11.9)
Standing Stature (m)	162.2 (7.7)	171.9 (7.5)
BMI (kg/m^2)	22.5 (1.1)	25.2 (3.4)
Skinfold sum (mm)	78.1 (21.5)	67.3 (34.7)
Adipose mass (%)	27.6 (4.1)	22.0 (4.1)
Muscle mass (%)	44.4 (3.5)	48.9 (3.2)
Residual mass (%)	10.9 (0.4)	12.4 (0.9)
Bone mass (%)	11.4 (1.1)	11.8 (1.1)
Epithelial mass (%)	5.5 (0.4)	4.9 (0.5)
Endomorph	3.5 (1.2)	2.9 (1.7)
Mesomorph	4.9 (1.1)	6.0 (1.3)
Ectomorph	1.9 (0.6)	1.7 (1.1)

BMI: body mass index.

Table 2 Results of the physical fitness and dynamic balance tests of surfers (mean and standard deviation).

	Men (n=8)	Women (n=22)
Physical fitness		
Sit and reach (cm)	13.9 (2.9)	4.9 (8.5)
Prone bridge (s)	147.1 (36.9)	163.4 (80.1)
Sargent Jump (m)	37.9 (4.8)	45.8 (5.3)
Illinois agility test (s)	18.2 (0.8)	17.1 (0.7)
Ball throw (m)	367.5 (45.7)	525.1 (73.9)
Shuttle run (ml*kg*min)	38.9 (4.1)	44.9 (5.3)
Y Balance Test Directions		
Anterior (%)	72.0 (8.7)	67.4 (5.5)
Posteromedial (%)	124.1 (12.7)	118.2 (6.9)
Posterolateral (%)	114.7 (9.8)	111.3 (9.3)

gender, body weight, standing stature, skinfold sum, adipose mass and Sargent jump height. This model has an explanation level of 55.1% and shows that women surfers, with less body weight, smaller in stature, thinner skinfolds, lower adipose mass and who achieve a greater height in the Sargent test, have a better dynamic postural balance.

The posteromedial direction of the Y Balance Test yielded a significant model that indicates that gender, skinfold sum and adipose mass are variables that together predict the dynamic postural balance. The model obtained has an explanation level of 30.2% and indicates that women surfers with thinner skinfolds and less adipose mass have a better dynamic postural balance.

For the posterolateral direction the model indicates that the BMI, skinfold sum, adipose mass, mesomorphism, ectomorphism and performance in the sit and reach test are the variables to influence performance of the *Y Balance Test*. Surfers with a lower BMI, thinner skinfolds, lower adipose mass, greater tendency to mesomorphism, lesser tendency to ectomorphism and greater performance in the Sit and Reach test, have a greater dynamic postural balance. The explanation level of the model is 55.2%.

Discussion

The principal result of this investigation indicates that the anthropometric profile and physical fitness explain the postural balance performance of surfers. Furthermore, the study also showed that gender is also a variable that has an influence on postural balance, where women offer a better performance. Specifically, it was observed that anthropometric variables relating to adiposity (BMI, sum of skinfolds and adipose mass), lower body explosive power and hamstrings - lower back flexibility, can together predict the performance in the *Y Balance Test*. To the best of

Table 3 Significant multiple linear regression models obtained for dynamic postural balance

Variables	R^2	B Coefficient	*p*	CI95%	
Anterior direction (%)	0.551				
Gendera		-18.66	0.003	-30.16	-7.16
Body weight		-2.14	0.001	-3.22	-1.06
Stature		-2.12	0.001	-3.27	-0.97
Skinfold sum		-1.29	0.001	-1.92	-0.66
Adipose mass		-7.51	0.001	-11.24	-3.78
Sargent Jump		0.52	0.039	0.02	1.02
Posteromedial direction (%)	0.302				
Gendera		-15.74	0.010	-26.14	-5.33
Skinfold sum		-0.17	0.041	-0.41	-0.06
Adipose mass		-2.11	0.021	-3.95	-0.2
Posterolateral direction (%)	0.552				
BMI		-5.84	0.011	-10.21	-1.47
Skinfold sum		-1.30	0.006	-2.19	-0.40
Adipose mass		-7.01	0.005	-11.68	-2.35
Mesomorph		9.60	0.012	2.28	16.93
Ectomorph		-9.48	0.024	-17.58	-1.38
Sit and reach		0.49	0.016	0.10	0.89

BMI: body mass index; CI95%: 95% confidence interval; ºGender: female=0; male = 1

knowledge, this is the first study to consider predictive dynamic postural balance models based on anthropometric and physical fitness variables.

A prior study demonstrated that surfers had a positive correlation between competition level and a mesomorph body type, while a negative correlation was reported between an endomorph body type, skinfold sum and fat percentage[10]. This could be related to the findings of our study, whereby those surfers who demonstrated greater ability in the *Y Balance Test* were observed to be more mesomorph and less endomorph. Another investigation reported that surfers with a higher competitive rank had a greater vertical jump ability[24], which is similar to our findings in which those surfers who had a greater postural balance in the anterior direction of the *Y Balance Test*, achieved a better performance in the vertical jump test evaluated.

For the general population, it has been reported that individuals with greater adiposity are associated with a lower dynamic postural balance performance[25]. The findings observed in this study indicate that the anthropometric variables for adiposity have a direct impact on the lower dynamic postural balance of surfers. It has been suggested that fat tissue accumulation around and in the muscle could alter the normal motor response mechanisms due to physiological and neuromuscular changes[26]. The accumulation of fat would increase the expression of proinflammatory cytokines in the muscle, which could reduce the electrochemical balance and neural conductance in the muscle fibre[27]. These changes in the muscle fibre would create an alteration in the action potential conduction velocity, giving slower muscle responses[26,27]. Likewise, it has been seen that individuals with higher body fat show alterations in the muscle activation patterns for anticipatory and compensatory responses alike[28]. This would affect the muscle response due to lower neuromuscular efficiency in motor unit recruitment.

In this study, the physical fitness tests were also a determining factor in the dynamic postural balance of the surfers, where the flexibility and explosive force of the lower limbs were predictor variables of the performance achieved in the *Y Balance Test*. It has been contended that optimum flexibility helps achieve an adequate dynamic postural balance[29]. A reduction in flexibility would provoke changes in musculotendinous stiffness and in the stretch reflex sensitivity[29]. It has been seen that constant flexibility stimulation, primarily in the hip, knee and ankle, would activate the mechanoreceptors located in the viscoelastic tissue of the joints, generating a desensitization process, which would contribute to the better controlof the stretch reflex according to the different postural oscillations[29]. For its part, the explosive force of the lower body was considered to be key to the execution of the principal and progressive manoeuvres in surfing competitions[24]. The lower limbs are ultimately responsible for mounting the surfboard and for performing the manoeuvres through foot contact with the board[24]. A number of studies have demonstrated that elite surfers have a greater explosive force in their lower body compared to surfers of a lower competition level[30,31]. The foregoing could explain the better performance of surfers with a greater flexibility and explosive force in the lower body.

This study revealed that women surfers have a greater dynamic postural balance than men in all directions of the *Y Balance Test*. Prior studies show that women athletes have a greater postural balance compared to men in the SEBT, primarily in the anterior direction[32]. Moreover, it has been suggested that women have greater flexibility than men, which could have an influence on the dynamic postural balance results, due to the fact that they may exhibit less joint stiffness[29]. The lack of flexibility would lead to an alteration in the muscle activation patterns[33], affecting the motor performance in general. It has been established that the ideal reach pattern in the anterior direction of the *Y Balance Test* involves the maximum flexion of the knee and hip[34], therefore the flexibility of the lower body plays a key part in achieiving optimal performance. It has been shown that the electromyographic activity of the vastus medialis oblique muscle and the vastus lateralis muscle for the limb evaluated in the *Y Balance Test* is greater in women in the anterior direction compared to the other directions, which is in keeping with the greater flexion of the knee and hip achieved by women in this test[34]. Women may possibly make more efficient use of the musculature, permitting better performance in the sagittal plane.

The study limitations include the small sample size, the non-probability selection of participants, the broad age range of the subjects and the lower percentage of women than men assessed in the investigation. This could limit the external validity of the study. Future investigations could consider evaluations on the shortening of muscles and joint ranges, as this could complement our results. Likewise, further investigations could include evaluations of the upper body strength given that surfers constantly use this part of the body when paddling.

Conclusions

In conclusion, this study has served to determine that certain variables relating to the anthropometric profile and physical fitness exert an influence on the dynamic postural balance performance of surfers. Furthermore, gender, skinfold sum, adipose mass, mesomorph body type, ectomorph body type, explosive power of the lower body and hamstring-lower back flexibility are all dynamic balance predicting factors in the sample studied. This initial data suggests that it could be possible to predict the dynamic balance of surfers based on physical fitness and anthropometric parameters, primarily related to adiposity.

Conflict of interests

The authors have no conflict of interest at all.

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Adherence to the Mediterranean diet, is there any relationship with main indices of central fat in adolescent competitive swimmers?

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Summary

Introduction: The relationship between adherence to the mediterranean diet and central fat of adolescent competitive swimmers is under-studied. The fat component is interesting because of its relationship to the horizontal floatation and speed during the swimming performance. An accumulation of central fat is considered a negative factor for health and performance. This study aimed to check the degree of adherence to the mediterranean diet and its relationship with some indices of central fat in competitive adolescent swimmers.
Material and method: A cross-sectional descriptive study was carried out. 74 adolescent swimmers participated in the study (males n= 34, 14.5 ± 1.3 y.o., females n= 40, 13.6 ± 1.2 y.o.). The swimmers completed the KIDMED questionnaire to assess their adherence to the mediterranean diet. A II level ISAK anthropometrist carried out the anthropometric data collection at the beginning of the evening swimming session.
Results: The swimmers showed a medium adherence to the mediterranean diet. Male and female swimmers showed similar KIDMED index score (males 8.09 ± 1.5, females 7.23 ± 2.2). Age seems to be a detrimental factor in the adherence to the mediterranean diet during adolescence. Female swimmers showed a significant lower waist/hip ratio compared to males (-0.028; p = 0.01). The adherence to the mediterranean diet was not correlated with the anthropometric measures of central fat.
Conclusions: Regardless of the adherence to the mediterranean diet, elevated swimming activity maintains indices of central fat in healthy values. Despite there was no correlation between adherence to the mediterranean diet and the anthropometric measures of central fat, there are reasons related to health to improve healthy eating habits of adolescent competitive swimmers.

Key words:
KIDMED. Body composition. Swimming. Central adiposity. Young athletes.

¿Existe una relación entre la adherencia a la dieta mediterránea y los principales índices de grasa central en nadadores adolescentes de competición?

Resumen

Introducción: La relación entre la adherencia a la dieta mediterránea y la grasa central en nadadores adolescentes está poco estudiada. La grasa es un componente interesante en natación debido a su relación con la flotabilidad horizontal y la velocidad de nado. Una acumulación de grasa a nivel abdominal se considera un factor negativo para la salud y el rendimiento deportivo. El objetivo de este estudio fue valorar el grado de adherencia a la dieta mediterránea y su relación con los principales índices de grasa central en nadadores adolescentes de competición.
Material y método: Se llevó a cabo un estudio descriptivo transversal. 74 nadadores adolescentes participaron al estudio (chicos n= 34, 14,5 ± 1,3 años, chicas n= 40, 13,6 ± 1,2 años). Se valoró la adherencia a la dieta mediterránea de los nadadores a través del cues-tionario KIDMED. Los nadadores fueron medidos antes de una sesión de entrenamiento vespertina. Los nadadores mostraron una adherencia moderada a la dieta mediterránea.
Resultados: Chicos y chicas mostraron puntuaciones similares (chicos 8,09 ± 1,5, chicas 7,23 ± 2,2). Durante la adolescencia, a mayor edad parece empeorar la adherencia a la dieta mediterránea. Las chicas mostraron un índice cintura-cadera más bajo en comparación con los hombres (-0,028; p = 0,01). No se encontró asociación entre la adherencia a la dieta mediterránea y los principales índices de grasa central.
Conclusiones: Independientemente del grado de adherencia a la dieta mediterránea, la elevada actividad natatoria mantiene los índices de grasa central en valores saludables en los nadadores adolescentes de competición. A pesar de que no encontramos asociación entre las medidas de grasa central y la adherencia a la dieta mediterránea, existen razones de salud para implementar habitos alimenticios saludables en nadadores adolescentes de competición.

Palabras clave:
KIDMED. Composición corporal. Natación. Adiposidad central. Jóvenes deportistas.

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Introduction

Diet has an important role in the health, growth, performance, and recovery of swimmers. An imbalanced diet have been described in young swimmers[1–3]. The Mediterranean Diet (MD) has long been reported to have a large number of benefits such as the prevention of non-communicable diseases[4], a lower risk of mortality[5], and a lower incidence of many types of cancers[6]. It could reduce central obesity and the associated chronic disease risks[7]. The MD is considered a healthy diet, and it is in line with general recommendations on nutrition for athletic performance. A recent review has provided data on the association between adherence to the MD and body composition[8]. However, in adolescents, there is still an unclear correlation between adherence to the MD, physical activity, and body composition[9–11]. Altough, the MD can be considered one of the best studied dietary pattern in the world, the data on adolescent athletes and adherence to the MD is sparse[9,12].

The swimmers have some "typical" anthropometric characteristics. They have long limbs and their musculoskeletal components are important in sport performance. In particular, the fat component is a paradoxical component in swimming, because of its relationship to the floatation and speed during the performance[13]. Previous studies have shown that the swimmers could accumulate central fat during short break from swimming activity[14,15]. Accumulation of central fat is an important risk factor in the development of insulin resistance, diabetes, metabolic syndrome, and cardiovascular diseases[16,17]. Anthropometric measures of central fat has been proposed as a great additional criteria for monitoring overweight and obesity[18–20]. Moreover, anthropometric measures of central fat maybe a reliable method to monitor early changes in body fat mass in adolescent swimmers[14].

There is little data on adherence to the MD and adolescent swimmers[21]. In our knowledge, there is no studies linking the MD and anthropometric measures of central fat in adolescent competitive swimmers. The purposes of this study were: to assess the degree of adherence to the MD and its relationship with some anthropometric indices of central fat in competitive adolescent swimmers.

Material and method

Participants

A cross-sectional descriptive study was carried out. We selected 74 competitive adolescent swimmers aged between 11 and 16 y.o. from four local swimming clubs. We included swimmers with a minimum of three years of sport experience. The study was carried out in March 2017, 3 weeks after the main national and regional championships. The swimmers are semiprofessional and they usually have five or six swimming sessions per week. Normally in each session, the swimmers swam between 90 and 120 minutes (min) and covered a minimum of 3.000 meters (m). All swimmers participated voluntarily in the study and their legal guardian signed a written informed consent. The ethics committee of the University of Alicante granted ethical approval, according to the Declaration of Helsinki.

Experimental design

To assess the adherence to the MD, the swimmers completed the KIDMED questionnaire. The KIDMED questionnaire was developed by Serra-Majem *et al.*[22] and revised to its Spanish version[23]. The questionnaires were provided to each participant by one or more researchers and the guidelines were explained to all participants to ensure that the questionnaire was completed appropriately. The KIDMED questionnaire is composed of sixteen questions, of which, four affirmative questions have been assigned with a negative score of -1. While the rest have been assigned with a positive sign of +1. The results of the KIDMED questionnaire were classified, according to the KIDMED authors, into three levels: 8-12 (high) optimal Mediterranean diet; 4–7 (medium) improvement needed to adjust intake to Mediterranean patterns; 0-3 (poor) very low diet quality[22,23]. Anthropometric data collection was carried out at the beginning of the afternoon swimming session. Participants were only wearing a swimsuit during anthropometric data collection. A II level anthropometrist accredited by the *International Society for the Advancement of Kinanthropometry* (ISAK) collected the measures according to the ISAK standards[24]. The height, waist, and hip circumference was measured with a standard flexible metallic measuring tape. Body mass was recorded using an electronic scale (Tanita BH 420MA, Tanita Corporation, Japan). Body mass index (BMI) was determined using standard equations: BMI=[body mass (kg)/ height^2 (m)]. The waist/hip ratio (WHipr) was calculated as waist circumference divided by hip circumference and the waist/height ratio (WHeir) was calculated as waist circumference divided by height. To avoid subjective error, all measurements were assessed twice, and the relative mean values were used. In case of a discrepancy from 5% to 10% between the two measurements, a third was taken.

Data analysis

Data were grouped according to sex and age group. A group included younger swimmers (aged 11 - 13 years) and the other included older swimmers (aged 14 -16 years) according to the youth swimming categories of the Royal Spanish Swimming Federation. All data are presented as mean with standard deviation (SD) and confidence intervals were calculated (95% CI). Each question of the KIDMED questionnaire was analyzed by age and sex, and the ORs and the combinations of them were calculated. Statistical analyses were performed using logistic regression adjusting for sex and age. For the latter analysis, the younger males group was the baseline. To assess the adherence to the MD a linear regression analysis was performed. A t-test was applied for differences between sexes and ages. Statistical analyses were performed using Statistical Package for the Social Sciences 18.0 software for Windows (IBM SPSS Software, Armonk, NY, USA) with statistical significance set at $p \leq 0.05$.

Results

Adherence to the MD

The swimmers showed medium adherence to the MD. The mean KIDMED score was 7.62 ± 1.86. 2 swimmers (2.7%) showed a poor index

score with a very low-quality diet, 30 swimmers (40.5%) showed medium adherence to the MD. 42 swimmers (56.8%) showed high adherence to the MD with an optimal diet. Male and female swimmers have similar KIDMED index scores. Male swimmers showed slightly higher adherence to the MD than females, although the difference did not reach statistical significance (males 8.09 ± 1.5 CI vs females 7.23 ± 2.2; p = 0.059). When sex and age statistical analysis was combined it showed that the older male swimmers (14–16 age group) have a higher index score of adherence to the MD than older female swimmers (p = 0.04). The older females of the 14-16 age group showed the worst adherence to the MD than the rest of the swimmers (p = 0.04) (Table 1). The overall results of all the questions of the KIDMED questionnaire are shown in Table 2. The majority of the swimmers consume a piece of fruit or fruit juice every day. It was revealed that only half of the swimmers consumed the second fruit daily. A small percentage of the swimmers usually go more than once a week to a fast-food (hamburger) restaurant. Male swimmers consumed more legumes per week than the female ones (question n. 7 p < 0.05). The female swimmers of the 14 - 16 age group consumed fewer legumes than the ones of the 11 - 13 age group (question n. 7 p < 0.05). There were five females of the 14 - 16 age group who usually skip breakfast (question n. 12), there were no males. Olive oil is a food usually consumed at the swimmer's home (question n. 11). The intake of cereals or grain products (question n. 9) and dairy products (question n. 13) during the breakfast were high among the adolescent swimmers. They did not consume daily sweets and candy (question n. 16) (Table 2).

Measurements of the central fat

The physical and anthropometric characteristics of the competitive adolescent swimmers are shown in Table 3. All the anthropometric measurements were within the normal range for these ages[25,26]. The swimmers showed healthy anthropometric values of central fat[20,27]. As expected there were differences in body mass and height between sexes, although BMI values were not. There also were differences in waist circumference between sexes, although there were not in hip.

There were differences in WHipr between sexes. Whereas the female swimmers showed a significant lower WHipr compared to males (-0.028; CI 95%: -0.05, -0.01; p = 0.01). There was no correlation between WHipr and age or KIDMED score. There was no correlation between WHeir or BMI and sex, age or KIDMED score.

Table 1. Scores of the KIDMED questionnaire. Linear regression by age, sex and age x sex.

	Mean (SD) (IC95%)	Age Coef. (Sig.) CI 95%	Sex Coef. (Sig.) CI 95%	Age x Sex Coef. (Sig.) CI 95%
Scores	7.6 ± 1.9 (7.2,8.1)	0.16 (0.78) (-0.98,1.38)	0.20 (0.74) (-0.98,1.30)	-1.1 (0.04*) (-2.1,-0.1)

Coef. Value of the linear regression. Sig. Significance. 95%CI: 95% Confidence interval, Baseline: Males between 11-13 years old; * P < 0.05.

Table 2. Overall results of the KIDMED Questionnaire.

Questions	No (%)	Yes (%)	OR_A (CI95%)	OR_S (CI95%)	$AOR_{A\|S}$(CI95%)	$AOR_{S\|A}$ (CI95%)	AOR_{SxA}(CI95%)
1	11 (14.9%)	63 (85.1%)	0.7 (0.2-2.5)	0.4 (0.1-1.6)	0.4 (0.9-5.1)	0.7 (0.1-9.7)	0.6 (0.0-13)
2	32 (43.2%)	42 (56.8%)	0.7 (0.3-1.9)	0.4 (0.2-1.1)	1.6 (0.4-6.8)	0.9 (0.2-3.9)	0.3 (0.1-0.9)*
3	24 (32.4%)	50 (67.6%)	0.6 (0.2-1.7)	1.3 (0.5-3.4)	1.3 (0.2-6.3)	0.7 (0.2-3.1)	0.8 (0.1-6.3)
4	48 (64.9%)	26 (35.1%)	0.7 (0.3-1.8)	1.2 (0.5-3.3)	1.8 (0.4-8.0)	1.1 (0.2-4.9)	0.4 (0.1-3.3)
5	21 (28.4%)	53 (71.6%)	0.9 (0.3-2.5)	1.4 (0.5-3.9)	0.7 (0.1-3.5)	0.4 (0.1-2.3)	3.5 (0.4-29.7)
6	67 (90.5%)	7 (9.5%)	1.1 (0.2-5.2)	0.6 (0.1-2.9)	1.3 (0.1-6.4)	2.0 (0.2-21.5)	0.2 (0.0-7.3)
7	21 (28.4%)	53 (71.6%)	0.9 (0.3-2.5)	0.2 (0.1-0.8)*	0.8 (0.1-9.7)	0.3 (0.1-0.8)*	0.7 (0.3-13.0)
8	36 (49.3%)	37 (50.3%)	0.5 (0.2-1.4)	1.0 (0.4-2.6)	0.8 (0.2-3.6)	0.5 (0.1-1.9)	1.2 (0.2-8.5)
9	15 (20.3%)	59 (79.7%)	1.5 (0.5-4.8)	0.5 (0.1-1.7)	0.9 (0.2-4.6)	2.8 (0.4-2.9)	0.3 (0.0-3.9)
10	23 (31.9%)	49 (68.1%)	0.7 (0.2-2.0)	0.8 (0.3-2.2)	0.6 (0.1-3.2)	0.6 (0.1-2.9)	1.3 (0.2-10.5)
11	1 (1.4%)	73 (98.6%)	❶	❶	❶	❶	❶
12	69 (93.2%)	5(6.8%)	1.2 (0.2-7.8)	❶	❶	❶	❶
13	4 (5.4%)	70 (94.6%)	0.4 (0.4-4.0)	0.4 (0.4-3.8)	❶	❶	❶
14	44 (59.4%)	30 (40.5%)	0.7 (0.2-1.8)	1.2 (0.5-3.0)	0.9 (0.2-3.9)	0.5 (0.1-2.4)	1.4 (0.2-9.2)
15	38 (51.4%)	36 (48.6%)	2.5 (1.0-6.3)	0.6 (0.2-1.5)	2.7 (0.6-13)	10.7 (2-54.7)	0.1 (0.0-0.6)
16	69 (93.2%)	5 (6.8%)	3.4 (0.4-32.5)	0.5 (0.8-3.5)	❶	❶	❶

Notes: Each question was identified by a number of the question in the same order of the questionnaire. ORA: Odds Ratio for Age, ORS: Odds Ratio for Sex, AORA|S: Odds Ratio for age-adjusted by sex. AORS|A: Odds Ratio for sex-adjusted by Age. AORSxA: Odds Ratio with the interaction between sex and age. Sig.: Signification. ❶ There are not enough data, did not calculate the OR and AOR. Baseline: Males between 11-13 years old; * P < 0.05.

Table 3. Physical and anthropometric characteristics of the adolescent swimmers.

	Males n = 34	Females n = 40	p-value
Age (y.o.)	14.5 ± 1.3	13.6 ± 1.2	0.03
Height (cm)	167.3 ± 9.5	158.4 ± 5.1	< 0.01
Waist circumference (cm)	69.1 ± 5.3	65.7 ± 5.9	0.01
Hip circumference (cm)	86.6 ± 6.5	85.5 ± 7.7	0.50
Body Mass (kg)	56.5 ± 9.8	50.2 ± 8.1	< 0.01
Whipr	0.80 ± 0.04	0.77 ± 0.05	0.01
Wheir	0.41 ± 0.03	0.41 ± 0.03	0.87
BMI	20.06 ± 2.5	20 ± 2.8	0.93

Values are expressed as mean ± Standard Deviation; WHipr: Waist/Hip ratio, WHeir: Waist/Height ratio, BMI: body mass index.

Discussion

The KIDMED scores of the swimmers were not correlated with the anthropometric measurements of central fat. Greater adherence to a Mediterranean diet should lead to a lower total and central fat in children and adolescents[8,28]. Regardless of the degree of adherence to the MD, a high level of swimming would disguise the possible effects of an unhealthy or imbalanced diet. Based on our results, the adherence to the MD worsens with age. An explanation could be that older adolescents have some money to spend on food and entertainment without any parental control. The adolescent swimmers spend many hours out of the home to go to and back from the swimming training and they usually share "food time" after the swimming session. The possibility of adolescents to spend money on food out of the home does not lead to a healthy diet[29], and it could increase bad eating habits with higher intake of ultra-processed food[30] and sweet beverages[31]. Previous data regarding sex and adherence to the MD in adolescents are unclear[32,33]. Our results showed that the female swimmers had a lower adherence to the MD than males ones. Moreover, it was observed that female swimmers had lower nutritional knowledge than male ones[34]. We have reported that the girls consumed less fruit and legumes and there were only females who usually skip breakfast. Several studies have shown that women, especially adolescent ones, have a higher prevalence of eating disorders than men[35,36]. Although swimming is not considered a high-risk sport regarding eating disorders, greater attention should be given to the nutritional behavior of the swimmers, especially female ones. Almost all the swimmers consumed a piece of fruit or fruit juice daily. We have expressed some concerns about the inclusion of fruit juice in the KIDMED questionnaire[37]. The repeated inclusion of fruit juice in the diet may have negative effects[31,38]. The percentage of intake of the second piece of fruit in the second answer was lower than the percentage recorded for the first one (see Table 1). Thus, the high percentage recorded of daily intake of fruit in the first answer could be a false "cognate" biased by fruit juice intake. The number of adolescent swimmers that consumed the second piece of fruit daily is alarming. We could deduce that few swimmers consume the recommended servings of fruit per day. The current dietary guidelines have been advocating for an increase of fruit intake instead of fruit juice[39]. An increase of fruit intake in adolescent swimmers is strongly advisable. A possible alternative to improve the fruit intake and to substitute the fruit juice could be fruit smoothie intake. The fruit smoothie is well accepted by adolescents and it supplies water, fat, dietary fibre, vitamins, and antioxidants.

The coaches reported to us that there is no nutrition education at swimming clubs. Nutritional education appears to be an effective resource to improve Mediterranean nutritional habits in adolescent swimmers[21]. Targets for such education should not be limited to swimmers but also include families, schools, and coaches. Several studies have shown that the coaches had inadequate sport nutritional knowledge[40]. Furthermore, they often provide nutritional advice to their athletes, even though they are not competent to do so[41].

Studies have reported an unclear correlation between adherence to the MD, physical activity, and BMI values[8,10,12,42]. Some studies have used the body mass index (BMI) to monitor fat component[43,44]. Although the male and female swimmers showed differences in height and body mass, they had similar healthy BMI. Some studies have suggested that male and female swimmers could have the same BMI with different proportions of lean mass and fat mass[45,46]. However, the results did not show any correlation between BMI and the adherence to the MD. We have some concerns about BMI, mainly because it does not provide any information about the distribution of body fat. The addition of measures of central fat to BMI should be considered as greater criteria for monitoring overweight and obesity[18–20]. In the present study, all swimmers were semi-professional and they had a minimum of three years of sport experience. Many of them have been swimming since childhood. The results showed that the high level of swimming since childhood maintains weight and the BMI of both sexes in a healthy range.

The relationship between adherence to the MD and waist circumferences is not clear[9,47]. Waist circumference could reflect total body fat and fat distribution in children and adolescents[20,48]. Accumulation of central fat is a negative factor in swimming because central fat increases the frontal surface of the body and increases the total drag force on a swimmer. In our study, the swimmers showed a low level of fatness and healthy values of waist circumference. To have low fatness indices with healthy waist circumference values could indicate a developed kick musculature, which is the key factor for high performance in swimming. However, some anthropometric measurements of central fat could be used as early predictive measurements to assess changes in body fat at least in young swimmers[14].

The female swimmers showed a significant lower WHipr than males. A low level of WHipr in women is correlated with a low risk of cardiovascular disease, diabetes, and hypertension[49].

Sedentary behaviors in adolescents commonly lead to overweight and obesity. Consistent with previous studies[50], our study has observed that all swimmers have healthy values in all anthropometric measurements and they did not show any accumulation of total or central fat. Thus, as expected an elevated level of swimming activity prevents the accumulation of total and central fat. Despite there was no correlation between adherence to the MD and the main indices of central fat, there are reasons related to health to im-prove healthy eating habits of adolescent swimmers.

Limitations of the study

The cross-sectional design of the current study has some limitations. The study is a "status study" and the results are a picture indicating what is being done. The conclusions could be used as valuable indications to be taken into account for future research. The size of the sample of the study is limited. However, to our knowledge, the number of participants is higher compare to other studies. The study did not measure the relationship between the degree of adherence to the MD and some anthropometric indices of central fat with the performance in competitive adolescent swimmers.

Conclusions

There was no correlation between adherence to the MD and the main indices of central fat in competitive adolescent swimmers. Regardless of the medium adherence to the MD, the elevated swimming activity had a protective role to prevent the accumulation of central fat.

Conflict of interests

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors. The authors have disclosed that they have no relationships with, or financial interest in, any commercial companies. Cesare Altavilla was a coach of 10 of the swimmers, who participated in the study.

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Professional attributions regarding health-related exercise from the Spanish Sports Medicine Society

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Summary

The regular practice of physical exercise is extraordinarily effective in the management of a growing number of chronic diseases, some of them with a prevalence of pandemic magnitude, for which the society must assume the incorporation of physical activity as a health strategy to prevent and to serve as a complementary treatment of the disease.

Not only medicine and physiotherapy play a fundamental role in the management of exercise for health but also, outside of health, Sports science and physical education degree is crucial in this field of work.

From a health point of view, medicine and physiotherapy have a primary role in the management of exercise for health and also, outside of health, sports science and physical education degree occupy a very prominent role in the promotion and implementation of strategies for the promotion of health.

These professions have been occupying a position in addressing this problem that, on some occasions, has led to points of friction with respect to their role, responsibilities and function. On the other hand, there is a need to resolve the question of the professions' areas of competence while maintaining the will to simultaneously recognize the growing areas of competence shared interprofessionally and the highly relevant areas specific to each profession.

This document is based on the need to address the incorporation of exercise in the prevention and management of disease in a solid and consistent way, considering the contribution of the professions involved from the perspective of multidisciplinary work and with a non-conflictual but cooperative, transparent and respectful collaboration. In addition, this collaboration should always aim at serving society in the most effective way possible, clearly defining the professional attributions of medicine, physiotherapy and physical activity and sport sciences in everything related to the use of exercise as a tool for health.

Key words:
Professional attribution. Exercise. Health. Chronic disease.

Atribuciones profesionales en el ejercicio para la salud de la Sociedad Española de Medicina del Deporte

Resumen

La práctica regular de ejercicio físico es extraordinariamente efectiva en el manejo de un número creciente de patologías crónicas algunas de ellas con una prevalencia de magnitud pandémica, por lo que la sociedad debe asumir la incorporación de la actividad física como estrategia de salud para prevenir y para servir como tratamiento complementario de la enfermedad.

La medicina y la fisioterapia tienen un papel primordial en el manejo del ejercicio para la salud y también, fuera de la sanidad, las titulaciones de ciencias de la actividad física y el deporte ocupan un papel muy destacado en este ámbito de trabajo.

Desde la sanidad, la medicina y la fisioterapia tienen un papel primordial en el manejo del ejercicio para la salud y también, fuera de la sanidad, las titulaciones de ciencias de la actividad física y el deporte ocupan un papel muy destacado en la promoción y ejecución de estrategias para el fomento de la salud.

Estas profesiones han venido ocupando una posición en el abordaje de este problema que, en algunas ocasiones, ha supuesto puntos de fricción respecto a su papel, responsabilidades y función. Por otra parte, existe la necesidad de resolver la cuestión de los ámbitos competenciales de las profesiones manteniendo la voluntad de reconocer simultáneamente los crecientes espacios competenciales compartidos interprofesionalmente y los muy relevantes espacios específicos de cada profesión.

Este documento parte de la necesidad de abordar la incorporación del ejercicio en la prevención y manejo de la enfermedad de una forma sólida y consistente, considerando la aportación de las profesiones implicadas desde la óptica del trabajo multidisciplinar y con una colaboración no conflictiva sino cooperativa, transparente y respetuosa y, siempre, con el objetivo de servir a la sociedad de la forma más efectiva posible, definiendo de una forma clara cuáles con las atribuciones profesionales de la medicina, de la fisioterapia y de las ciencias de la actividad física y el deporte en todo lo relacionado con la utilización del ejercicio como herramienta de salud.

Palabras clave:
Atribución profesional. Ejercicio. Salud. Enfermedad crónica.

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Introduction

Developed Western society has seen major transformations including discarding more physical jobs which, along with wide availability of often extremely calorific food, has led to a real sedentary lifestyle and obesity epidemic.

Spain's life expectancy is only surpassed by Japan, which increases the number of elderly and very elderly population significantly. One consequence of this state of affairs is a large increase in elderly pluripathology patients.

Medicine moves forwards by providing effective treatment for many pathologies that can be accessed by most of the population, but scientific progress doubtlessly also demonstrates that regular physical exercise, even at low intensity, is extraordinarily effective both to prevent and as a contributory factor to treat a growing number of chronic pathologies,[1] some of which have a pandemic-sized prevalence. This problem is so large that the Council of the European Union advised "working on effective policies across sectors such as sport, health, education, the environment and transport".[2]

In Spain, promoted by the Sports Council, a *Comprehensive Plan for Physical Activity and Sport*[3] is in force during the 2010-2020 period. There is no doubt that society as a whole must incorporate physical exercise as a health strategy to prevent and to act as a complementary treatment to illness.

From the health sector, medicine and physiotherapy take a primordial role in handling health-related exercise and also outside the health sector, sports scientists play an outstanding role in promoting and performing forms of active living as health-enhancing strategies.

These professions have been addressing this problem in a way that might occasionally cause friction regarding their role, responsibilities and function.

On the other hand, the question of each profession's competence fields should be resolved, in an attempt to simultaneously recognise growing competence areas shared between professions and the highly relevant specific areas for each profession[4].

This document works from the need to address incorporating exercise into prevention and handling of the disease both solidly and consistently, considering the contribution made by the professions involved from the perspective of multidisciplinary work and with cooperative, transparent and respectful, rather than conflictive, collaboration in an attempt to be used as effectively as possible by society, clearly defining the professional attributions of medicine, physiotherapy and sports sciences in terms of using exercise as a health tool.

Definitions

Addressing any subject requires accurately determining all concepts within it as it affects the entire development of the topic. In the case of health-enhancing exercise, it is essential to define all concepts accurately to avoid incorrect interpretations, inappropriate presumptions and to be able to talk about all the aspects clearly, avoiding misunderstandings, conflicts and disagreements.

The concepts of interest are described below in the context of performing physical exercise for health purposes.

Definitions related to physical activity/exercise

- Physical activity. Any form of bodily movement caused by contracting muscles that causes a substantial increase in energy use over a resting situation[5].
- Aptitude, condition or physical form. Set of physical qualities that allow physical activity to be performed, related to physical performance and to health, and that can be measured by specific tests.[5] Physical aptitude components include stamina, strength, speed, flexibility, balance, coordination and agility.
- Physical exercise. Type of physical exercise that consists of carrying out planned, structured and repetitive bodily movements, done to improve or maintain one or more components of the aptitude or physical condition[5].
- Therapeutic exercise. Conceptually, this is a physical activity intended to promote, prevent or treat various diseases, disorders or syndromes. In a wider sense, therapeutic exercise is understood to be the systematic, planned performance of bodily movements, postures and physical activities so that the subject has the means to correct or prevent disturbances, to improve, re-establish or strengthen physical functioning, to prevent or reduce health risk factors or to optimise the general state of health, physical conditioning or the feeling of well-being[6].
- Sport. "Sport" is understood to be all types of physical activities that, by means of participation, organised or otherwise, have the purpose of expressing or improving physical and mental condition, developing social relations or achieving results in competitions at all levels. (European Sports Charter; Rodas 1997. Reviewed in 2001).

Within the many types of sports (competitive, leisure, school, university, by age, etc.), there is what is known as health-enhancing sport, performed with the fundamental aim of maintaining or improving health.

Definitions related to health/healthcare

- *Patient*. Person who is sick or in treatment[7].
- *Healthy*. In good health. Not sick[7].
- *Diagnosis*. Area of medicine that aims to identify a disease based on its symptoms[7].
- *Physiotherapy assessment or evaluation*. This is the result of a clinical reasoning process that leads to identifying existing or potential impediments, limitations in activities and restrictions in participation and factors that influence bodily functions positively or negatively. The physiotherapy assessment or evaluation addresses the signs and symptoms commonly associated with a disorder, syndrome or

category of deficiencies in the structures and functions of the body, limitations of the activity or restrictions in participation.

- *Prescription or Formula*. A note that the doctor writes indicating how to prepare and administer a remedy. It comprises three parts: inscription, that contains the names and doses of the ingredients; subscription or method of *preparation*, and *instruction*, which tells the patient how to use it. A Spanish prescription usually begins with the letter R (Receta in Spanish) and is signed by the doctor[7].
- *Functional assessment*. The functional assessment consists of measuring and objectively evaluating the functional capacities of a subject to carry out a sport-related or motor task. It requires registering and measuring (quantification) one or more physiological or physical variables (indicators) when the subject carries out one or more particular motor tasks (functional tests) and issuing an objective value judgement for a functional capacity[8].
- *Treatment*. Set of all types of hygienic, pharmacological and surgical resources that are implemented to heal or relieve diseases[7].
- *Healthcare activity*. Set of actions to promote, prevent, diagnose, treat or rehabilitate, aiming to encourage, restore or improve the health of people, carried out by healthcare professionals[9].
- *Healthcare authorisation*. Administrative ruling that, according to the set requirements, authorises a centre, service or healthcare establishment to set up, operate or modify its healthcare activities or, when appropriate, close them[8].
- *Health centre*. Organised set of technical resources and installations where skilled professionals, thanks to their official qualification or professional entitlement, basically carry out healthcare activities for the purposes of improving people's health. Health centres can be made up of one or several health services, that constitute its care offer[9].

Exercise

Understanding exercise conceptually as the type of physical exercise that is planned, structured and repetitive and that aims to improve or maintain physical form, it seems clear that some forms of exercise have considerable influence over the health of the human organism.

Exercise carried out for leisure, entertainment, domestic, transport, educational, sporting purposes and even some forms of work-related exercise have beneficial effects on a person's health. However, exercise is also specifically used as a form of treating various diseases, disorders and pathologies.

In this health context, we can talk about exercise carried out for preventive purposes and exercise carried out as treatment, also known as therapeutic exercise.

Therapeutic exercise is understood as defined above, and preventive exercise is exercise that has a positive effect on health but that is not performed as therapy.

Therapeutic exercise is performed exclusively by healthcare professionals in a healthcare context, as determined by the standard in force.[9]

It cannot be called therapeutic exercise if the following defining elements are not met:

- *Diagnosis*. Unavoidable first step to consider and initiate a therapeutic exercise programme.
- *Functional assessment*. Before starting the therapeutic exercise programme, an evaluation should be run on the function or functions that are going to be treated, using the procedures set by the doctor in order to find out about the patient's functional situation and so that it can be used as an evaluation criterion for how treatment is evolving.
- *Prescription*. This is the formula for the exercise, just as given for medicines, and it should contain all the necessary elements to perform the exercise programme: type of exercise, intensity, duration, number of repetitions and series, frequency, rest periods, progression criteria, evolution, etc.

  The prescription should be made after considering any contraindications and precautions for the therapeutic exercise, adapted to each patient. It must obey an indication devised according to the scientific and clinical evidence and must form part of the patient's overall treatment.

  The therapeutic exercise programme, intended to improve one or some of the physical aptitude components, must be prescribed considering the pathology, the medical treatment and other treatments, functional situation, socio-economic aspects and patient preference so that the programme can be kept up without dropping out because the right exercise programme will lead to regular participation, enjoyment and safety for the programme participants[10].

The periodic evaluation of the response to the therapeutic exercise programme is an essential part of the prescription and the actual programme, so the professional in charge of the subject must consult the doctor in the following circumstances:

- Goals set at the start have not been achieved.
- Symptoms or signs of excessive effort appear.
- Inappropriate responses to physical exercise appear.
- The person rejects the programme.

Spanish legal framework

It is not necessary to consult any legal texts to know that it is the role of Medicine, Physiotherapy and other healthcare professions and, more indirectly, other professions, to preserve others' health, both people who are suffering from some type of pathology and people who are not, which corresponds to treatment and prevention of disease.

The Spanish Constitution recognises the right to health protection in article 4311 and from this point, several Spanish laws develop various health protection strategies, defining health protection as "the set of actions, provisions and services intended to prevent adverse effects that products, elements and processes from the environment, physical, chemical and biological agents, might have on the health and well-being of the population"[12].

In general, all the laws consider a sedentary lifestyle to be a factor to fight by promoting physical activity[12] both from the actual public administration and from social organisations[12].

Provision of any health service is subject to strict regulation to ensure required safety and quality guarantees that society must be offered, therefore, prior administrative authorisation is required to set it up and operate it, as well as to make any modifications determined by its structure and initial regime[9].

The health centre, where healthcare events take place, including therapeutic exercise, must meet minimum operating requirements that must guarantee that the health centre, service or institute has the minimum technical resources, facilities and professionals required to develop its intended activities, clearly displaying an emblem that allows users to know what type of centre or institute this is and its authorisation, with its care offer. Only authorised healthcare centres, services and establishments will be able to use terms in their publicity, without being misleading, that suggest that any type of healthcare activity is carried out, limited to services and activities that it is authorised to provide[9].

On the other hand, patient rights are enormously important as a basic axis for clinical-care relations, so these rights should be mentioned whenever referring to the use of physical exercise for health purposes and as determined by the legislation in force[13].

Professional attributions of the doctor, physiotherapist and accredited sports scientist when performing health-enhancing exercise

The law governing healthcare professionals[4] determines the functions of the different healthcare professions.

Doctors

"Medicine graduates are given the indication and performance activities intended to promote and maintain health, prevention of diseases and the diagnosis, treatment, therapy and rehabilitation of patients, as well as the judgement and prognosis of the processes being considered."

Regarding exercise for health purposes, the specialist doctor (Medicine of Physical Education and Sport, Cardiology, Pulmonology, etc.) is trained to prescribe exercise for sedentary patients without need for referral. However, it is advisable that the doctor should identify collaborating professionals (physiotherapists and accredited sports scientists) to create work groups on health-enhancing exercise[14].

Physiotherapists

"People with a university diploma in Physiotherapy provide their discipline-related care, through treatments featuring resources and physical agents, focused on recovery and rehabilitation of persons with somatic dysfunctions or disabilities, and prevention of the above."

Graduates in Sports and Physical Activity Sciences

Although the professional work by graduates in Sports and Physical Activity Sciences and the future Sports Science degree is not regulated by any specific standard[15], these are professionals with the ability to "plan, run and assess processes and programmes of high quality physical activity-sport and sports training, in a wide range of contexts and situations, and for different population groups in a framework that allows their personal and social development and positively affects their health and quality of life, as well as their free time and leisure"[16].

Role of the professions involved

When describing the professional attributions related to exercising for health, it is advisable to remember some extremely important aspects from the Spanish healthcare professionals law4 that are mentioned below.

All healthcare professionals must take active part in projects that can benefit health and well-being of persons in health and illness situations, particularly in the field of preventing diseases and exchanging information with other professionals and with the health authorities, to better guarantee these purposes.

Professionals will be guided in their work by service to society, the interest and health of the citizens to whom the service is provided, rigorously meeting ethical obligations, determined by the actual professions in compliance with the legislation in force, and the normal-praxis criteria or, when appropriate, general uses corresponding to their profession.

Professionals and healthcare centre managers will make it easier for their patients to exercise their right to know the name, qualifications and speciality of the healthcare professionals who are caring for them, plus their category and function.

Comprehensive healthcare involves multidisciplinary cooperation, integrating processes and continuity of care, and it avoids hiving off or simply superimposing care processes covered by various certified persons or specialists.

A specialist qualification is official and valid throughout Spain and a specialist qualification is required to explicitly describe yourself as a specialist, to carry out the profession as such and to take specialised positions in public and private centres and institutes.

The concept and procedures for sports readaptation have not been sufficiently developed in the scientific literature. Injury readaptation has been defined as "the set of medical-therapeutic and physical-sporting measures intended to prevent risks of injury, recover and develop sporting health and improve or optimise the athlete's performance to give them a greater life in sport,"[17] with two functional fields for professional work.

Functional recovery, with a clinical action field.

Sports and physical readaptation, that belongs to a non-clinical area of action, whose main means of intervention involves re-training the physical effort once the pathological process has been overcome.

However, this definition has a conceptual contradiction, given that the prefix "re" implies that there was a phase prior to applying the readaptation programme and this should be understood as a process that

emerges as a consequence of a situation (injury or similar) appearing that requires work from the time of the injury and not before. To do this, it seems more correct to define it as "the set of medical-therapeutic measures intended to re-establish and develop sports-health and physical-sports measures intended to improve or optimise the athlete's performance to give them a greater sports life."

Field of influence for the document

In terms of performing exercise to maintain and improve health, various situations are presented below that might occur and the attributions of the professions involved are described, presenting a diagram of how the injury/pathology evolves in relation to physical exercise.

The graph schematically shows the most important points, where a pathological process requires actions to be taken, that imply exercise related to health (Figure 1).

It is clear that, once the diagnosis and the prescription have been made, the physiotherapist will begin the treatment (including therapeutic exercise) and this will extend to the point when the medical release form is signed. It is a well-known fact that medical discharge does not allow the person to go back to their usual physical activity and requires a period of adaptation. It is the physiotherapist's attribution to carry out the readaptation after medical discharge in the event that signs or symptoms of the pathology remain and this phase is called functional readaptation. If there are no clinical signs or symptoms after medical discharge, the sports readaptation period will begin, and this is attributed to the accredited sports scientist.

After sports discharge, the patient re-joins the activity/competition.

Situations of using exercise for health purposes

The usual situations are considered where physical exercise is carried out for health purposes, as summarised in Table 1.

Pathology of injury and locomotive system until medical discharge

In the cases considered in this section, there is the diagnosis and functional assessment and the recommendation for treatment (attribution and responsibility of the doctor) and performing the treatment that might include therapeutic exercise (corresponding to the physiotherapist). The accredited sports scientist plays no part.

Pathology of injury and locomotive system after medical discharge

Once the doctor gives the medical discharge, the doctor must check over the patient again in the case of relapse or that their condition deteriorates. At this point, two situations may occur. Firstly, that the patient still shows clinical symptoms or signs of their pathology, such as pain, swelling, rigidity, disturbed balance or coordination, clear muscular atrophy, etc. Or they have no clinical signs or symptoms. In the former case, the physiotherapist will continue the prescribed treatment and therapeutic exercise for functional readaptation purposes. In the latter case, the accredited sports scientist will perform readaptation on the sport-related movement.

Non-determined chronic medical pathology

The doctor makes the diagnosis and functional assessment and prescribes the treatment. The physiotherapist carries out the prescribed treatment that might include therapeutic exercise and the accredited sports scientist plays no part.

Determined chronic medical pathology

The doctor checks over the patient again in the case of relapse or deterioration of their condition. The physiotherapist carries out the

Figure 1. Actions related to performing exercise after an injury.

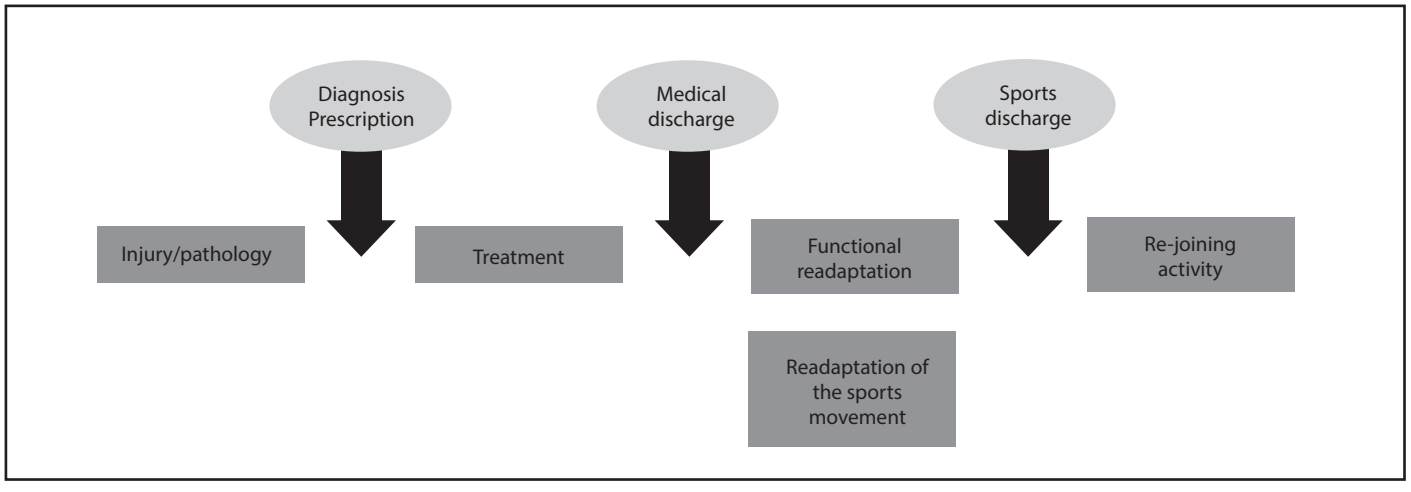

Table 1. Professional attributions in all suppositions.

Type of situation	Attribution of the Doctor	Attribution of the Physiotherapist	Attribution of the Accredited Sports Scientist
Pathology of injury and locomotive system until medical discharge	– Diagnosis – Functional assessment – Treatment	– Prescribed treatment – Therapeutic exercise	– No functions
Pathology of injury and locomotive system after medical discharge	– Check-up if relapse or poor evolution	– Prescribed treatment – Therapeutic exercise - Functional readaptation (with symptoms/signs)	– Readaptation of the sport-related movement (no signs/symptoms)
Non-determined chronic medical pathology	– Diagnosis – Functional assessment – Treatment	– Prescribed treatment – Therapeutic exercise	– No functions
Determined chronic medical pathology	– Check-up if relapse or poor evolution	– Prescribed treatment – Therapeutic exercise	– Exercise for maintenance and prevention
Healthy	– Diagnosis – Functional assessment (prevention)	– Exercise for prevention	– Exercise for maintenance and prevention
Pregnancy, puerperium and the elderly (healthy)	– Diagnosis – Functional assessment (prevention)	– Exercise for prevention	– Exercise for maintenance and prevention
Disability	– Diagnosis – Functional assessment (prevention)	– Exercise for prevention	– Exercise for maintenance and prevention

prescribed treatment and the therapeutic exercise if it exists. The accredited sports scientist runs the exercise programme for maintenance and prevention.

Healthy persons

The doctor makes the diagnosis and functional assessment for preventive purposes. The physiotherapist can carry out preventive exercise and the accredited sports scientist can run the exercise programme for maintenance and prevention.

Pregnancy, puerperium and the elderly (healthy)

The doctor makes the diagnosis and functional assessment for preventive purposes. The physiotherapist can carry out preventive exercise and the accredited sports scientist can run the exercise programme for maintenance and prevention.

People with disabilities

The doctor makes the diagnosis and functional assessment for preventive purposes. The physiotherapist can carry out preventive exercise and the accredited sports scientist can run the exercise programme for maintenance and prevention.

Conflict of interests

The authors do not declare any conflict of interests.

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Optimum training programme during pregnancy to prevent gestational hypertension and preeclampsia: a systematic review

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Summary

Gestational hypertension and pre-eclampsia are hypertensive disorders which are the world's leading cause of maternal and perinatal mortality. Currently, evidences support the benefit of moderate physical exercise (PE) during uncomplicated pregnancies in the prevention of HTG and pre-eclampsia. However, there is no evidence on which kind of training is more effective for its prevention.

The aim of this study was to analyze which kind of exercise, duration of the intervention and session, frequency and intensity produce the greatest benefits in the prevention of gestational hypertension and pre-eclampsia in women with uncomplicated pregnancies.

An exhaustive search of PubMed and Web of Science was carried out until October 21, 2020. From 705 studies found, we analyzed 14 original full-text intervention articles in English or Spanish, with a PE program in pregnant women without complications, evaluating BP and including in their methodology, at least, frequency, duration, intensity, or kind of exercise.

Exercise training in healthy women with uncomplicated pregnancies reduces the incidence of HTG and preeclampsia. The program with most benefits is concurrent training combined with flexibility, with a minimum duration of 29 weeks, from the 8th-9th gestational week to 36, but can be extended until the end of pregnancy. It's recommended to get to a training frequency equal to or greater than 3 days a week, with sessions at 50-70% of the maximum heart rate and 10-14 on the Borg Scale, and a duration of 45 and 60 minutes per session.

Key words:
Pregnancy. Gestational hypertension. Pre-eclampsia. Exercise. Hypertension.

Programa de entrenamiento óptimo durante el embarazo en la prevención de la hipertensión gestacional y preeclampsia: una revisión sistemática

Resumen

La hipertensión gestacional (HTG) y preeclampsia son trastornos hipertensivos, y la principal causa mundial de mortalidad materna y perinatal. Actualmente, la evidencia avala el beneficio del ejercicio físico (EF) moderado durante embarazos sin complicaciones en la prevención de HTG y preeclampsia. Sin embargo, no existe evidencia sobre qué tipo de entrenamiento es más eficaz para su prevención.

El objetivo de este estudio es analizar qué tipo de ejercicio, duración de la intervención y sesión, frecuencia e intensidad producen mayores beneficios en la prevención de la HTG y preeclampsia en mujeres con embarazos sin complicaciones.

Se llevó a cabo una búsqueda exhaustiva en PubMed y Web of Science hasta el 21 de octubre de 2020. De 705 estudios encontrados, analizamos 14 artículos originales de intervención a texto completo en inglés o español, con un programa de EF en embarazadas sin complicaciones, que evaluaran la presión arterial e incluyeran en su metodología, al menos, frecuencia, duración, intensidad o tipo de ejercicio.

El entrenamiento en mujeres sanas con embarazos sin complicaciones reduce la incidencia de HTG y preeclampsia. El programa con más beneficios es el entrenamiento concurrente combinado con flexibilidad, con una duración mínima de 29 semanas, desde la 8ª-9ª semana gestacional hasta la 36, pudiendo extenderse hasta el final del embarazo. Se recomienda una frecuencia de entrenamiento igual o mayor a 3 días semanales, con sesiones al 50-70% de la frecuencia cardiaca máxima y 10-14 sobre 20 en la Escala de Borg, con una duración de 45 y 60 minutos por sesión.

Palabras clave:
Embarazo. Hipertensión gestacional. Pre-eclampsia. Ejercicio. Hipertensión.

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Introduction

The National Institute of Children's Health and Human Development (NICHD) defines pregnancy as the period when a fetus is developing in a woman's uterus[1]. This is a physiological process with a standard duration of 36-41 weeks, divided into 3 trimesters when anatomical, physiological, hormonal and emotional changes take place to allow adaptations that maintain the necessary maternal and fetal homoeostasis in a fast-changing medium[2-4].

Focussing on physiological changes at a vascular level, we can highlight an increase in blood flow volume, plus an accumulative retention of sodium[5-7]. However, arterial pressure (AP) tends to drop, mainly in the second trimester, principally due to the drop in periphery vascular resistance, associated with the action of nitric oxide, relaxin and progesterone on the muscles of the arterial wall[7,8]. From the start of the third trimester, average AP rises until it reaches pre-pregnancy values[8].

Arterial hypertension (AHT) is considered a risk factor for cardiovascular mortality, independently of any other[9]. This pathology presents modifiable risk factors, such as being overweight or obese, high cholesterol levels in the blood, consumption of alcohol and tobacco, and physical inactivity. Unmodifiable risk factors are genetic, being black and being male. Among women, the most likely period to suffer this pathology is after the menopause[10].

According to the American College of Obstetricians and Gynaecologists (ACOG), gestational hypertension (GHT) is defined as a resting systolic AP over 140 mmHg or diastolic AP of 90 mmHg after 20 weeks of gestation (or within 12 weeks of giving birth), without proteinuria (protein/creatinine quotient in urine ≥300 mg/g) or shut-down of vital organs[4]. It is usually transitory but it can become chronic and a precursor for preeclampsia or early stages of preeclampsia where proteinuria has yet to appear[11]. It is related to prenatal complications, including premature birth[12].

In turn, preeclampsia is a specific disease to human pregnancy, characterised by AHT and proteinuria after 20 weeks of gestation[13,14]. It is considered severe when the aforementioned symptoms are accompanied by signs that multiple organs are affected. In most cases, severe preeclampsia leads to miscarriage[11]. As for GHT, its aetiology is unknown, although some sources suggest dysfunction of vascular endothelial cells, which reduces the synthesis of vasodilators, leading to a vasospasm that will cause AHT[15,16]. In addition, their risk factors are similar, which might indicate similarities in the aetiology of the two conditions[17]. These risk factors are genetics, obesity, excessive weight gain during pregnancy, nulliparity, history of preeclampsia, diabetes, AHT and a sedentary lifestyle[16].

These hypertensive disorders are the main cause of maternal and perinatal mortality throughout the world[22]. Both GHT and preeclampsia develop after the 20th week of pregnancy and follow the same pathogenic process[11]. Onset of GHT is characterised by an increase in cytokine levels in plasma, while preeclampsia is characterised by greater placenta dysfunction[18-20].

Prevention of these disorders is based on prenatal medical checks, and intake of calcium and anti-hypertension and antiplatelet drugs[21]. However, calcium supplements have only been shown to be effective in populations with nutritional deficiency[22]. The efficacy of low doses of aspirin is only recognised among women with preeclampsia in more than one previous pregnancy and in cases of chronic AHT with added preeclampsia in prior pregnancies[23].

Due to lack of knowledge on what causes these disorders, there is not one specific preventive method for the general obstetric population[11], which brings about the need to investigate possible non-pharmacological preventive strategies such as physical activity (PA) as, when performed regularly, it improves cardiovascular capacity and reduces risk factors for these hypertensive disorders, such as lowering the risk of diabetes, endothelial dysfunction and obesity prior to pregnancy, and not gaining excessive weight during gestation[24-26]. All this would help reduce the risk of GHT and preeclampsia, which would open doors to a new preventive strategy.

Many institutions support pregnant women remaining physically active during pregnancy and post-partum to improve their maternal-foetal health without any counter-indications[27,28]. The latest Canadian Guideline for Physical Activity during Pregnancy sets a minimum of 150 minutes a week of moderate PA, in at least 3 sessions per week, combining aerobic training (AT) and strength training, also known as concurrent training (CT)[28].

The ACOG has recently published recommendations for training during pregnancy for healthy women: 3 or 4 days a week, at an intensity of 60-80% of maximum heart rate (HR_{max}) or 12-14 on the Borg Rating of Perceived Effort (RPE)[29], from the first trimester to birth, in 30- to 60-minute sessions[27]. During pregnancy, CT is the type of exercise that seems to bring the greatest benefits to maternal health[30].

Although studies on the effect of physical exercise (PE) during pregnancy on the foetus and the new-born have begun recently, scientific evidence indicates the safety and efficacy of maternal training during pregnancy in terms of foetal and neonatal health[24].

Among the general population, moderate regular PE reduces the incidence of AHT, helping lower systolic and diastolic AP, and ensuring adequate venous blood flow to the heart[31]. Furthermore, it has been seen that carrying out supervised PE can safely and significantly improve physical performance and quality of life for patients with AHT[32].

Knowing that physical inactivity is a modifiable risk factor, PE is shown as a possible tool to lower the risk of suffering GHT and preeclampsia[33-35].

Although evidence supports the benefits of PE during pregnancy in terms of GHT and preeclampsia, the type of training which is most effective to prevent these pathologies is still unclear, as mentioned in ACOG (2020) for pregnancies without complications, generically.

Consequently, this review aims to analyse which type of exercise, intervention duration and which session, frequency and intensity produce the greatest benefits in preventing GHT and preeclampsia in women with uncomplicated pregnancies.

Methodology

This study carried out an exhaustive search of 2 scientific literature databases. PubMed and Web of Science (WOS), up to 21/10/2020. Intervention studies were included that analysed the effect of training during pregnancy among healthy women in relation to GHT and preeclampsia. Consequently, the search descriptors used are grouped into pregnancy, training, GHT and preeclampsia (Table 1).

The PubMed search used a combination of keywords and MeSH terms, while WOS used keywords, selecting its "Main Collection" as a database. Regarding the search field, the "Topic" filter was used.

After determining the search strategy, inclusion and exclusion criteria were given to select studies that would form part of the review.

The inclusion criteria were: 1) Complete text studies in Spanish or English, published on PubMed or WOS; 2) Original studies of PE intervention programmes for pregnant women, that include a detailed description of the intervention (at least frequency, duration, intensity and type of exercise); 3) Studies that evaluate the AP.

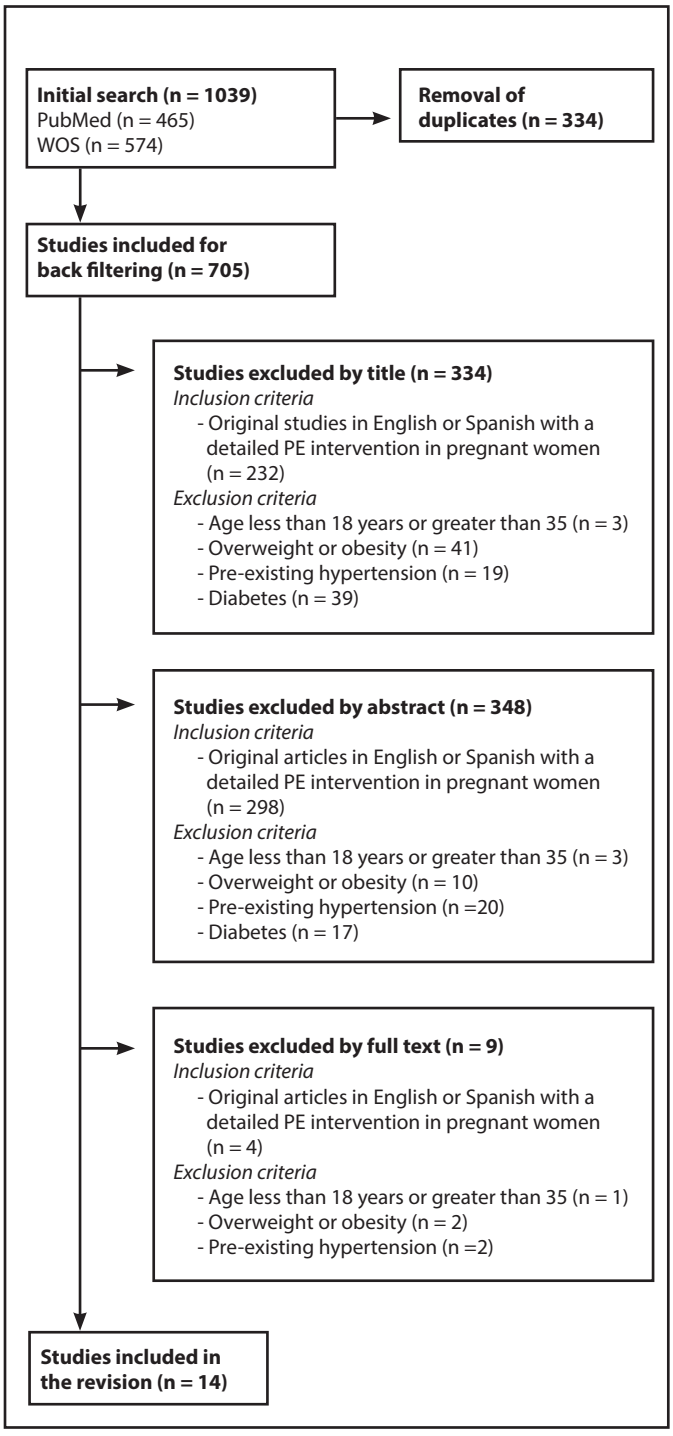
Studies were excluded if their main sample had at-risk pregnancies according to the NICHD:[1] 1) Age under 18 or over 35; 2) Illnesses prior to pregnancy: Prior AHT, diabetes or being HIV positive; 3) Overweight or obesity; 4) Multiple pregnancy; 5) Consumption of tobacco, alcohol and drugs.

Two researchers (SSP and ASD) independently evaluated the titles, abstracts and complete texts of the recovered articles using the search strategy to determine eligibility according to the inclusion criteria. When they did not reach a consensus between the two of them, a third researcher (JCP) took the final decision on inclusion. Out of the 705 studies found, 14 were included after the review. The reasons for excluding studies are shown in Figure 1.

Table 1. Search strategies used in the databases.

Database	Search strategy	Limits
Pubmed	("Pregnant women"[Mesh] OR "Pregnant women" OR "Pregnancy"[Mesh] OR "Pregnancy") AND ("Exercise"[Mesh] OR "Exercise") AND ("Hypertension, Pregnancy-Induced/prevention & control" [Mesh] OR "Hypertension" OR "Pre-Eclampsia/ prevention & control"[Mesh] OR "Preeclampsia")	Publication date: "Up to 2020/10/21" Species: "humans"
WOS	("Pregnant women" OR "Pregnant Women*" OR "Pregnant Woman*" OR "Pregnancy" OR "Pregnancies*" OR "Gestation*") AND ("Exercise" OR "Physical Activity*" OR "Physical Activities*" OR "Physical Exercise*" OR "Physical Exercises*" OR "Acute Exercise*" OR "Acute Exercises*" OR "Isometric Exercises*" OR "Isometric Exercise*" OR "Aerobic Exercise*" OR "Aerobic Exercises*" OR "Exercise Training*" OR "Exercise Trainings*") AND ("Hypertension, Pregnancy-Induced/prevention & control" OR "Gestational Hypertension*" OR "Transient Hypertension*" OR "Pre-Eclampsia/prevention & control" OR "Pre Eclampsia*" OR "Preeclampsia*" OR "Pregnancy Toxemias*" OR "Pregnancy Toxemia*" OR "Edema Proteinuria Hypertension Gestosis*" OR "Toxemia Of Pregnancy*" OR "Toxemia Of Pregnancies*" OR "EPH Complex*" OR "EPH Toxemias*" OR "EPH Toxemia*" OR "EPH Gestosis*" OR "Preeclampsia Eclampsia 1*")	Document types: "article"

Figure 1. Article selection process according to PRISMA.



Results

After study selection, 14 intervention studies were included in the review whose characteristics and results are given in Table 2.

Sample

The 14 studies included in the review comprise a total sample of 4,756 women with uncomplicated pregnancies. Out of them, 2,778 were included in a control group, while 1,978 carried out a specific PE programme.

Table 2. Table summarising the articles included in the review.

Study	Sample	Type of exercise	Duration of the intervention	Frequency, duration and intensity of the session	Results of the training programme	Conclusions
(42)	N: 765 IG: 383 CG: 382	Aerobic, strength and flexibility	Week 9/11 of pregnancy - end of pregnancy	F: 3 days/week. D: 50-55 minutes I: <70% HR_{max} 12-14 RPE	GHT incidence (IG *vs* CG): 2.1% *vs* 5.7% (OR=2.96; CI= 1.29-6.81; p=0.01 between groups) Preeclampsia incidence (IG *vs* CG): 0.5% *vs* 2.3% (p=0.03 between groups) Excessive weight incidence (IG *vs* CG): 26.4% *vs* 34.2% (OR=1.47; CI= 1.06-2.03; p=0.02 between groups) Macrosomia incidence (IG *vs* CG): 1.8% *vs* 4.7% (OR=2.53; CI= 1.03-6.2; p=0.04 between groups)	Maternal exercise can prevent AHT and helps control maternal and fetal weight gain
(2)	N: 200 IG: 93 CG: 107	Aerobic, flexibility and pelvic floor	Week 9/13 of pregnancy - end of pregnancy	F: 3 days/week. D: 55-60 minutes I: 55-60% HRmax 12-13 RPE	Excessive weight incidence (IG *vs* CG): 21.2% *vs* 35.6% (p=0.02 between groups)	Moderate regular exercise did not represent a maternal-fetal risk and helps control maternal weight gain.
(36)	N: 171 G1: 54 G2: 60 CG: 57	Aerobic	Week 13 (G1) / 20 (G2) – 38 of pregnancy	F: 3 days/week. D: > 15 minutes I: 60-80% HR_{max} 12-16 RPE	VO_{2max} (G1 *vs* G2 *vs* GC): ↑11.2% *vs* ↑11.1% *vs* ↓1.16% (p=0.03 between groups) With no significant relationship between groups in preeclampsia, macrosomia, AP and pulsatility index (p>0.05)	The intervention improved the physical condition of the pregnant women without affecting the placenta blood flow or fetal growth.
(44)	N: 639 IG: 426 CG: 213	Aerobic, strength and flexibility	Week 16/20 – 32-36 of pregnancy	F: 3 days/week. D: 60 minutes I: 12-14 RPE	No significant relationship with the risk of premature birth, preeclampsia, weight gain, gestational diabetes and macrosomia (p>0.05)	Although it does not relate exercise during pregnancy with premature births or preeclampsia, it does not present a risk for the fetus.
(37)	N: 61 IG: 26 CG: 35	Aerobic and strength	Week 12 – >24 of pregnancy	F: 2 days/week. D: 60 minutes I: 12-14 RPE	Systolic resting AP (IG *vs* CG): ↓2.6% *vs* 3.4% (CI=1.5-12.6; p=0.013 between groups)	The exercise reduces the AP in previously inactive pregnant women
(41)	N: 358 IG: 147 CG: 211	Aerobic and strength	Not specified	F: 3 days/week. D: 60 minutes I: <1.25 on 5-point Likert Scale	Premature births (IG *vs* CG): 4% *vs* 7% (p=0.0065 between groups) Bradycardia (IG *vs* CG): 10% *vs* 16.3% (p=0.001 between groups) Preeclampsia incidence (IG *vs* CG): 6.6% *vs* 12.3% (p=0.002 between groups)	The intervention reduced the intensive care for new-borns and the health costs
(43)	N: 1348 IG: 660 CG: 688	Aerobic, strength, flexibility and pelvic floor	Week 9-38/39 of pregnancy	F: 3 days/week. D: 50-55 minutes I: <60% HR_{max} 10-12 RPE	Excessive weight (IG *vs* CG): ↓ (OR=0.6; CI=0.52-0.84; p = 0.001) GHT incidence: ↓ GHT (OR= 0.39; CI=0.67; p=0.001) Diabetes incidence (IG vs CG): ↓ (OR=0.48; CI=0.28-0.84; p = 0.015) Cardiometabolic diseases (IG vs CG: ↓ (OR=0.27; CI=0.08-0.95; p = 0.041) Macrosomia incidence (IG vs CG): (OR=0.36; IC=0.2-0.63; p=0.007) Previous weight in 6 months (IG *vs* CG): ↑ (OR=2.37; CI=1.26-4.54; p = 0.007)	Exercise during pregnancy can protect maternal-fetal health.

(keep going)

Study	Sample	Type of exercise	Duration of the intervention	Frequency, duration and intensity of the session	Results of the training programme	Conclusions
(26)	N: 62 IG: 31 CG: 31	Aerobic	Week 12/14 - >36 of pregnancy	F: 4 days/week. D: 45-60 minutes I: 12-14 RPE	VO_{2max} (IG *vs* CG): ↑ GI (p<0,05) Strength (IG *vs* CG): ↑ GI (p<0.01) C-section incidence (IG *vs* CG): 6% *vs* 32% (p<0.01) Post-partum recovery time (IG *vs* CG): ↓ IG (p<0.05) GHT incidence (IG *vs* CG): ↓ IG (p=0.16)	Exercise improved physical aptitude among previously inactive women and reduced complications during the birth
(38)	N: 20 IG: 10 CG:10	Aerobic and strength	Week 16/20 – 28/32 of pregnancy	F: 3 days/week. D: 85 minutes I: 55-75% HRmax	Nitrous oxide and nitric oxide (IG *vs* CG): ↑ IG (p=0.05) Mitochondrial superoxide (IG *vs* CG ↓ 8% compared to CG (p=0.05) Hydrogen peroxide in the placenta mitochondria (IG *vs* CG): ↓ 37% compared to CG (p=0.05)	The changes caused by exercise at a placenta level benefit the vascular system and reduce the risk of preeclampsia, diabetes and GHT
(45)	N: 64 IG: 31 CG: 33	Aerobic	Week 16/20 – 32/36 of pregnancy	F: 3 days/week. D: 60 minutes I: 50-65% HR_{max}	VO_{2max} (IG *vs* CG): ↑ 2.4 *vs* ↓ 4.7% (p=0.014 between groups) Dilatation measured by flow (IG *vs* CG): No changes *vs* ↓ 0.01% (p=0.02 between groups) Resting HR (IG *vs* CG): ↑11.2% *vs* ↑19.8% % (p=0.02 between groups)	The intervention improved the endothelial dependent vasodilation in pregnancy, which could prevent disorders due to endothelial dysfunction
(46)	N: 855 IG: 429 CG: 426	Aerobic, strength and balance	Week 20 – 36 of pregnancy	F: <3 days/week (1 supervised) D: 60 minutes I: 13-14 RPE	Gestational diabetes incidence (IG *vs* CG): 7% (CI=4.3-9.7) *vs* 6% (CI=3.3-8.6) (p=0.52 between groups) GHT incidence (IG vs CG): 2.9% *vs* 3.2% (OR=0.9; CI= 0.4-2; p=0.77 between groups) Preeclampsia incidence (IG *vs* CG): 3.8% *vs* 3.8% (OR=1; CI= 0.5-2; p>0.99 between groups)	The exercise intervention did not avoid gestational diabetes or improve resistance to insulin among healthy pregnant women.
(39)	N: 10 IG: 5 CG: 5	Aerobic	Week 20 – 36 of pregnancy	F: 5 days/week. D: not specified (walking 0.6-3km) I: <40% reserve HR	Systolic AP (IG *vs* CG): ↑ 1.8% *vs* ↑ 3.7% (p<0.05 between groups) Diastolic AP (IG *vs* CG): 2.6% *vs* 1.35% (p>05 between groups)	Aerobic exercise could alleviate the increase in AP and reduce the incidence of GHT
(16)	N: 124 G1: 60 G2: 64	G1: flexibility G2: aerobic	Week 18 of pregnancy - end of pregnancy	F: 5 days/week. D: 40 minutes I: 55-69% HR_{max} 12-13 RPE	Resting HR (G1 *vs* G2): ↑ 8±11ppm (CI=5,1-11,2) *vs* ↑14±16 ppm (CI=9.1-17-9; p<0.01 between groups)	Regular flexibility training during pregnancy can reduce the risk of preeclampsia
(34)	N: 79 G1: 41 G2: 38	G1: flexibility G2: aerobic	Week 18 of pregnancy - end of pregnancy	F: 3-5 days/week. D: 31-40 minutes I: 55-69% HR_{max} 12-13 RPE	Preeclampsia incidence (G1*vs* G2): 2.6% (CI=0.07-13.8) *vs* 14.6% (CI=5.6-29.2) (p<0.05 between groups) GHT incidence (G1 *vs* G2): 40% (CI=23.2-55.8) *vs* 22% (CI=8.7-35.2) (p<0.05 between groups)	Regular flexibility training during pregnancy can reduce the risk of preeclampsia

Abbreviations: CG, control group; IG, intervention group; F, frequency; D, duration; I, intensity; HR, heart rate; AHT: arterial hypertension; GHT, gestational hypertension; AP, arterial pressure; CI, confidence interval at 95%; RPE, Borg Rating of Perceived Effort.

Seven studies included pregnant women who had previously been sedentary (n = 527);[16,26,36–40] while one analysed active pregnant women (n = 358)[41]. Two studies included as many previous active pregnant women (n = 346), as sedentary pregnant women (n = 1.767)[42,43]. Four studies did not provide details of the PE prior to the sample[2,44–46]. Thereby, 76.5% of the women studied in this review were sedentary (n = 2.294), while 23.5% (n = 704) were physically active.

The average age was 29.62 years old, and the body mass index was 24.24. 64.3% of the pregnant women were nulliparous (n = 2,882), while 35.7% (n = 1599) had given birth previously.

Intervention

Type of exercise

All the studies in this review include AT in their intervention. The methodology differed according to the authors, but the most often repeated aerobic activities were walking[2,16,26,34,36,38,39,42] and dancing sessions[2,37,43,46].

Four studies carried out an exclusively AT intervention[26,36,39,45], three combined AT and strength[37,38,41], and two combined AT and strength and flexibility[42,44]. Two studies, that include pelvic floor (PF) training in their programme, analyse the combined effect of AT, flexibility and PF on the one hand[2], and combining AT, flexibility, PF and strength on the other[43]. Two studies divided their sample into women who did AT and those worked on flexibility1[6,34]. Finally, one study combined AT, strength and balance[46].

Duration of the training programme

The average duration of the programmes being analysed was 20 weeks. Three studies featured an intervention less than or equal to 16 weeks[37,38,46], while 3 ran their programme for more than 26 weeks[2,42,43]. Lombardi *et al.*[41] did not specify the duration of their intervention.

Most studies finished their training programme after the 36th week of pregnancy, with the exception of 2 studies that finished beforehand[37,38] and another that did not specify it.[41]. However, there is reasonable heterogeneity at the start of the intervention. Five studies began in the 9th-14th gestational week[2,26,37,42,43], and 7 studies in the 16th-20th week[16,34,38,39,44–46]. One study divided its sample into women who began training in the 13th week, and those who began in the 20th week; 36 while another study did not provide data on the start of its programme[41].

Weekly frequency

In general, the studies included a training frequency of 3 days a week. Some studies set a greater frequency[16,26,34,39,46]. In the study by Haakstad *et al*.,[37] the sample trained for a minimum of 2 days a week.

Intensity of the sessions

To monitor the intensity of the sessions, HR_{max} and/or RPE 6-2029 was used with the exception of one study[41]. Six used both measurements[2,16,34,36,42,43]. 4 studies only used RPE[26,37,44,46], and 2, HR_{max} [38,45]. Stutzman *et al.*[39] monitored the combined intensity of reserve HR and RPE, while Lombardi *et al.*[41] used the Likert scale.

In terms of the most used measurement techniques (HRmax and RPE), the average maximum intensity for the interventions was 68.5% of the HR_{max} and an RPE of 13.6. The minimum[39,45] and maximum[36] intensity values compiled were between 50-80% of the HR_{max} and an RPE of 11-16.

Duration of the sessions

Ten out of the 14 articles carried out sessions lasting between 40 and 60 minutes. Only two interventions programmed training with a duration outside this interval, lasting 85 minutes[38] and 31-40 minutes each session[34]. Two articles did not provide this detail[36,39]. The average total duration of the sessions from the included studies was approximately 60-65 minutes.

Study results

After analysing the included studies, we saw that none of the interventions presented a risk for maternal-foetal health. All the studies except two[44,46] reported significant improvements in the intervention group in some of the evaluated measurements compared to the controls.

Seven studies directly analysed the effect of the training on the risk of GHT and/or preeclampsia[26,36,41-44,46]. Four studies did not find significant differences between groups[26,36,44,46]. Although Price *et al.*[26] did not find this difference, there was no case of GHT in the intervention group.

Barakat *et al.*[42] concluded that women who were inactive during pregnancy were 3 times more likely to develop AHT, independently of their body mass index, compared to women who followed a training programme (OR = 2.96; 95% CI = 1.29-6.81; $p = 0.01$). They also found that the controls were 1.5 times likely to gain excessive weight during pregnancy (OR = 1.47; 95% CI = 1.06-2.03; $p = 0.02$). This coincides with the study by Barakat *et al.*[2] and Perales *et al.*[30] (OR = 0.60; 95%CI = 0.46-0.49).

Lombardi *et al.*[41] found a significant reduction among women that remained active during pregnancy in relation to the risk of preeclampsia ($p = 0.0002$). Perales *et al.*[30] concluded that PE during pregnancy reduced the risk of GHT (OR = 0.39; 95%CI = 0.23-0.67).

Lower incidence of GHT and preeclampsia and a lower resting HR have been observed among pregnant women who trained with flexibility[16,34]. On the other hand, de Oliveria *et al.*[36] compared the same training programme among pregnant women that began in week 13 (G1), those that began in week 20 (G2) and controls (G3). In week 28, there was a greater VO_{2max} in G2 (VO_{2max} = 27.3±4,3 (G1); 28±3.3 (G2); 25.5±3.8 (G3); $p = 0.03$). In week 32, they saw an increase in VO_{2max} with no significant differences between G1 and G2, although higher than the controls (3.2±0.43 (G1); 3.1±0.55 (G2); 1.4±0.41 (G3); $p = 0.001$).

Stafne *et al.*[46] studied the effect of an AT, strength and balance programme, without finding any significant differences between groups in terms of gestational diabetes (7%; 95%CI =4-11.4 (IG); 6%; 95%CI=3.3-8.6 (CG)), GHT (2.9%(IG) *vs* 3.2%(CG)); OR=0.9; 95%CI=0.4-2(CG)) and preeclampsia (3.8% in both groups).

Except for Oliveria *et al.*[36] and Stafne *et al.*[46], they found that AP and HR dropped in the intervention groups compared with the controls[37,39,45].

Regarding foetal weight, a greater risk of macrosomia was found among inactive women during pregnancy[42,43], while another 2 did not bring up any significant differences[36,44]. Barakat *et al.*[42] observed that women who were inactive during pregnancy were 2.5 times more likely to give birth to a macrosomic baby (OR = 2.53; 95% CI= 1.03-6.20; $p = 0.04$). Perales *et al.*[43] also ratified it (OR = 0.36; 95% CI =0.20-0.63).

To evaluate the cardiorespiratory capacity, the test used 6 minutes walking[45], the 2-mile test[26] or the treadmill test[36]. All the studies agreed that the women who were active during pregnancy presented greater cardiorespiratory capacity: $p = 0.01445$, $p < 0.0526$ and $p < 0.001$[36].

Discussion

The purpose of this review was to analyse which type of exercise, duration of intervention and session, frequency and intensity produce the greater benefits in preventing GHT and preeclampsia in women with uncomplicated pregnancies. The results obtained show that there is a beneficial relationship for healthy women between carrying out a PE programme in pregnancy and the risk of suffering these hypertensive disorders.

Type of exercise

After reviewing the literature, we conclude that healthy pregnant women can carry out PE during gestation without negatively affecting their maternal-foetal health[36,44].

The aerobic PE mainly used among this population is walking, dancing and the exercise bike[2,16,26,34,36–39,42,43,46]. Strength exercise mainly used hand weights, elastic bands or exercises to strengthen the pelvic floor[2,37,38,41-44]. In addition, flexibility was also widely studied[2,16,34,42-44]. The ACOG fundamentally recommends carrying out a CT programme[27].

Price *et al.*[26] found that pregnant women who have followed an AT programme during their gestation reduced the incidence of C-sections and their recovery time after the birth.

Stutzman *et al.*[39] related AT to a drop in resting AP and incidence of GHT. However, this contradicts Oliveria *et al.*[36] who, although they related it to an increase in VO_{2max}, did not find any significant differences in the risk of preeclampsia, macrosomia, AP and the pulsatility index. Ramírez-Vélez *et al.*[45] endorse other benefits of AT in pregnancy, such as the increase in average dilation per flow or reduction of the resting HR.

Yeo *et al.*[16,34] compared AT and flexibility in pregnant women. Their results show that the group that carried out flexibility training presented lower resting AP and incidence of preeclampsia. However, this group showed lower incidence of GHT, which might be due to the fact that this disorder can occur as a precursor to preeclampsia[11], and a programme of flexibility exercises could prevent it from developing.

Currently, training recommendations in pregnancy are focussed on CT programmes[27]. Barakat *et al.*[2,42] and Perales *et al.*[30] relate it to a greater gain in excess maternal weight and, except for Barakat *et al.*[2], who do not mention it, also with a lower risk of fetal macrosomia. In turn, de Stafne *et al.*[46] and Ginar *et al.*[44] do not find this relationship. Three studies made a CT intervention[37,38,41] and another 3 combined CT and flexibility[42–44]. Four studies investigated the effect of the training on the incidence of GHT[42,43] or preeclampsia[41,42,44]. They all reduced the risk of suffering these hypertension disorders, except for Ginar *et al.*[44], who did not find significant differences. Compared with AT, there is greater evidence on the preventive effect of CT on the incidence of GHT or preeclampsia[41-43] than any that only use aerobic training. By comparing AT and flexibility, pregnant women who carry out flexibility training had lower evidence of preeclampsia and reduced their resting HR[16,34].

To do so, optimum training to reduce the risk of GHT and preeclampsia would be to combine CT and flexibility.

Duration of the training programme

The recommendations indicate that healthy pregnant women should start training after the 12th week of gestation[27], because, as explained by the Office on Women's Health in the US Department of Health and Human Services (OWH), in the first trimester of pregnancy, there is a greater risk of a spontaneous miscarriage, particularly in the first 8 weeks[47]. In the studies analysed, nobody began their intervention in the first 8 weeks of pregnancy, and the majority did so once they had passed the 12 week mark[16,26,34,36-39,44-46]. However, there is evidence to back up that, for healthy women, training in the first trimester of pregnancy does not represent a risk for maternal-fetal health[2,42,43].

The ACOG (2020) does not set recommendations on the duration of the training programme that women with uncomplicated pregnancies should undertake. This might explain why there is great heterogeneity in the duration of the interventions of this review, as there are studies where the training lasts 12 weeks[37] and others that run for practically the entire pregnancy[43].

The end of the training programme is much more uniform. The majority pick interventions that continue until at least week 36[2,16,26,34,36,39,42-46].

Studies where the training programme lasts longer (29-31 weeks)[42,43] demonstrate a lower incidence of GHT among the pregnant women. Studies with a programme lasting less than 12 weeks[37,38] do not measure this variable, although Haakstad *et al.*[25] obtained a lower systolic resting AP in their intervention group compared to the control group. De Oliveria *et al.*[36] carried out an intervention lasting 25 and 18 weeks, depending on the groups into which their sample was divided, and Ginar *et al.*[44], for 12-16 weeks. Nobody found a significant relationship between the risk of GHT and preeclampsia and training in pregnancy. The study by Price *et al.*[26] did not report cases of GHT in the intervention group, which lasted 22-28 weeks, although the differences between groups were not significant. Oliveria *et al.*[36] suggest that one possible cause for there being no significant differences in their measurements might be that the intervention began in week 13 or 20 depending on the group, as opposed to another study that they used as a reference, that began its programme at 8-9 weeks[48], just like Perales *et al.*[30] and Barakat *et al.*[42], who did find a significant relationship. In the same way, Ginar *et al.*[44] did not find a relationship in the incidence of preeclampsia when beginning their intervention at week 16-20 of pregnancy. Furthermore, the training ended at week 32-36, the typical time for preeclampsia to begin[44]. Nor did Stafne *et al.*[46] find any differences in the incidence of GHT or preeclampsia, which might be due to the short duration of the intervention programme (16 weeks), or the high experimental mortality of the study.

For all these reasons, it seems that there is a greater reduction in the incidence of GHT and preeclampsia in interventions with a minimum duration of 29 weeks, and its preventive effect is seen to increase if the duration increases. The best results have been seen in interventions that began between the 8th and 9th week, finishing after the 36th week of pregnancy. More studies would be required to accurately determine the duration of a training programme for a greater reduction of the incidence of GHT and preeclampsia.

Weekly frequency

The ACOG recommends that women with uncomplicated pregnancies train at least 3-4 times a week[27].

Most studies carried out an intervention of 3 days a week[2,36,38,41-45]. From them, Barakat *et al.*[42] and Perales *et al.*[30] found that the women who had carried out the intervention had a lower risk of GHT, and Lombardi *et al.*[41] found a lower incidence of preeclampsia. Price *et al.*[26], with a training frequency of 4 days a week, found a reduced risk of GHT, although it was not significant. De Oliveria *et al.*[36] Ginar *et al.*,[44] with a frequency of 3 days a week, did not find significant differences in the incidence of preeclampsia, just like Stafne *et al.*[46], with a minimum frequency of 3 days a week. Stutzman *et al.*,[39] with a frequency of 5 days a week, obtained a lower resting AP among the pregnant women who were training. Haakstad *et al.*[37], whose women trained for a minimum of 2 days per week, found that the intervention group obtained a lower systolic resting AP, but the same did not happen for the diastolic AP.

Consequently, the ACOG[27] recommendations are ratified, indicating that a minimum training frequency of 3 days per week would be ideal to reduce the risk of GHT and preeclampsia.

Intensity of the sessions

Current recommendations for training during pregnancy state that the intensity of the sessions must be between 60-80% of the HR_{max}[27].

The average maximum intensity of the studies in this review is 68.5% of the HR_{max} and 13.6 out of 20 for RPE. The majority trained with an intensity between 12-14 of RPE[2,16,34,37,42,44,46]. However, Ramírez-Vézez *et al.*[45] and Stutzman *et al.*[39] ran studies with a lower intensity. Although Ramirez-Vélez *et al*[45] did not directly study the incidence of GHT or preeclampsia, they obtained a drop in resting HR and an improvement in aerobic capacity and dilation measured by flow. Stutzman *et al.*[39] observed a drop in AP in the intervention group, which might induce lower incidence of GHT.

The study carried out by De Oliveria *et al.*[36] involved greater intensity, following ACOG recommendations[27]. However, they did not find a significant relationship between training and lowering the risk of preeclampsia, just like Ginar *et al.*[44] and Stafne *et al.*[46] whose training sessions ranged between 12 and 14 of RPE. The studies that found a drop in GHT or preeclampsia followed training with intensity between 12-14 of RPE[26,42], or even less,10-12 as the case of the study by Perales *et al.*[30] Lombardi *et al.*[41] also found significant improvements in the risk of preeclampsia, in sessions with intensity under 1.25 on the 5-point Likert Scale.

Consequently, the results show that the optimum training intensity to reduce the risk of GHT and preeclampsia would be between 50-70% of the HR_{max} and between 10-14 out of 20 of the RPE.

Duration of the sessions

The ACOG recommends that, in uncomplicated pregnancies, training should be done in 30- to 60-minute sessions[27].

All the studies fall within this margin, except for Ramírez-Vélez *et al.*,[38] with 85 minutes, and de Oliveria *et al.*,[36] whose sessions lasted a minimum of 15 minutes. Perhaps, the limited duration of the sessions for this study[36] might explain why it is the only one, along with Ginar *et al.*[44] and Stafne et al.,46 that when studying the incidence of preeclampsia, did not find a drop among the pregnant women who were training. The studies that registered a lower risk of GHT[42,43], preeclampsia[41] or a reduction of resting AP[37,39] had 45- to 60-minute sessions, except for Stutzman *et al.*[39] who did not mention the duration.

Consequently, 45- to 60-minute training sessions would be effective to reduce the risk of GHT and preeclampsia.

Conclusion

Training during pregnancy for healthy women reduces the incidence of GHT and preeclampsia. The intervention programme with the most benefits is CT combined with flexibility training and with a minimum duration of 29 weeks, that ranges between the 8th-9th week of pregnancy, up to the 36th week, and can be extended to the end of pregnancy. A minimum training frequency of 3 days a week is recommended, with sessions between 50-70% of the HR_{max} and an RPE of 10-14 out of 20. For an optimum effect for the training in terms of reducing GHT and preeclampsia, the sessions must range between 45 and 60 minutes.

These recommendations mostly concur with the recommendations suggested by ACOG for training among healthy women in pregnancy.

Conflict of interests

The authors do not declare any conflict of interests.

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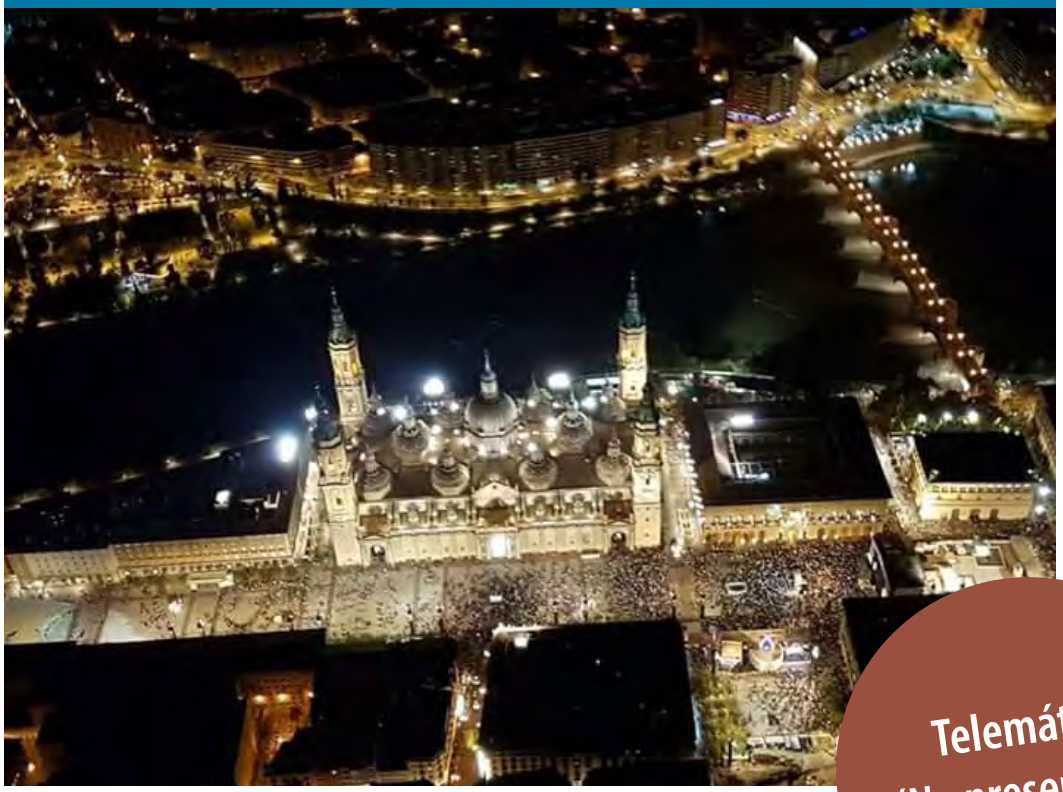
IX JORNADAS NACIONALES DE MEDICINA DEL DEPORTE

CONMOCIÓN CEREBRAL Y TRAUMATISMO CRÁNEO-ENCEFÁLICO EN EL DEPORTE

Sociedad Española de Medicina del Deporte (SEMED)

Asociación Aragonesa de Medicina del Deporte (ARAMEDE)

27-28 de noviembre de 2020



Telemáticas (No presenciales)

Comunicaciones orales / Oral communications

CO-01. Manejo y seguimiento de taquicardias supraventriculares en deportistas de élite

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Introducción: El estudio y manejo de las arritmias en los deportistas de élite supone un tema controvertido por su frecuencia y repercusión. Sin embargo, las arritmias supraventriculares tienen una prevalencia similar a la población general, con la misma distribución por edades, exceptuando la fibrilación auricular.

Objetivo: En este estudio se analizan los casos de dos deportistas profesionales que presentaron episodios de taquicardia supraventricular paroxística sintomáticas, con la finalidad de profundizar en el manejo y seguimiento de estas arritmias benignas en el deportista.

Material y método: Fueron estudiados 91 futbolistas de élite con un tiempo de entrenamiento semanal de 14,11 ± 3,5 horas/semana, en el periodo comprendido entre 2010-2020. En todos ellos, se realizó un ECG de superficie de 12 derivaciones, así como holter de monitorización prolongada a los sintomáticos.

Resultados: Dos sujetos presentaron episodios sucesivos de taquicardia supraventricular documentados mediante monitorización electrocardiográfica durante el esfuerzo, realizándose a posteriori un estudio electrofisiológico para su adecuada valoración de cara a una eventual ablación. En uno de ellos, se objetivó la presencia de taquicardia auricular con foco ectópico cercano al nodo AV, impidiendo ablacionar el sustrato arritmogénico por su localización. El manejo consistió en tratamiento médico con beta-bloqueantes. En el otro caso, se objetivó una taquicardia supraventricular por reentrada por vía accesoria, no siendo posible la ablación por la localización anatómica. En este caso, no se pautó tratamiento. Durante el seguimiento a largo plazo (6-8 años), no se registraron nuevos episodios en ambos sujetos.

Conclusiones: Los deportistas de élite no están exentos de sufrir eventos arrítmicos, a pesar de que predominen los de etiología benigna. Según las recomendaciones, los deportistas con presencia de taquicardias regulares de QRS estrecho deberían ser estudiados al menos con electrocardiografía y ecocardiograma transtorácico. El tratamiento de elección recomendado en taquicardias sintomáticas es la ablación con catéter. Sin embargo, en ocasiones donde la ablación no es factible, puede considerarse igualmente seguro el tratamiento conservador, tal y como queda patente en este estudio.

Palabras clave: Cardiología deportiva. Taquicardias supraventriculares. Arritmias.

CO-02. Recomendaciones y seguimiento post-síndrome coronario agudo en deportista de alto rendimiento: a propósito de un caso

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Introducción: Las recomendaciones en pacientes con cardiopatía isquémica en relación con la práctica deportiva de alta intensidad es una cuestión muy discutida últimamente. Esto puede deberse a la reciente evidencia que pone de manifiesto una mayor prevalencia de enfermedad ateroesclerótica en deportistas de alto rendimiento en comparación con sujetos sedentarios. Sin embargo, las últimas guías no establecen restricciones en cuanto a la práctica deportiva en aquellos pacientes con cardiopatía isquémica que cumplan una serie de criterios.

Objetivo: Establecer recomendaciones en relación al pronóstico y seguimiento en deportistas de alto rendimiento que han presentado un síndrome coronario e intervencionismo coronario percutáneo.

Material y método: Varón de 32 años, jugador profesional de baloncesto, sin antecedentes personales de interés, con antecedentes familiares de cardiopatía isquémica precoz, que presentó un síndrome coronario agudo con elevación del ST.

Resultados: La exploración física fue normal. Se realizó ECG de 12 derivaciones en ritmo sinusal a 86 lpm, QRS estrecho, eje normal, con elevación del segmento ST en V2-V4. En analítica se documentó elevación de marcadores de daño miocárdico, estableciéndose el diagnóstico de SCACEST. Se realizó cateterismo objetivándose trombosis de la DA proximal, implantándose stent, con resto de coronarias sin lesiones. El paciente fue dado de alta con doble antiagregación con ácido acetil salicílico (AAS) y ticagrelor durante 3 meses, y posteriormente AAS. En ecocardiograma de control se evidenció buena función VI, sin valvulopatías significativas. Se realizó ergometría tras un mes del evento, sin hallazgos de isquemia, con una carga de trabajo de 18 METS.

Conclusiones: Es fundamental establecer unas recomendaciones en cuanto al seguimiento de estos pacientes tras un síndrome coronario agudo. En este paciente, dado que tenía enfermedad coronaria totalmente revascularizada, con buena función ventricular izquierda, sin isquemia inducible ni inestabilidad eléctrica, 3 meses después del evento coronario, podría estar permitida la actividad física sin restricciones en dichos sujetos. Sin embargo, esto puede ser contradictorio en muchos casos. Asimismo, se debe valorar el riesgo hemorrágico en pacientes que compiten en deportes de contacto y están bajo tratamiento con doble antiagregación.

Palabras clave: Cardiopatía isquémica. Deportista. Cardiología.

CO-03. Cardiopatía isquémica y enfermedad coronaria multivaso en el deportista: a propósito de un caso

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Hospital Universitario de Gran Canaria Dr. Negrín. Las Palmas de G.C.

Introducción: La evaluación de la cardiopatía isquémica en el deportista se presenta como un tema de gran actualidad en nuestra población; en la que la práctica de actividad física crece exponencialmente día a día. Asimismo, se ha descrito una mayor prevalencia de placas coronarias de cualquier grado de severidad en deportistas frente a controles. Todo ello, evidencia la necesidad de prestar especial atención a este tipo de población.

Objetivo: Evaluar el manejo de la cardiopatía isquémica, tanto el diagnóstico como su seguimiento, en el paciente atleta.

Material y método: Varón de 62 años, triatleta, que ingresa en cardiología por cuadro de dolor centrotorácico con irradiación a brazo izquierdo que apareció en reposo, de moderada intensidad, acompañado de cortejo vegetativo. No había presentado episodios anginosos previos. Tiene 2 hermanos con antecedentes de cardiopatía isquémica precoz, uno falleció por infarto de miocardio y otro portador de stent desde los 41 años.

Resultados: Presentó exploración física dentro de la normalidad. En el electrocardiograma se objetivó arritmia sinusal a 56 lpm, eje normal, con descenso del ST-T en I, aVL, V4-V6. Se realiza ecocardiograma destacando buena función global VI con hipoquinesia inferior e insuficiencia aórtica ligera. En el cateterismo cardiaco se objetiva enfermedad coronaria multivaso, con lesiones severas en arteria descendente anterior, coronaria derecha y circunfleja. Se implantan 3 stents, con buen resultado angiográfico final. Durante el seguimiento, el paciente se encuentra totalmente asintomático desde el punto de vista cardiológico. Se realizó ergometría de control a los 4 meses, que resulta clínica y eléctricamente negativa, alcanzando 16 METS. En este momento, dado que presentaba enfermedad coronaria aterosclerótica totalmente revascularizada, después de 3 meses tras un IAM en un paciente asintomático, con FE del VI conservada y sin isquemia inducible, es razonable permitir la práctica de deportes sin restricción.

Conclusiones: Los deportistas de élite no están exentos del riesgo de sufrir un evento cardiovascular. De hecho, tal como queda reflejado en nuestro caso, pueden desarrollar enfermedad coronaria difusa que pueda condicionar el desarrollo de un evento agudo que ponga en peligro la vida del paciente. Por tanto, proponemos una intensificación en el seguimiento de estos atletas, ahondando en su historia familiar de cara a estratificar correctamente su riesgo cardiovascular.

Palabras clave: Cardiopatía isquémica. Deportista. Cardiología.

CO-04. Correlación entre la respuesta ventilatoria oscilante y los valores de la ergoespirometría

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Introducción: La respuesta ventilatoria oscilante (RVO) que se observa en pacientes con insuficiencia cardiaca (IC) que se realizan una ergoespirometría se asocia a mal pronóstico, siendo un predictor independiente de mortalidad y es posible modificarla con tratamiento médico y con los programas de rehabilitación cardiaca.

Objetivo: Determinar la relación entre la fracción de eyección (FE), la clase funcional según la NYHA, el VE/VCO_2 slope, el VO_2 máximo y la existencia de una RVO.

Material y método: Estudio observacional y retrospectivo, en una muestra de pacientes con IC, a los que se le realizó una ergoespirometría con consumo de oxígeno (periodo Enero/2016, Mayo/2018). Los parámetros del intercambio gaseoso se analizaron mediante el analizador de gases Ultima Series Medgraphic, y la base de datos del Breeze Software. Se utilizó el criterio de la AHA para definir la RVO (oscilaciones en la ventilación >60% del tiempo de prueba y de una amplitud mayor 15% del valor de la ventilación basal).

Resultados: La muestra la componen 87 pacientes (58,6% varones, media de edad 50,90+12,6 años), 74,7% diabéticos tipo 2, el 59,8% son hipertensos, y el 34,5% son dislipémicos. La mediana de la FE fue del 30%, el VO_2 pico medio de 11,3 ml/kg/min, VO_2 % (48+-18), el VE/VCO2 slope medio 35 ± 9. El 79,3% de los pacientes tenían una clase funcional de la NYHA I-II. El 73,6% presentaban una RVO, de los que el 57,8% tenían una FE < 40%. La RVO no se relacionó de manera significativa con la clase NYHA, FE, VO_2 máximo ni con el VE/VCO_2 slope.

Conclusiones: La RVO está presente en la mayoría de los pacientes con IC, siendo más prevalente ante una peor clase funcional y FE, VO_2 máximo más bajo y una VE/VCO_2 slope más grande, aunque sin significación estadística, en probable relación al tamaño muestral.

Palabras clave: Programa de rehabilitación cardiaca. Respuesta ventilatoria oscilante. Ve/VCO_2 Slope.

CO-05. Impacto del confinamiento domiciliario sobre la fuerza y la movilidad en personas con esclerosis múltiple

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Introducción: La COVID-19 ha provocado que los gobiernos de todo el mundo tomen acciones drásticas con el objetivo de minimizar el ritmo de contagios de la población. Entre estas medidas, el confinamiento domiciliario, que en España se extendió durante más de 2 meses, ha provocado que la población disminuya drásticamente los niveles de actividad física diarios. En este contexto, hay ciertas poblaciones de riesgo, como las personas con esclerosis múltiple (EM), que se benefician del ejercicio físico a la hora de atenuar los síntomas y ralentizar la

progresiva disminución de la fuerza o la capacidad funcional, en las que el confinamiento puede haber provocado pérdidas más acentuadas en las variables mencionadas.

Objetivo: Por ello, el objetivo de este estudio fue analizar las consecuencias del confinamiento domiciliario sobre el rendimiento neuromuscular y la capacidad funcional en personas con EM. 17 personas con EM (edad: 43,4±10,9 años; *Expanded Disability Status Scale*: 2,9±1,3) participaron voluntariamente en el estudio. La máxima contracción voluntaria isométrica de rodilla (MVIC) y el ratio de fuerza desarrollado (RFD_{peak}) fue medido en ambas piernas durante la extensión de rodilla. Además, el test de levantarse y sentarse de la silla, así como el test de 6 minutos marcha fue analizado pre-post confinamiento. RFD_{peak} disminuyó significativamente en la pierna derecha [*Effect size* (ES)=0,52] y mostró una tendencia a la disminución en la izquierda (ES=0,36). En cuanto a la capacidad funcional, el tiempo requerido para llevar a cabo el test de sentarse y levantarse de la silla mostró una tendencia al aumento (ES=-0,48).

Resultados: Nuestros resultados sugieren que el confinamiento domiciliario ha provocado disminuciones en la fuerza y en la capacidad funcional en personas con EM. Por ello, sería interesante que, de producirse otra situación similar a la acontecida, se estableciesen estrategias para que las personas con EM realizasen programas de entrenamiento en casa.

Palabras clave: Ejercicio. Neuromuscular. Enfermedad neurológica.

CO-06. Deportista con daño cerebral: de la espasticidad al dolor miofascial

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Introducción: La parálisis cerebral es un trastorno neurológico no progresivo que ocurre en torno al nacimiento y condiciona el desarrollo del niño. Se muestra la historia de un paciente que creció afecto de paraparesia espástica. Llegó a la edad adulta con marcha autónoma tras tres intervenciones quirúrgicas en las que se llevaron a cabo tenotomías múltiples en la musculatura de los miembros inferiores. En los periodos entre intervenciones precisaba infiltraciones periódicas con toxina *onabotulinum* tipo A para inhibir la exaltación del reflejo miotático propio de la espasticidad, tras la última tenotomía no precisó más infiltraciones. El paciente competía federado en natación adaptada. Consulta por síndrome doloroso de carácter mecánico en nalga izquierda, regiones lumbar y abdominal derechas que le dificultan la práctica deportiva.

Material y método: En la exploración física se encuentran puntos gatillo propios de síndrome miofascial de los siguientes músculos: piramidal izquierdo, cuadrado lumbar derecho y recto del abdomen derecho (éste último en el contexto de una entesopatía del pubis por la batida de la patada en natación). No presentaba clínica en los adductores debido a la elongación quirúrgica sufrida en los mismos. La entesopatía del pubis fue confirmada mediante ecografía que mostró aumento de heterogeneidad con focos hipoecogenicos y calcificaciones groseras en la entesis de la musculatura pubiana con angiogénesis. Se le propone tratamiento de los puntos gatillo con infiltración de toxina *onabotulinum* tipo A intramuscular.

Conclusiones: El tratamiento con toxina botulínica inhibió la hipercontractilidad de los puntos gatillo disminuyendo el dolor del paciente y permitiendo su reincorporación a la práctica deportiva. La dosis y localización de las infiltraciones ha de adaptarse al objetivo terapéutico, en este paciente los objetivos fueron evolucionando de mejora del patrón de marcha a alivio de clínica dolorosa.

Palabras clave: Entesopatía pubiana. Deporte adaptado. Dolor. Síndrome miofascial. Daño cerebral. Toxina botulínica.

CO-07. Enfermería del deporte, necesidad de formación vía EIR (enfermería interno residente)

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Introducción: La enfermería tiene un papel importante en el seguimiento del deportista y de toda aquella persona que practique actividad física no sólo a nivel competitivo sino también como parte de sus cuidados para la salud. Contar con personal experto en los equipos multidisciplinares facilita la asistencia al deportista.

Material y método: Búsqueda bibliográfica en bases de datos de palabra clave: enfermería deportiva (Pubmed, Scopus, Cochrane).

Resultados: Existe dificultad para encontrar trabajos específicos sobre el papel de la enfermería en el deporte aun encontrando referencias sobre equipos multidisciplinares en Medicina del Deporte. La prevención, promoción de cuidados específicos y rehabilitación que puede ofrecer el personal de enfermería no está extendido en el deporte. Se requiere que la sociedad conozca a estos profesionales. Atender a lesionados, colaborar en la prescripción de actividad física saludable en pacientes crónicos en atención primaria, valorar la forma física de la persona en consultas de cardiología o medicina del deporte es un trabajo multidisciplinar. La promoción de programas individualizados para que pacientes crónicos (hipertensos, EPOC, cardiópatas, diabéticos, obesos…) tengan mejor adherencia al ejercicio requiere que exista personal de enfermería especializado en el ámbito del deporte trabajando en equipos multidisciplinares, donde la salud sea preventiva y terapéutica. No existiendo en España posibilidad de formación vía EIR (enfermería interno residente) sino sólo a través de formación postgrado.

Conclusiones: Es necesario fomentar que la sociedad conozca a la enfermería del deporte. Se deben impulsar actividades y contactos con otros profesionales y organismos públicos y privados para mejorar la formación de la enfermería deportiva. Y velar porque la competencia y habilidades de estos profesionales sea excelente. Que las sociedades científicas de otras profesiones del deporte como la Medicina, Fisioterapia, Podología, Psicología o Ciencias del Deporte contribuyan a hacer visible la enfermería deportiva es esencial.

Palabras clave: Enfermería. Deporte. Formación especializada. Trabajo multidisciplinar.

CO-08. Prevalencia de patologías más frecuentes en entrenamiento funcional de alta intensidad: revisión sistemática

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Introducción: El entrenamiento funcional de alta intensidad o *Crossfit* es un programa de fitness considerado de alta intensidad, basado en movimientos principalmente mutiarticulares, como levantamiento de pesas, habilidades gimnásticas y ejercicios de resistencia. Este programa de entrenamiento está abierto a cambios en cuanto a la progresión e intensidad del ejercicio, lo que permite a una gran población con diferentes niveles de acondicionamiento físico realizarlos de manera segura y efectiva. La popularidad de dicho programa de entrenamiento ha crecido exponencialmente en los últimos 10 años.

Objetivo: El objetivo de este estudio fue analizar la prevalencia de lesiones ocurridas en entrenamientos basados en las modalidades *Cross Training* o entrenamiento funcional de alta intensidad, mediante una revisión sistemática. La gran mayoría de los estudios han utilizado diseños de estudios retrospectivos.

Material y método: Se utilizaron tres bases de datos diferentes para la búsqueda: PubMed, Science Direct y Research Gate. En ellas se ingresaron como palabras clave "Crossfit" "Injuries". Se incluyeron las publicaciones en inglés comprendidas entre el 2010 (año de origen del concepto) hasta 2020.

Resultados: En la primera etapa de la estrategia de búsqueda, identificamos un total de 58 artículos. Tras varias etapas de exclusión, se seleccionaron sólo 12 estudios para el análisis final, los cuales realizaron protocolos de entrenamiento tipo *Cross Training* y que a su vez reportaron algún tipo de lesión ocasionada por la práctica del programa.

La zona con mayor proporción de lesiones fue el hombro, ya que el 75% de los estudios reportaron lesiones en esta región. En la espalda y el área de la rodilla se documentaron lesiones en el 66,6% y 58,8% de los estudios. La presencia de lesiones previas fue un factor de riesgo muy importante para que ocurrieran nuevas lesiones, ya que el 50% de los estudios confirmaron este factor como la causa de la lesión, mientras que el 33,3% no reseñan esta información, y en el 16.6% de los estudios los sujetos no presentaban lesiones previas.

Conclusiones: La presencia de atletas novatos (menos de un año) se encontraba en la muestra en el 50% de los estudios, y los experimentados (más de un año) en el 58,3%, En cuanto a competidores, se incluían en el 25% de los estudios.

Palabras clave: Lesiones. Entrenamiento. Funcional.

CO-09. Edad y condición física inicial determinan la entrenabilidad de la aptitud cardiorrespiratoria en mujeres mayores

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Introducción: La aptitud cardiorrespiratoria es un importante indicador de funcionalidad y salud en los adultos mayores. Programas de entrenamiento orientados a la mejora neuromuscular y la educación de la marcha, como EFAM-UV©, han mostrado mejorar la velocidad en el test de 6 minutos (6MM), y por ende esta aptitud. El objetivo de este trabajo es analizar la influencia de parámetros como el nivel de condición física inicial, y/o la edad, en relación con esta mejora, en un grupo de mujeres mayores, pues la entrenabilidad puede verse afectada por ambos factores.

Material y método: 96 mujeres (71,24±6,28 años; 69,94±12,99 kg; 1,55±0,07 m) participaron durante 9 meses en el programa EFAM-UV© y realizaron, entre otros, el test 6MM antes y después del entrenamiento. Tras analizar la normalidad de la muestra, se realizó un análisis de correlación (Coeficiente de Spearman) entre el nivel inicial en este test y su cambio tras el entrenamiento (delta: Δ6MM). Igualmente se estudió la asociación entre este delta y la edad, seguido de los gráficos de dispersión y el coeficiente de determinación (R^2).

Resultados: La inclusión de la covariable edad reveló una asociación pequeña y negativa (r=-0,23; p=0,02), con un tamaño del efecto igualmente pequeño (R^2 = 0,03) entre 6MM-pre (516,11±80,99 m) y su mejora (6MM-post= 539,88±89,52 m; Δ6MM: 4,88±10,06%). Esta significación se mantuvo al analizar Δ6MM vs edad, pero en este caso, tanto sin controlar el nivel cardiorrespiratorio de partida (r=-0,21; p=0,03; R^2=0,04), como al incluirlo como covariable (r=-0,22; p=0,03; R^2=0,04).

Conclusiones: Aunque moderadamente, la entrenabilidad cardiorrespiratoria confirma su dependencia de la condición de partida y la edad. Sea cual sea este nivel de partida, los beneficios son mayores cuanto más jóvenes son las participantes, por lo que es importante implementar cuanto antes este tipo de programas. Igualmente, importante es tener en cuenta el nivel inicial de estas deportistas senior, para modificar la carga y/o el tipo de entrenamiento, pues la estructura grupal de los programas puede derivar en una carga insuficiente en las mujeres más entrenadas, al menos en las más mayores.

Palabras clave: Educación de la marcha. Entrenamiento temprano. Test de 6 minutos.

CO-10. Evaluación deportiva, muscular y hormonal en atletas de crossfit® que emplean la "Elevation Training Mask"

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Introducción: La posibilidad de realizar entrenamientos intensos sin caer en fatiga crónica, estimula el uso de dispositivos que mejoren

la funcionalidad muscular y hormonal en deportistas. La *Elevation Training Mask* (Training Mask LLC) (ETM) permite la aplicación de una situación de hipoxia durante el ejercicio integrándola en las rutinas de entrenamiento para mejorar el estímulo físico y la recuperación con el propósito de incrementar el rendimiento. Evaluamos el impacto de la ETM sobre los entrenamientos del día o *Workouts Of the Day* (WODs), el comportamiento muscular y hormonal en atletas de *Crossfit®*.

Material y método: Estudio de cohorte prospectivo. Durante 12 semanas 20 atletas de *Crossfit®* entrenaban 60 minutos 3 días a la semana fueron divididos aleatoriamente en 2 grupos, grupo control (GC) (n=10) y grupo ETM (GE) (n=10) aplicando una altitud simulada adicional progresiva entre 914 y 2743 metros. Los WODs (*press, squat, deadlift,* CF total y *grace*), marcadores maculares: lactato deshidrogenasa (LDH); creatina quinasa (CK); mioglobina (Mb) y hormonas: testosterona (TT); cortisol (C), se evaluaron en 2 momentos del estudio: día 1 (T1) y día 84 (T2).

Resultados: En todos WODs y los parámetros LDH, CK, Mb, TT y C no mostraron ninguna diferencia significativa (p>0.05) en la interacción grupo tiempo. En el GE se observó un porcentaje de cambio (Δ) entre T1 y T2 sustancialmente menor en Mb (-16,01±25,82), CK (6,16±26,05) y C (-0.18±4.01%) que en GC (Mb: -094±4.39; CK: 17,98±27,19; C: 4.56±3.44). Los Δ T1-T2 en los WODs fueron similares.

Conclusiones: Tras 12 semanas de entrenamiento en condiciones simuladas de hipoxia con ETM no existen mejoras del rendimiento deportivo evaluadas mediante los WODs. Sin embargo, la mayor tendencia a disminución de Mb, CK y C, tras el uso ETM, podrían estimular la recuperación e indicar un menor catabolismo muscular del atleta de *Crossfit®* a largo plazo.

Palabras clave: *Elevation Training Mask*. Hipoxia. Rendimiento. Músculo. Hormonas. *Crossfit®*.

CO-11. Análisis de la coordinación y la fuerza explosiva del tren inferior en futbolistas con discapacidad

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Introducción: Encontramos estudios que comparan las variables de coordinación y fuerza en un mismo tipo de discapacidad de cara a la práctica de fútbol. Sin embargo, en el panorama actual, personas con discapacidad intelectual (DI), parálisis cerebral (PC) y daño cerebral adquirido (DCA) pueden competir conjuntamente en las modalidades de fútbol 7 y fútbol 8 en función de si tienen o no afectación cognitiva. Ante la necesidad de ajustar la labor del entrenador a las características y potencialidades de cada jugador, el objetivo de este estudio fue conocer si existen diferencias en la coordinación y la fuerza explosiva del tren inferior entre futbolistas con DI, PC, DCA con y sin afectación cognitiva.

Material y método: De los 37 jugadores, 21 tenían DI, 11 PC, 4 traumatismo craneoencefálico y 1 anoxia. En función del dictamen de discapacidad fueron asignados al grupo DI (N=21) 27±8 años, PC sin afectación cognitiva (n=6) 26±8 años o PC o DCA con afectación cognitiva (n=9) 26±7 años. En el período precompetitivo fueron evaluadas la coordinación mediante el *Side-Stepping, Split Jumps* y *Rapid Heel-Toe* y la fuerza explosiva del tren inferior mediante el *Standing Broad Jump* y 4 *Bounds for distance* y el Índice de Masa Corporal (IMC). Los datos se analizaron con el paquete estadístico jamovi. (Version 1.0). Las variables cuantitativas presentaron una distribución normal (p > 0,05) y se utilizó estadística paramétrica para determinar las diferencias entre grupos, realizando ANOVA de una vía.

Resultados: No se hallaron diferencias significativas en las variables de IMC, porcentaje de discapacidad, de coordinación y fuerza explosiva del tren inferior entre los 3 grupos.

Conclusiones: Es necesario ampliar la muestra para conocer si hay diferencias entre los grupos con el objetivo de tener más datos para planificar los entrenamientos.

Palabras clave: Futbol adaptado. Traumatismo craneoencefálico. Daño cerebral adquirido. Discapacidad intelectual. Parálisis cerebral.

CO-12. Efecto del ejercicio físico sobre la calidad de vida en enfermedad inflamatoria intestinal

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Introducción: Aunque ha sido demostrado que el ejercicio físico mejora el estado de salud y la calidad de vida de la población en general, no se ha determinado con exactitud la importancia que tiene este en personas que presentan enfermedad inflamatoria intestinal (EII). En un intento de demostrar qué cambios aporta el ejercicio físico a la calidad de vida de estas personas, el objetivo de esta investigación fue evaluar dichos cambios tras la realización de una intervención de ejercicio físico supervisado durante 16 semanas.

Material y método: 6 sujetos con EII, de diferente edad y sexo, realizaron 2 sesiones semanales de ejercicio físico supervisado mediante circuitos de entrenamiento de fuerza en grandes grupos musculares alternándolos con ejercicios anaeróbicos. Cada sesión tuvo 1h de duración y el programa completo fue de 16 semanas. Antes y después de la intervención los sujetos rellenaron el CCVEII-9, un cuestionario específico de calidad de vida para EII. Para el análisis de los datos se utilizó el programa PSPP para establecer la comparación de la calidad de vida antes y después de la intervención.

Resultados: La Tabla 1 muestra la evolución de cada parámetro cuantificado tras la intervención.

Tabla 1.

	% sujetos que mejoraron post intervención	% sujetos que no mejoraron post intervención	% sujetos que se mantuvieron
Fatiga	100%	0%	0%
Energía	33,4%	0%	66,6%
Retortijones	16,7%	83,3%	0%
Malestar general	16,7%	16,7%	66,6%
Náuseas	16,7%	0%	83,3%
Gases	66,6%	0%	33,4%
Contento/ feliz	16,7%	0%	83,3%

Conclusiones: La práctica de ejercicio físico, basado en entrenamiento de fuerza y resistencia anaeróbica 2 días en semana durante 16 semanas, evita el deterioro de la calidad de vida de personas con EII.
Palabras clave: Actividad física. Calidad de vida. Enfermedad inflamatoria intestinal. Enfermedad de Crohn. Colitis ulcerosa.

CO-13. Maduración biológica y composición corporal en jugadores de fútbol jóvenes

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Introducción: En los deportes de competición, hay ciertos atributos físicos y antropométricos que juegan un papel clave en la consecución de un rendimiento óptimo. Según las características del deporte, la disciplina o la posición de juego, estos atributos son diferentes. Además, su desarrollo durante la infancia y la adolescencia está fuertemente influenciado por la madurez biológica. Tradicionalmente, la composición corporal y la fuerza han sido factores a tener en cuanta en el rendimiento en futbol. El objetivo de este estudio fue comparar la distribución de la composición corporal y la fuerza en función de porcentaje de altura adulta prevista como medida de maduración.
Material y método: Veintidós jugadores de fútbol jóvenes (11,41 ± 0,73 años de edad) completaron una batería de test antropométricos y físicos según las directrices marcadas por la ISAK *(International Society for the Advancement of Kinanthropometric)*. La fuerza de agarre de la mano se valoró mediante un dinamómetro TKK 5105 (Takei, Japan). La predicción de la estatura adulta se midió siguiendo las directrices definidas por Sherar *et al.*, (2005), a fin de asignar a los deportistas en dos grupos según el porcentaje de su estatura actual con respecto a su estatura adulta prevista: <82% y >82%. Las diferencias entre los grupos (media) se analizaron utilizando la prueba *t*-test para muestras independientes.
Resultados: Los resultados de las diferencias morfológicas y de fuerza de agarre se muestran en la Tabla 1.
Conclusiones: Los jugadores de fútbol más maduros no presentaron una composición corporal diferente. Sin embargo, parece que si existen unos atributos físicos más desarrollados como demuestra la fuerza de agarre.

Tabla 1. Diferencias morfológicas y de fuerza de agarre en función del porcentaje de altura actual respecto a la predicción de altura adulta

	< 82% (n=12)	> 82% (n=10)	Valores *p*
Edad cronológica (años)	11,04 ± 0,53	11,71 ± 0,31	<0,01
Talla (cm)	141,53 ± 5,88	152,74 ± 4,21	<0,01
Masa Corporal (kg)	37,01 ± 7,68	42,46 ± 3,99	0,07
APHV (años)	14,03 ± 0,52	13,77 ± 0,35	0,23
% Masa grasa	18,60 ± 5,90	17,75 ± 5,99	0,75
% Masa muscular	40,47 ± 3,27	38,30 ± 2,29	0,11
Fuerza de agarre derecha (kg)	16,29 ± 4,08	17,68 ± 3,20	0,41
Fuerza agarre izquierda (kg)	14,93 ± 3,70	18,27 ± 2,52	0,03

APHV: Edad de pico máximo de crecimiento.

Palabras clave: Composición corporal. Fuerza de agarre. Fútbol. Maduración biológica.

CO-14. "Educación y compromiso como estrategia en la lucha contra el dopaje" Proyecto Europeo ECASFAD

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Introducción: Según el Código Mundial Antidopaje, el principio básico de la educación se basa en la creación de programas educativos para deportistas y su personal de apoyo para preservar la deportividad evitando así el dopaje, siendo el objetivo principal la prevención del dopaje en el deporte. Por ello, el objetivo principal de este proyecto es "Desarrollar una estrategia global de información, formación y educación como medio indiscutible de prevención del dopaje, aprovechando las directrices establecidas por los programas Erasmus Plus Sport".
Material y método: Este programa, financiado por la Unión Europea, se llevará a cabo por países e instituciones miembro como son: la organización coordinadora, la Sociedad Española de Medicina del Deporte (España), junto con la Universidad Católica San Antonio de Murcia (España), la Asociación Deportiva y Ambiental Crosskovacsi (Hungría), la Fundación Klitschko (Ucrania), la Asociación de Medicina del Deporte de Serbia (Serbia), la Agencia Nacional Antidopaje Eslovaca (Eslovaquia) y la Universidad Médica de Lodz (Polonia).
Las actividades de los programas de información, educación y prevención contra el dopaje deben proporcionar información actualizada, centrándose en los valores del deporte. La población destinataria serán los deportistas y el personal de apoyo a los deportistas, centrándose en particular en los más jóvenes, y proporcionando la información de forma adecuada a su etapa de desarrollo.
Conclusiones: A modo de resumen, el proyecto se dividirá en tres etapas, las cuales tendrán como finalidad la lucha contra el dopaje a través de la educación. Estas etapas se dividen en:

- Etapa 1: Manual de recursos existentes para la prevención del dopaje, preparación de cursos y webs informáticas.
- Etapa 2: Determinación y selección de los grupos que participarán en las formaciones.
- Etapa 3: Reporte y difusión de los materiales y cursos de prevención.

Palabras clave: Compromiso. Dopaje. Educación. Proyecto Europeo.

CO-15. Nutrición de precisión en la fatiga en futbolistas: un caso clínico según la metodología CARE

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Introducción: El fútbol es un deporte intermitente con cambios en la actividad cada 4-6 s con un componente aeróbico-anaeróbico. La fatiga en el fútbol se manifiesta en tres períodos a lo largo de un encuentro: transitoria durante el partido, principio de la segunda parte y final del encuentro. La fatiga disminuye el rendimiento y se atribuye a una disminución de K+ en el intersticio y/o aumento del lactato y/o acidosis metabólica, y/o compromiso de la vía ATP-fosfocreatina y/o deplección del glucógeno muscular en fibras específicas y/o hipoglucemia y/o hipertermia y/o cambios hormonales. La Testosterona Biodisponible (bioT), forma biológicamente activa, incluye la Libre (FT) y la unidad de forma laxa a la albúmina. Como la medición de la FT directa no es viable en la práctica clínica, se han propuesto distintas ecuaciones de predicción para estimar la libre (CFT), siendo la de Vermeulen A, et al., una de las más empleadas. El ratio FT/cortisol se considera un indicador de la homeostasis de los procesos anabólicos y catabólicos y un subrogado de sobreentrenamiento.

Descripción del caso: Jugador de fútbol de Primera División de 20 años, que refiere fatiga persistente en consulta inicial. La bioquímica sanguínea basal reporta una Testosterona total (TT) = 3,23 ng/ml (11,2 nmol/L), SHBG = 38,6 nmol/l, albúmina = 4,6 g/dl y cortisol = 15,7 µg/dl.

Discusión: La CFT (Vermeulen A, *et al*) = 0,2 ng/dl = 0,196 nmol/L y bioT = 136,58ng/dl = 4,91 nmol/L. González-Sánchez V *et al* hallaron valores medios en jóvenes 24±3,6 años) de CFT = 0,34-0,5 y bioT = 8,5-12,7 nmol/l (P25-P75) respectivamente que corresponden a <P2,5 y P2,5. El ratio TT (µg/dl)/cortisol (µg/dl) = 0,021 fue inferior al valor más bajo hallado en futbolistas profesionales griegos (0,28±0,02) e italianos de Primera División (0,37). Se pautan 100 mg glutamina/kg, 250 mg/día de ubiquinol por su efecto antifatiga, 500 mg/día de extracto de semillas de fenogreco *(Trigonella foenum-graecum)* por su capacidad para incrementar la TT (13) y 500mg/día de raíz de ashwagandha *(Withania somnnifera)* por reducir la actividad del eje Hipotálamo-Pituitario Adrenal (HPA), durante 21 días.

Conclusiones: El ejercicio de una nutrición de precisión en el fútbol requiere una descripción detallada del fenotipo. El uso de biomarcadores hormonales como la TT, CFT, bioT y cortisol son útiles para el despistaje de la fatiga continuada en el fútbol. La suplementación con glutamina, ubiquinol, fenogreco y ashwagandha contribuiría a mejorar la fatiga en futbolistas profesionales en base a la evidencia científica preliminar (Tabla 1).

Tabla 1. Valores hormonales basales del futbolista profesional de primera división.

Hormonas/Unidades	ng/ml	nmol/l	µg/dl	g/dl
Total Testosterone	3,23	11,2	0,32	
Sex Hormone Binding Globulin		38,6		
Albumina				4,6
Calculated Free Testosterone*	0,2	0,2		
Bioavailable Testosterone**		4,91		
Cortisol			15,7	

*Vermeulen A, *et al*. CFT = f (TT, SHBG, albúmina).
**Vermeulen A, *et al.* bioT = f (albúmina, CFT).

Palabras clave: Fútbol. Fatiga. Biomarcadores hormonales.

CO-16. Encefalopatía traumática crónica y deportes de lucha: una revisión sistemática en la Web of Science

Rovira V, Molina JP.

Universitat de València. Valencia.

Introducción: La encefalopatía traumática crónica es una enfermedad neurodegenerativa producida principalmente por lesiones cerebrales traumáticas repetidas. Se ha documentado en practicantes que realizan deportes de contacto, como boxeo, fútbol americano, hockey y en actividades de lucha. Sin embargo, cuando se hace referencia a este último tipo actividades se integran prácticas muy diversas, y cabría distinguir las que se desarrollan a través de golpes y las que lo hacen mediante acciones luctatorias desde agarres.

Objetivo: El objetivo de este trabajo es distinguir entre ambos tipos de lucha al asociarlas con esta enfermedad. Atendiendo a las recomendaciones PRISMA, se realizó una revisión sistemática de la producción científica publicada en revistas indexadas en la base de datos *Web of Science* (incluye Medline) en relación con la encefalopatía traumática crónica y las actividades de lucha, diferenciando las que utilizan los golpes y las que se desarrollan mediante agarres. La selección final de artículos fue de 101 para las primeras y de 12 para las segundas.

Resultados: Los resultados evidencian que no todas las actividades de lucha se asocian de la misma manera con la encefalopatía traumática crónica. Existe un mayor riesgo de padecerla en practicantes de actividades de lucha con golpes que en los de lucha con agarre. El desarrollo de esta enfermedad está directamente asociado con golpes recibidos en la cabeza. Aunque la intensidad y la frecuencia de los impactos son las dos principales variables que afectan al desarrollo de la enfermedad, estudios recientes señalan que el daño cerebral también está relacionado con desplazamiento de la masa encefálica dentro del cráneo. A este respecto, diversos estudios indican que el uso de protecciones puede ser contraproducente, pues al evitar el daño de la contusión, pueden permitir recibir un mayor número de golpes que se traducen en una mayor frecuencia del desplazamiento de la masa encefálica.

Palabras clave: Artes marciales mixtas. Boxeo. Judo.

CO-17. Composición pentacompartimental y somatotipo en periodo pre-competitivo de deportistas de judo Colombia

López J, Berdugo B, Rincón E.

Institución Universitaria Escuela Nacional del Deporte.

Introducción: Los Judocas en periodos previos a una competencia aumentan las cargas físicas, esta exposición junto con algunas modificaciones en la alimentación de los deportistas pueden llegar a desarrollar cualidades típicas en la contextura física. El propósito del estudio fue describir la composición Penta compartimental y somatotipo de los judocas del Valle del Cauca durante el periodo precompetitivo a los Juegos Nacionales.

Materiales y método: Se estudiaron 11 deportista, 7 mujeres y 4 hombres pertenecientes a la modalidad mayores, asistentes a la liga regional del Valle del Cauca, quienes fueron seleccionados para competir en los Juegos Nacionales 2019, con entrenamientos de 18 horas semanales, aproximadamente 3 horas por día; compiten por divisiones de peso.

Se evaluó de acuerdo con el protocolo de la Sociedad Internacional para el Avance de la Cineantropometría ISAK, 34 variables que permite determinar el fraccionamiento del peso corporal total en cinco masas según Kerr, se estableció el somatotipo propuesto por Heath & Carter y los índices de proporcionalidad. Se utilizó el programa Excel y Bodymetrix® para su análisis y el procesamiento de datos se usó el programa estadístico SPSS V. 25.0, se aplicaron las pruebas no paramétricas de Wilconxon para grupos dependiente siendo un valor de $p< 0,05$ estadísticamente significativo.

Resultados: La edad media 25,3±6,4 años, peso corporal 60,2kg y talla 166,3±10,1 cm. En las masas corporales se encontró masa adiposa 14,5±3,6 kg, masa muscular 33,3±7,7 kg y masa ósea fue de 7,1±2 kg. Respecto al somatotipo hay una predominancia del meso-endomorfo y la mayoría presento tronco medio en forma trapezoidal, con envergadura relativamente larga 104,3±2,7 e índice musculo óseo 4,7±0,5.

Conclusiones: En general los judocas presentan una masa adiposa aceptable y una masa muscular buena. Existe diferencia significativa entre sexos en las diferentes masas corporales.

Palabras clave: Judo. Composición corporal. Somatotipo. Antropometría.

CO-18. Análisis fisiológico de la transición aeróbica-anaeróbica, con patinadores de carreras de la liga de norte de Santander con el test de campo TIVRE-Patín

Lozano RE[1], Bustos BJ[2], Acevedo A[1].

[1]Universidad de Pamplona. Colombia. [2]Fundación Universitaria Juan de Castellanos. Colombia.

El patinaje de carreras es un deporte muy antiguo, que ha ido evolucionando en las últimas décadas, siendo escasos los estudios científicos los cuales lo abordan, hecho por el cual se planteó conocer la transición aeróbica-anaeróbica con patinadores de carreras, siendo Colombia potencia Mundial en esta disciplina deportiva. La mayoría de test son en el laboratorio y de una forma inespecífica, para ello se desarrolló el test de campo TIVRE-Patín, cuyo objetivo es determinar el cambio de un metabolismo aeróbico hacia uno anaeróbico de una forma indirecta, para conseguir el punto de inflexión de acuerdo a la metodología desarrollada por Conconi y al igual su capacidad máxima aeróbica expresada en el volumen máximo de oxígeno durante el esfuerzo físico, teniendo en cuenta que el único test de campo para conocer estos parámetros de una forma confiable, valido y reproducible, desarrollado en la tesis doctoral de Lozano 2010, en la Universidad de León (España), siendo un protocolo continuo, maximal e interválico, logrando parámetros muy objetivos al momento de optimizar el rendimiento; durante la investigación participaron seis deportistas de género masculino (edad 15,33±1,03 años; peso corporal de 66,50±4,23 kg y una talla de 174,50±3,94) y seis deportistas de género femenino (edad 15,33±2,66 años; peso corporal de 55,15±2,79 kg y una talla de 161,00±2,07 cm) pertenecientes a la Selección del Departamento Norte de Santander (Colombia), a partir de los resultados en el test fue posible evidenciar el umbral anaeróbico estando en un 186,17 ppm y 95,45% de la Frecuencia Cardiaca máxima respectivamente, con un volumen máximo de oxígeno de 58,52 y 57,75 ml.kg.min en cada género; no existieron diferencias estadísticamente significativas entre géneros y especialidades ($p>0,05$), en consecuencia estos resultados han sido relevantes para optimizar el rendimiento deportivo e influyentes en la planificación para ajustar las cargas de entrenamiento.

Palabras clave: Test de Campo. Patinaje de carreras. Transición Aeróbica-Anaeróbica.

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