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Summary / Sumario

Clinical physiology and the prescription of physical exercise in hospitals

Fisiología clínica y prescripción de ejercicio físico en el medio hospitalario

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Physiology is the branch of biology that studies the organs and how the body functions. Exercise physiology is the branch of physiology that studies the functioning of the body during physical exercise and how the body adapts when exercise is performed on a regular basis.

Clinical physiology studies the response of patients with chronic diseases (psychiatric, neurological, metabolic, cardiovascular, pulmonary) to physical exercise and their limitations to it, and uses physical exercise as an additional therapeutic resource (prescription of physical exercise).

There is unquestionable evidence of the positive relationship between physical activity or physical exercise and health, particularly over the last two decades, in which numerous studies have highlighted the importance of exercise as a first-line treatment of chronic diseases, being a cornerstone in the primary and secondary prevention of at least 35 chronic pathologies.

Non-communicable chronic diseases represent a serious public health problem and are one of the leading causes of death and disability in developed and developing countries alike. They are directly related to lifestyle, in which physical inactivity together with smoking and an unbalanced diet are the key risk factors responsible for almost 60% of deaths and 46% of global diseases.

Due to their reliability and effectiveness, interventions on lifestyle must be the main strategy for the prevention and treatment of metabolic diseases. Although much attention has been paid to a reasonable diet and weight control, doctors and patients often overlook the role of exercise.

Medicine is advancing, providing effective treatments for many pathologies that are accessible to most of the population. Furthermore, scientific advancement is also providing unquestionable evidence that the regular practice of physical exercise, even at low intensities, is extraordinarily effective in both preventing and complementing treatment for a growing number of chronic pathologies. Recent studies have reported that by performing half the physical exercise recommended by the WHO, it would be possible to prevent up to 10% of premature deaths.

Physical exercise is a "polypill" and is an essential part of medicine, as highlighted in the United States by the American College of Sports Medicine: *"Exercise is Medicine"*, and also in Europe by Pedersen and Satin: *"Exercise as Medicine"*.

Physical condition is an excellent predictor of life expectancy and quality of life. Numerous studies have reported an inverse association between physical condition and morbidity - mortality in the population, which is more pronounced in patients with cardiovascular risk factors.

Physiological values such as maximal oxygen uptake (VO_{2max}.) represent an excellent marker of the maximal cardiovascular capacity, observing an almost linear relationship between a decrease in mortality and an increase in physical condition (METs). Therefore, for each MET of improvement, there is a 12% increase in life expectancy in men and 17% in women. These figures indicate that poor physical condition is an added risk factor, as well as being a morbidity - mortality predictor.

Likewise, higher muscle strength levels are associated with a 40% decrease in the risk of death in women and 31% in men. It has even been quantified that, for every 5-kg decrease in handgrip strength, the risk of death increases by 16%.

Clinical physiology is the branch of exercise physiology which, following an assessment of a patient, prescribes physical exercise.

Good clinical physiology practice requires: a thorough knowledge of the medical pathology, exercise physiopathology and of the use of the most suitable functional assessment tests. It must be part of the overall treatment of the patient.

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Hospital-integrated sports medicine must provide a cross-cutting service that is capable of assessing patients referred from other services. Following an assessment, a personalised exercise prescription must be made, adapted to each patient's specific characteristics, by taking account of medical history, treatment, functional situation, socioeconomic and cultural aspects and patient preferences. This will ensure that the exercise programme can be maintained without the patient dropping out, achieving adherence to treatment, the enjoyment and safety of the participants in the programme.

There is a profound lack of knowledge of this branch of sports medicine at an institutional level, and also that held by most private healthcare insurance companies and even our own medical colleagues. It is now time to highlight the importance of this area of our specialty and to uphold its use. To do so, we need to be trained and retrained in clinical physiology.

Patients referred to the sports medicine unit at a hospital have their medical history taken and are treated and studied with complementary tests, which must be supplemented with any other tests considered necessary in order to obtain an adequate profile of the patient.

The assessment must include tests that evaluate the health-related physical condition qualities. The tests may either be complex such as ergometry, ergospirometry, isokinetic, or simple such as the 6-minute test, dynamometer hand-grip-or the chair sit-to-stand test.

The use of ergospirometry is essential for the quantity and quality of the data offered, making it possible to clearly establish morbidity - mortality risk values. Further research is required into the physiological personalisation of the programme, using ventilatory, lactate, dyspnoea, angina, claudication thresholds.

If it is not possible to conduct ergospirometry tests, then indirect ergometry tests are also useful, making it possible to prescribe exercise through the heart rate reserve.

A methodological proposal would be to perform, during the first visit, an ergospirometry (or ergometry) test, as well as the 6-minute walk test and the strength assessment test using the handgrip dynamometer and the chair sit-to-stand test. Physical exercise shall be prescribed based on the data obtained and the patient's characteristics. Subsequently, during the progress controls, the 6-minute and the strength assessment tests shall be performed with the tests mentioned above. Then, with the data obtained, an assessment shall be made of the patient's progress and a new physical exercise prescription shall be made.

The basic objective is to improve the health-related physical condition qualities, thereby reducing the cardiovascular morbidity and mortality risks. VO_{2max}, tolerance to aerobic resistance-exertion, muscle strength, body composition, balance and flexibility.

The prescription for physical exercise must be like any other prescription for medicine, and must contain the following: type of exercise, intensity, duration, number of repeats and sets, rest periods, progression criteria, evolution, etc.

The most obvious examples of the need to assess and prescribe physical exercise of quality, include surgical rehabilitation, cardiac rehabilitation, persistent COVID, which add to the pathologies that were typically the target of prescription, such as cardiovascular, respiratory, metabolic, oncological pathologies, among others.

We are in a situation in which, although scientific evidence indicates the benefit of the prescription of exercise for the health of individuals and populations and its positive effect on all levels of the health care systems, including economic benefits in the medium and long term, the general public is not offered this service on a widespread or generalised basis.

There is a need to raise the awareness of healthcare providers, so that they invest in a medical area which, in the medium and long term, improves the health of individuals and populations and represents a saving for the public healthcare services.

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Índice

Relationship between extra-curricular physical exercise and physical fitness, lifestyle and academic performance

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Summary

Introduction: The practice of physical activity (PA) triggers positive adaptations on health. Extracurricular sport activities represent a strategy to increase hours of PA. The aim of this study was to evaluate the impact of extracurricular PA on physical condition (PC), health-related quality of life (HRQoL), screen time, and academic level.
Material and method: In collaboration with three educational centers of Soria, the participants of the study completed several validated questionnaires related to PA information and lifestyle. Different physical tests were conducted to assess pupils' PC and the centers provided information related to academics.
Result: A total of 199 students (51.3% females), mean age 9.9 (standard deviation [ED] 1.4) years, were included in the study. Average weekly of PA hours was 3.3 (DE 1.6), and 51.3% of the pupils performed extracurricular sport activities. The results of the study showed statistically differences (P <0.05) on body mass index, screening time, and academic records between those pupils that performed extracurricular sport activities and those that did not perform any extracurricular activity. We observed a moderate negative correlation between weekly PA hours and screen time (r = -0.46, P <0.001) and a moderate strong positive correlation for academic records (r=0.56, P <0.001). The multivariate logistic regression model revealed that boys had a higher likelihood (odds ratio [OR] 3.59, confidence interval [CI] 95% 1.17-11.05) of practicing extracurricular sport activities compared to girls. Moreover, practicing extracurricular sport activities was significantly associated with lower screen time (OR 0.68, CI 95% 0.57-1.81) and better performance on academics (OR 3.63, CI 95% 2.07-6.37).
Conclusion: Our results reinforce the need to develop strategies for the promotion and management of environments that promote extracurricular sport activities.

Key words:
Physical activity. Extracurricular. Screen time. Academic performance. Health-related quality of life. Physical condition.

Asociación entre la actividad física extraescolar con la condición física, estilo de vida y expediente

Resumen

Introducción: El deporte extraescolar representa una estrategia para aumentar las horas de actividad física (AF) y estimular hábitos saludables. El objetivo del estudio fue evaluar la asociación de la AF extraescolar con la condición física (CF), el estilo de vida, la calidad de vida relacionada con la salud (CVRS), y el expediente.
Material y método: Los participantes 199 escolares (51,3% niñas) con una edad media de 9,9 (desviación estándar [DE] 1,4) años de 3 colegios de Soria, cumplimentaron cuestionarios validados para recoger hábitos de práctica deportiva y el estilo de vida. Se realizaron diferentes pruebas para evaluar la CF y el centro proporcionó información sobre el expediente académico.
Resultado: La media de horas semanales de AF practicada por el total de la muestra fue de 3,3 (DE 1,6) horas, y el 51,3% de los escolares realizaban AF extraescolar. Los resultados del estudio demostraron diferencias significativas (p <0,05) en el índice de masa corporal, las horas de pantalla, y el expediente académico entre los alumnos de que realizan AF extraescolar y los que no la practicaban. Se observó una correlación negativa moderada entre las horas de AF semanales y las horas de pantalla semanales (r=-0,46, p <0,001) y positiva moderadamente fuerte para el expediente académico (r=0,56, p <0,001). El modelo logístico de regresión multivariada determinó que los niños tienen una probabilidad más elevada de practicar AF (*odds ratio* [OR] 3,59, intervalo de confianza [IC] 95% 1,17-11,05) que las niñas. Además, la realización de AF extraescolar, se asoció significativamente con un menor número de horas de pantalla semanales (OR 0,68, IC 95% 0,57-1,81) y con un mejor expediente académico (OR 3,63, IC 95% 2,07-6,37).
Conclusión: Estos resultados refuerzan la necesidad de establecer estrategias de promoción y de gestión de entornos, que favorezcan el aumento de la AF extraescolar.

Palabras clave:
Actividad física. Extraescolares. Horas de pantalla. Rendimiento académico. Calidad de vida relacionada con la salud. Condición física.

First Prize for the best scientific paper at the 18th International Congress of Sports Medicine, Murcia (Spain) 2021.

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Introduction

Humans are designed to move. Even human body cells, as the basic units of life must move in order to keep their functionality and maintain their life cycle. Physical inactivity is unnatural behaviour and is something that has been progressively increasing to turn a sedentary lifestyle into a habit[1]. Furthermore, physical activity (PA) in the population in general is becoming increasingly less frequent, particularly with regard to children. These low levels of PA, together with unhealthy eating patterns, have caused an alarming increase in the incidence of chronic diseases and a decrease in the general state of health[2]. In this regard, the World Health Organisation (WHO) has reported that physical inactivity is the fourth leading risk factor for mortality in the world[3]. At present, a number of studies have reported that the global levels of PA in adolescents aged between 11-17 years do not meet the minimum recommendation established by the WHO[4] of at least 60 minutes of physical activity a day. Likewise, the results of the Spanish study ANIBES indicate that 73% of girls aged 9-17 years do not meet the recommendations of the WHO, while the percentage of boys is 45%[5].

In order to mitigate this serious public health problem there is a need to promote PA among the population and among young people in particular. This role could be assumed by schools given that they offer a suitable context for the promotion of PA[6]. The teaching of PA at school, with no gender-related stereotypes, is the start of a strategy to allow students to learn to develop an active and healthy lifestyle[7]. However, in Spain, the current development of study plans disregards the international recommendation on the number of hours of physical education in the official education system and, what is more, they are far from regulating extra-curricular time in order to promote a positive impact on PA8. Recently the European Commission indicated that Spain was in one of the lowest positions with regard to the number of teaching hours dedicated to PA and, despite this, there was no modification of the extra-curricular commitment regarding PA[8].

In view of this situation, extra-curricular PA should be regarded as a healthy practice which, as a complementary physical-recreational activity, makes it possible to promote healthy lifestyle strategies. PA would therefore be used to improve the physical fitness (PF), quality of life and health of school pupils now and in the future[9]. Moreover, PA serves to stimulate improvements in cognitive processes and academic performance[10].

Given this situation, we set out to conduct a cross-sectional study on boys and girls at different schools in the city of Soria, directed at evaluating the impact of the practice of extra-curricular PA and the relationship with PF indicators, lifestyle, including health-related quality of life (HRQOL), and the school environment. A knowledge of these relationships could be of great interest in establishing the links between PA practised on an extra-curricular basis and different variables relating to health and academic performance, thereby supporting the need to develop strategies to promote out-of-school PA, which could be designed, directed and implemented by specialists in sports medicine.

Material and method

Participants

A cross-sectional study was conducted on a sample of primary school students from Soria from years 2 to 6, during the first semester of academic year 2020-21. A document was sent to all schools in Soria, inviting them to participate. However, only three schools accepted the invitation. Likewise, a letter was sent to the parents of the participants to explain the nature and purpose of the study, and to request them to sign their informed consent to permit their children to take part in the study. This investigation was designed in accordance with the Declaration of Helsinki (2008), with the Revised Version (2013) (World Medical Association, 2013). The Ethics Committee of the Faculty of Health Sciences of the Soria Campus of the University of Valladolid, Soria, Spain, approved this study with internal number CCSS/2020/03.

Instruments

To collect information on the study variables, the questionnaire *"School Health Action Planning and Evaluation System"* (SHAPES) physical activity module was used to measure the weekly physical activity and weekly screen time. This questionnaire reports on participation in physical activities, sedentary activities (watching TV, playing video games, mobiles or tablets)[11]. KIDSCREEN-10 was also used, a questionnaire to evaluate the children's quality of life, comprising a series of 10 questions each rated from 1 to 5 in a Likert scale[12,13]. The academic performance was obtained from the academic management programme at the schools. Furthermore, height and weight were measured and the following PF tests were conducted: Hand-held dynamometer test (dynamometer Jamar Plus) (Eurofit Physical Fitness Test Battery)[14]; standing broad jump, with feet together[14] (Eurofit battery); abdominal strength (Fitnessgram battery)[15]; forward flexion of the trunk in the standing position[16]; Flamingo balance test (Eurofit Battery)[14]; coordination/agility circuit with hurdles starting from a lying down position[17]; measurement of the heart rate using the Polar® Vantage M heart rate sensor (Polar Electro, Kempele, Finland) after the coordination/aglity exercise.

Statistical analyses

For the statistical analyses, the means and standard deviations were calculated for the continuous variables and frequencies, and percentages for the categorical variables. The Student t-test was used to compare the continuous variables, and the chi square test (χ^2) for the categorical variables. The correlations were estimated with Spearman's rank correlation coefficient. Multivariate logistics regression models were made with their corresponding *odds ratio* (OR) and 95% confidence interval (CI) in order to study the relationship between the different study variables and PA A two-tailed p-value <0.05 was considered to be statistically significant. All the analyses were made using the STATA version 15 (STATA Corp., TX, USA) statistical package.

Results

The results of Table 1 describe the characteristics of the 119 students included in the study, 58 boy pupils (48.7%) and 61 girl pupils (51.3%) aged 8-12 years (mean age 9.9 years, standard deviation [SD] 1.4), corresponding to five primary education years from 3 schools of the provincial capital of Soria. The students do an average of 3.3 hours of PA a week (SD 1.6), they spend 25.1 hours (SD 3.6) in front of a screen and have an average grade of 7.1 (SD 1.1) in their academic record. As was to be expected, those students practising extra-curricular PA do significantly more hours of PA per week compared to those who do no out-of-school PA (4.5 *vs*. 2.0 hours, p <0.001), and they also have a lower body mass index (BMI) (17.4 Kg/m^2 *vs*.18.7 Kg/m^2, p = 0.017), a better average grade in their academic record (7.7 *vs*. 6.5, p <0.001), and they spend fewer hours per week in front of a screen (23.5 *vs*. 26.8, p <0.001). Stratified by gender, it can be seen that girls spend significantly fewer hours per week in front of a screen than boys (24.2 *vs*. 26.0, p <0.001).

Table 2 shows the correlations between the total number of hours of PA per week and PF, lifestyle, and academic environment for the total of the sample and by sex. The correlations between PA and the physical

Table 1. Characteristics of the study population stratified by out-of-school physical activity and by the sex of participants (n=119).

Characteristics	Total	Extra-curricular physical activity			Sex		
	(n=119)	No (n=58)	Yes (n=61)	p-value	Girls (n=58)	Boys (n=61)	p-value
Age. years, mean (SD)	9.9 (1.4)	10.1 (1.3)	9.8 (1.4)	0.259	9.9 (1.3)	9.9 (1.4)	0.961
Weekly hours of physical activity, mean (SD)	3.3 (1.6)	2 (0)	4.5 (1.5)	**<0.001**	3.2 (1.5)	3.4 (1.8)	0.508
BMI. kg. m^2, mean (SD)	18.0 (2.9)	18.7 (3.1)	17.4 (2.5)	**0.017**	18.0 (3.0)	18.1 (2.8)	0.795
Primary education, n (%)				0.575			0.920
2nd year	17.6	13.8	21.3		17.2	18.0	
3rd year	26.9	27.6	26.2		25.9	27.9	
4th year	18.5	15.5	21.3		19.0	18.0	
5th year	21.0	25.9	16.4		24.1	18.0	
6th year	16.0	17.2	14.8		13.8	18.0	
Type of school, n (%)				0.405			0.642
State	51.3	55.2	47.5		53.5	49.2	
Private, state subsidised	48.7	44.8	52.5		46.5	50.8	
Weekly screen hours, mean (SD)	25.1 (3.6)	26.8 (3.2)	23.5 (3.3)	**<0.001**	24.2 (3.7)	26.0 (3.3)	**0.007**
Academic performance, marks, mean (SD)	7.1 (1.1)	6.5 (1.0)	7.7 (0.9)	**<0.001**	7.0 (1.1)	7.2 (1.1)	0.250

SD: standard deviation; BMI: body mass index.
The bold type shows statistically significant values at p-value <0.05.

Table 2. Correlations between the number of physical activity hours and physical fitness, lifestyle and academic environment.

Characteristics	Number of hours of physical activity					
			Sex			
	Total		Male		Female	
	r	p-valor	r	p-valor	r	p-valor
Physical fitness						
Dynamometer	0.07	0.475	0.04	0.743	0.08	0.541
Standing jump	**0.19**	**0.036**	0.04	0.790	**0.32**	**0.011**
Abdominal strength	**0.27**	**0.003**	**0.27**	**0.038**	**0.27**	**0.034**
Flexibility (standing position)	-0.13	0.157	-0.18	0.188	-0.09	0.506
Balance (Flamingo test)	-0.05	0.587	-0.13	0.333	0.02	0.890
Coordination (faults)	-0.05	0.621	0.02	0.890	-0.09	0.494
Heart rate (after exercise)	0.01	0.971	0.01	0.952	-0.01	0.999
Lifestyle						
Quality of life (Kidscreen test)	-0.04	0.651	-0.05	0.730	-0.02	0.855
Screen time	**-0.46**	**< 0.001**	**-0.44**	**< 0.001**	**-0.54**	**< 0.001**
Academic performance						
Marks	**0.56**	**< 0.001**	**0.51**	**< 0.001**	**0.60**	**< 0.001**

Correlations (r) are based on the Spearman's rank correlation coefficient.
The bold type shows statistically significant values at p-value <0.05

condition variables are weak or very weak, only observing one positive and statistically significant correlation for the standing jump (r = 0.19, p = 0.036) and abdominal strength (r = 0.19, p = 0.003). However, a moderate negative correlation between the total number of hours of PA per week and the weekly screen hours (r =-0.46, p <0.001) and a moderately strong positive correlation for academic performance (r = 0.56, p <0.001), being significant in both cases.

Stratified by gender, the correlations follow the same pattern, observing slightly stronger correlations for girls. We would emphasise the correlation of the total weekly hours of PA and weekly screen hours in which a moderate negative correlation can be seen for boys (r = -0.44, p <0.001) and moderately stronger for girls (r = -0.54, p <0.001), being statistically significant in both cases (Figure 1).

We would also highlight the fact that the greater relationship between the study variables was observed for the total weekly hours of PA and academic performance, where the correlations are positive and moderately strong for both boys (r = 0.51, p <0.001) and girls (r = 0.60, p <0.001), being significant in both cases (Figure 2).

Figure 1. The dispersion graph shows the weekly screen hours vs. the number of weekly physical activity hours, stratified by gender. Each participant in the study (n=119) is represented by a point. The shaded grey area represents the confidence interval at 95% (CI 95%). The line inside the shaded area represents the correlation fit line.

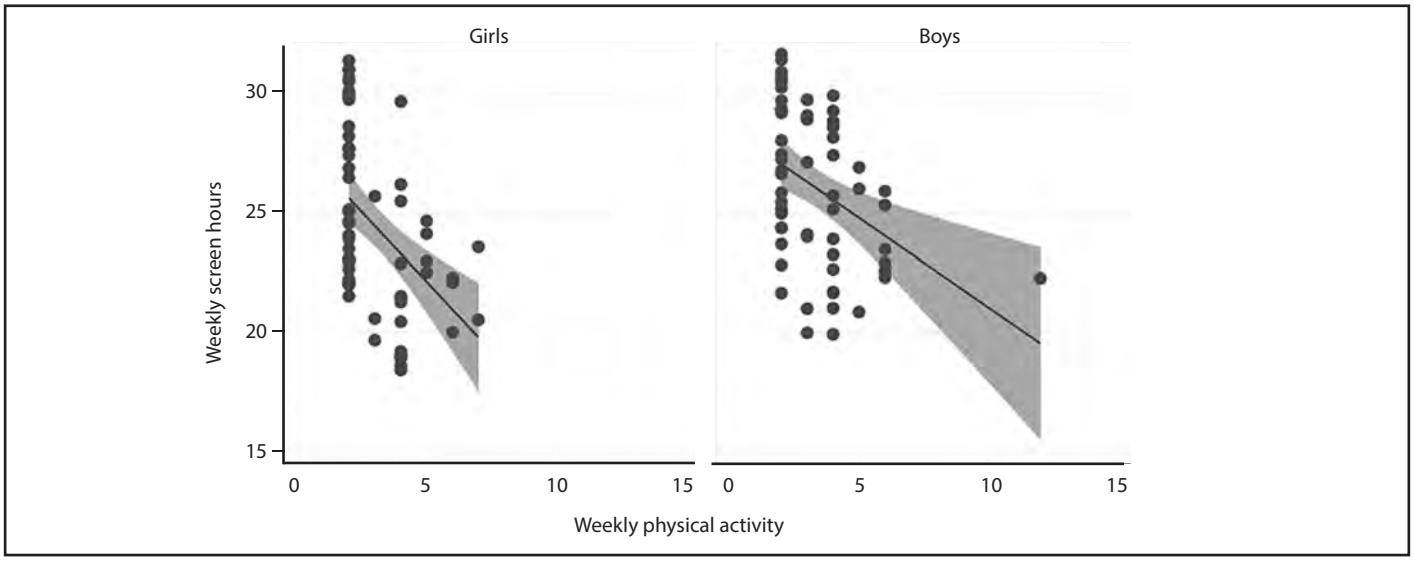

Figure 2. The dispersion graph shows the academic performance vs. the number of weekly physical activity hours, stratified by sex. Each participant in the study (n=119) is represented by a point. The shaded grey area represents the confidence interval at 95% (CI 95%). The line inside the shaded area represents the correlation fit line.

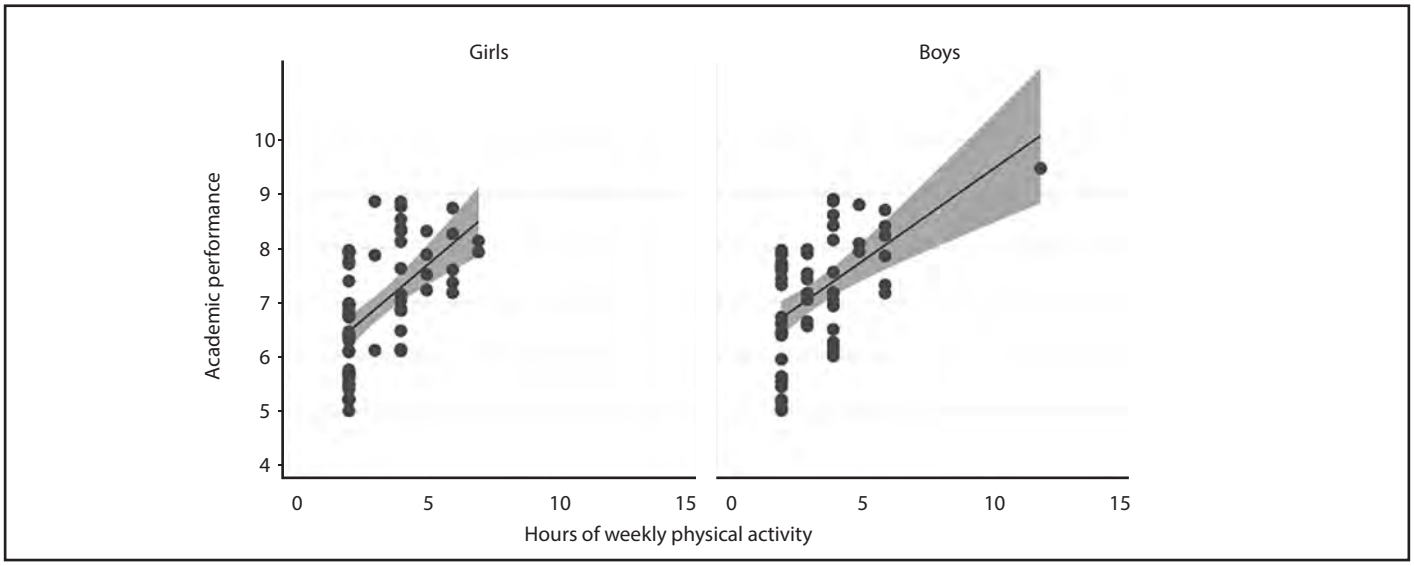

Table 3. Characteristics of the study participants associated with out-of-school physical activity. *Odds Ratio* (OR) and confidence intervals 95% (CI 95%).

Characteristics	Total		Boys		Girls	
	OR (CI 95%) Crude	OR (CI 95%) Multivariate[1]	OR (CI 95%) Crude	OR (IC 95%) Multivariate[1]	OR (CI 95%) Crude	OR (CI 95%) Multivariate[1]
Sex						
Girls	1.00 (ref.)	--	--	--	--	--
Boys	1.56 (0.75-3.21)	**3.59 (1.17-11.05)**	--	--	--	--
Age, years	0.86 (0.65-1.12)	0.94 (0.61-1.44)	0.71 (0.47-1.07)	0.57 (0.30-1.09)	0.99 (0.69-1.43)	1.81 (0.79-4.16)
Type of school						
Private, state subsidised	1.00 (ref.)	--	1.00 (ref.)	--	1.00 (ref.)	--
State	1.36 (0.66-2.79)	1.92 (0.69-5.40)	0.47 (0.16-1.36)	0.26 (0.06-1.20)	0.94 (0.34-2.58)	1.18 (0.23-6.04)
BMI., kg/m^2	0.85 (0.74-0.97)	0.94 (0.75-1.19)	0.92 (0.76-1.11)	1.06 (0.78-1.44)	0.79 (0.64-0.96)	0.72 (0.45-1.16)
Weekly screen hours	0.75 (0.66-0.85)	**0.68 (0.57-0.81)**	0.75 (0.62-0.91)	**0.67 (0.50-0.88)**	0.63 (0.49-0.81)	**0.62 (0.46-0.85)**
Academic performance	3.65 (2.24-5.95)	**3.63 (2.07-6.37)**	2.87 (1.52-5.41)	**2.82 (1.37-5.84)**	4.72 (2.20-10.15)	**4.34 (1.71-10.97)**

CI: Confidence Interval; BMI: Body Mass Index; OR: Odds Ratio; Ref: reference
[1]Multivariate model: adjusted for all the variables in the table.
The bold type shows statistically significant values at p-value <0.05.

The results of the multivariate logistic regression analysis give a diagnostic/predictor model for practising extra-curricular PA comprising three variables: sex, screen time and academic performance (Table 3). Thus, boys have a greater probability of practising extra-curricular PA than girls (OR 3.59, CI 95% 1.17-11.05). Likewise, the practice of out-of-school PA by students was associated with fewer weekly screen hours (OR 0.68, CI 95% 0.57-1.81) and with better academic performance (OR 3.63, CI 95% 2.07-6.37). Estimates of the relationships were similar when stratified by gender, highlighting the greater probability of better academic performance of girls practising extra-curricular PA compared to girls that do not do so (OR 4.34, CI 95% 1.71-10.97).

Discussion

PA is an essential starting point to ensure that girls and boys learn life competencies and acquire the commitment to implement a healthy and active lifestyle[8]. Furthermore, it is considered that PA practised in and out of schools is the right environment to stimulate the cognitive functions of young people, with no gender distinction, so that they can successfully address the exacting demands of learning[8]. For this reason, the objective of this study was to evaluate the impact of extra-curricular PA on important variables relating to health, PF and academic performance.

Given that our results show that the girls and boys practising extra-curricular PA have a significantly lower BMI, increasing the number of PA hours could be the most effective mechanism to combat obesity[19]. In this way, the relationship between BMI and the PA time is inversely proportional, demonstrating that the higher the number of weekly PA hours the lower the BMI. These results are in line with other investigations that have studied the relationship between BMI and PA time in school children[20-22].

With regard to the relationship between the number of PA hours and PF, evaluated through different physical tests, our results show very weak almost non-existent correlations. These results may be due to the fact that the number of hours of PA dedicated by the school children in the study are insufficient to show improvements in PF. In this regard, the average number of weekly hours of PA dedicated by the boys and girls at the schools in Soria, are far lower than the minimum recommendations given by the WHO, which established at least 1 hour a day of moderate or strenuous PA[23]. It has been demonstrated that compliance with these recommendations leads to improvements in muscle strength, speed, agility and flexibility[24]. The practice of PA by our school children from Soria would be in line with the recommendations of Spain's Ministry of Eduction and Ministry of Health, both of which recommend 30 minutes a day[25], considerably less than the recommendations given by the WHO[3]. Our results indicate that the guidelines established by the Spanish government are insufficient to bring about improvements in the PF of school children. There is therefore a pressing need to bring these recommendations into line with the guidelines established by the professionals in the area of PA, who suggest doubling the times[8]. In this regard, the design and supervision of new PA recommendations would best be performed by sports medicine specialists, given their expertise and knowledge in the promotion of the health of the general public by encouraging a physically active lifestyle.

PF has a direct influence on the HRQOL in childhood and adolescence alike[26]. PA increases muscle strength in relation to body weight, and strength of the lower body, testosterone secretion, improvement in neuro muscular coordination, speed/agility, optimal gynoid redistribution of adipose tissue in women, increased cardiorespiratory values and aerobic capacity[27,28]. These positive changes to the different physiological capacities have resulted in clear improvements in HRQOL[9]. Our results show no relationship between the hours of PA and the HRQOL measured by the KIDSCREEN-10 questionnaire, which provides a subjective global

assessment of the perception of physical, psychological and social well-being, contrary to other studies conducted on schoolchildren aged 8-12 years[28] and adolescents aged 12-18 years[30]. The insufficient number of hours of weekly PA could be the reason why schoolchildren in Soria show no overall improvement in PF and, therefore, there is no relationship with HRQOL. This serves to confirm that the number of hours of PA for the boys and girls in Soria is inadequate. The promotion of extra-curricular PA by regional and municipal schools could be a strategy to encourage school children in Soria to practice sport and to improve their physical capacities. Some models of campaigns to practice PA are available, such as those conducted in the years prior to the Barcelona Olympics of 92[31] and the plans for the prevention / treatment of drug addiction[32] that have achieved improvements in PF and in HRQOL. A successful model that could be taken as a reference is the campaign conducted by the Sociedad Española de Medicina del Deporte (SEMED - Spanish Society of Sports Medicine) "Physical Fitness, Sport and Health" in 2016. This campaign was based on three fundamental pillars, advocated by sports medicine specialists: Practice sport for reasons of health and to improve physical fitness, so that it becomes a permanent habit.

The results of the study also show that the most physically active schoolchildren spend less time in front of a screen, observing a statistically significant negative correlation between the hours of PA performed and screen time. These results are in line with those reported by other studies on young people aged 6-17 years[33-35]. Therefore, the practice of out-of-school sport could minimise the negative impact of excessive screen time. Although the study made by Abarca *et al.*[36] reports the absence of a relationship between PA and screen time, it was categorical in stating that both (PA and screen time) are health-related habits of life that can be changed[18]. In this regard, schoolchildren, with no gender differences, by dedicating more time to electronic media would have less time for other activities relating to a healthy lifestyle, particularly PA and sleep, which could result in a lower perception of quality of sleep and of HRQOL[37].

As for the number of hours dedicated to PA and academic performance, we observed a statistically significant positive correlation. With regard to the school children from Soria taking part in this study, this relationship is greater for girls than for boys. It is important to point out that the time spent by the school children from Soria on PA had a positive impact on academic performance, as opposed to the negative impact reported by other studies[38,39]. Academic performance is conditioned by three factors: personal, school-related and psychosocial[40]. The positive relationship between PA and academic performance has already been described[41], in school[10,42-44] and out of school[45,46]. In our study, the difference of more than one point in the academic performance of those practising extra-curricular PA compared to those pupils who do not, not only serves to encourage students to comply with the recommendations to practice PA but also to exceed them. These results could include PA as the fourth factor relating to the academic performance of students[10]. Therefore, consideration should be given to the promotion and implementation of PA schemes, paying particular attention to the inclusion of the female gender, due to the greater relationship with PA observed in this study.

The results, evaluated using the multivariate logistic regression model, show sex, screen time, and academic performance as independent factors relating to the practice of extra-curricular PA. These results indicate that, for each additional hour of screen time, the probability of practising PA drops by 32% while, for each additional point of academic performance, the probability of practising PA is 3 times higher. When stratified by gender, the results are similar to those of the total sample. Therefore, based on the overall results obtained for screen time and academic performance, recommendations could be established with regard to the hours of sedentary leisure and promoting a habit of greater physical activity. In other words, schemes could be designed for the purpose of replacing sedentary screen time with extra-curricular PA time, in order to improve the health profiles of school children in Soria.

One significant aspect derived from the data collected from the sample of pupils at the schools in the provincial capital of Soria is that the probability of boys doing extra-curricular PA is 3 times greater than for girls. Scientific literature has reported that the percentage of girls practising sport is 20% lower than for boys[47]. This situation is probably a result of the distribution of spaces for sports and of the fact that stereotypes promoted by society conspire to reduce the interest and facilities to allow girls to practice sport48. In order to reverse this situation of inequality, the institutions or associations that organise sports activities must create schemes that positively discriminate in favour of the female gender in order to stimulate the involvement and active participation of girl pupils in any physical or sporting activity. This would make it possible to enhance sports practices in relation to those that are traditionally associated with the female cultural model, by stimulating critical competition in the face of PA stereotypes and sport.

One of the greatest strengths of the study is the quantity of measurements taken by the investigators. Notwithstanding this, the study does have a few limitations, such as the small sample size, that could limit the statistical power. However, the current healthcare situation makes it difficult to collect data and obtain the parents' consent. Another limitation relates to the fact that the HRQOL and PA and screen times were self-reported by the pupils. The self-reported measurement could have memory or social desirability biases. However, the validity of the questionnaires used has been demonstrated given that most of them have been validated and used in a number of studies[11-13].

In conclusion, the study makes it clear that the extra-curricular PA of pupils in Soria does not comply with the recommendations given by the WHO. Furthermore, extra-curricular PA is related to a lower BMI, better academic performance and less screen time. Notwithstanding this, the weekly extra-curricular PA hours are insufficient to improve the PF and HRQOL. All this information reported in our study reinforces the need to establish and strengthen future policies for intervention strategies directed at increasing the PA of schoolchildren in this context, particularly those policies that are directed at combating discrimination and making it possible to implement specific actions in favour of equality and the incorporation of the gender perspective.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Effects of the foam roller on athletes' jumping ability: a systematic review

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Summary

Introduction: It is proposed that the use of the foam roller (FR) in the sports field can be a good complement to optimize the acute improvement of range of motion and to cause an analgesic effect, however, its use in warm-up to improve neuromuscular variables such as vertical jump is controversial in athletes. Therefore, the objective of this systematic review was to analyze the effects of FR on jumping ability in athletes.
Material and method: A comprehensive, exhaustive, and structured search was carried out following PRISMA recommendations in the following databases: Pubmed/MEDLINE, Cochrane, Scopus, Sciencedirect and Web of Science. The studies that met the inclusion criteria were assessed for their methodological quality using the PEDro scale.
Results: A total of 262 records were found in the study identification phase. In the screening phase, duplicates were eliminated, and the studies were filtered by selecting the title, abstract and keywords, obtaining 47 references as a result. A total of 18 studies were analyzed in full text, 12 of which were excluded. Therefore, the total number of studies that met all the selection criteria was six.
Conclusions: The selected studies show that the application of RF is a technique that contributes to increasing the performance of jumping capacity in athletes and its effect can last up to 10 minutes after its application. However, protocols and duration times should be standardized to maximize results.

Key words:
Massage. Fascia. Athletic performance. Sports.

Efectos del *foam roller* sobre la capacidad de salto en deportistas: una revisión sistemática

Resumen

Introducción: Se plantea que la utilización del *foam roller* (FR) en el ámbito deportivo puede ser un buen complemento para optimizar la mejora aguda del rango de movimiento y para provocar un efecto analgésico, no obstante, su utilización en el calentamiento con el fin de mejorar las variables neuromusculares como el salto vertical es controversial en deportistas. Es por esto que el objetivo de esta revisión sistemática fue analizar los efectos del FR sobre la capacidad de salto en deportistas.
Material y método: Se realizó una búsqueda comprensiva, exhaustiva y estructurada siguiendo las recomendaciones PRISMA en las siguientes bases de datos: Pubmed/MEDLINE, Cochrane, Scopus, Sciencedirect y Web of Science. Los estudios que cumplieron los criterios de inclusión fueron valorados en cuanto a su calidad metodológica a través de la escala PEDro.
Resultados: Un total de 262 registros se encontraron en la fase de identificación de estudios. En la fase de screening se eliminaron los duplicados y los estudios fueron filtrados seleccionando el título, resumen y palabras clave obteniendo como resultado 47 referencias. Un total de 18 estudios fueron analizados a texto completo, siendo 12 de ellos excluidos. Por lo tanto, el número total de estudios que cumplió con todos los criterios de selección fue de seis.
Conclusiones: Los estudios seleccionados muestran que la aplicación del FR es una técnica que contribuye a aumentar el rendimiento en la capacidad de salto en deportistas y puede perdurar su efecto hasta 10 minutos después de su aplicación. Sin embargo, se debe estandarizar los protocolos y tiempos de duración para maximizar los resultados.

Palabras clave:
Masaje. Fascia. Rendimiento deportivo. Deportes.

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Introduction

The fascia is a connective tissue, mainly made up of collagen and elastin, that surrounds the muscles, nerves and blood vessels and connects the body's structures[1]. Fascia mobility can be restricted due to an injury, disease, inactivity or inflammation, affecting its normal function[2]. This can cause pain and change physical performance, reducing flexibility, muscle strength, endurance and coordination[2]. Some studies have demonstrated that fascia relaxation and stretching techniques have positive effects on the range of motion (ROM) and the muscle reaction time, generating improvements in flexibility of muscle groups such as quadriceps and hamstrings[3,4]. Over the last few years, in the field of rehabilitation and sports science, use of the Foam Roller (FR) has grown quickly as a technique to relax the fascia to prepare for exercise and recover muscle functions[5].

The FR is a self-myofascial release tool in the shape of cylinder, which comes in different sizes and densities. Its action mechanisms are based on the pressure exerted by the body mass on the FR.[6,7] It has been reported that using an FR improves the range of articular movement[8-10], reduces pain[7], assists post-exercise recovery[9,11] and improves neuromuscular performance[7].

On the other hand, jumping ability has been a focus of interest among sports-related researchers as it directly affects performance. In this respect, strategies such as dynamic stretching and myofascial release techniques have been used to improve jumping ability[12,13]. The assessments most used to measure the jumping ability include the Squat Jump (SJ), the counter movement jump (CMJ) and the Abalakov[14,15]. It has been highlighted that the reduction of muscle-tendon and myofascial structure flexibility causes a delay in muscle activation, affecting motor performance in sporting skills such as jumping[15]. It is also suggested that using an FR in sport can provide a good complement to optimise the acute improvement in the ROM and cause an analgesic effect. However, its use in warm-up to improve neuromuscular variables such as vertical jumping is controversial among athletes[16]. Consequently, the purpose of this systematic review was to analyse the effects of the FR on jumping ability among male and female athletes aged over[18].

Material and method

Search strategy

A comprehensive, exhaustive and structured search was performed following PRISMA-P recommendations in five generic databases: Pubmed/MEDLINE, Cochrane, Scopus, Sciencedirect and Web of Science, between 21 March and 21 May 2021. All the articles found in the search were downloaded and cross-referenced manually to identify duplicates. The titles and abstracts were selected for subsequent review of the complete text. The articles included in this search ranged from 2011 to 2021. The following key words were used to build the information search chain in the aforementioned databases: ("**foam roller"** OR *"roller massager"* OR *"self myofascial release"* OR *"foam rolling")* AND *("jump"* OR *"squat jump"* OR *"countermovement jump"* OR *"performance").*

Eligibility criteria

Controlled experimental (clinical trials), quasi-experimental and pre-experimental studies were considered. The inclusion criteria for this review were as follows:

- original articles written in English, Spanish or Portuguese;
- published between 1 January 2011 and 21 May 2021;
- the study population is adult athletes, irrespective of gender. Adults are understood to be over the age of 18;
- interventions that use a foam roller;
- with or without a control group;
- that include at least one jumping ability assessment before and after the intervention.

On the other hand, the exclusion criteria were:

- cross-discipline, retrospective and prospective studies or when the intervention is not focused on using the foam roller;
- studies that are not original research publications (such as letters to the editor, translations, notes, book reviews);
- duplicate articles;
- review articles (such as meta-analysis, systematic reviews, narrative reviews);
- case studies (meaning studies that only use one person).

Selection of the studies and data compilation

The studies were exported into the EndNote reference administrator (version X8.2, Clarivate Analytics, Philadelphia, PA, USA), where they were filtered once the title, abstract and keywords had been selected. It was only necessary to use the complete text of the article in a few cases. Two authors (MAR, EGM) carried out the process independently. Any possible discrepancies between the two reviewers on the study conditions were resolved by consensus with a third author (PVB). Subsequently, the full text of potentially eligible studies was reviewed and the reasons for excluding studies that did not meet the selection criteria were justified. The study data was extracted by two authors independently, using a form created in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA).

Assessment of the methodological quality

The selected studies were assessed using the PEDro scale. This scale assesses the methodological quality of the research, considering 11 points that include bias procedure, statistical analysis, information on randomising and presentation of the results in the research being assessed[17]. Criterion 1 assesses external validity, and it is not included in the final result. Criteria 2 to 11 assess the internal validity of the article using a standardised scoring system (ranging from 0 to 10). Studies with a ≥6 score on the PEDro scale were considered to have excellent methodological quality, 4-5 regular and ≤3 poor[18].

Results

The search process is explained in Figure 1. A total of 262 records were found in the study identification phase (PubMed/MEDLINE = 21, Cochrane = 67, SCOPUS = 64, Sciencedirect = 59, Web of Science = 51). The screening phase removed any duplicates, and the studies were filtered by selecting the title, abstract and keywords which selected 47 references. A total of 18 studies were analysed using the full text, and six were excluded because the sample was not athletes; one because comparisons were not made pre and post intervention; one because it did not assess jumping ability and two because they did not use the foam roller as the main intervention method. After this process, six studies met all the selection criteria[19-24].

The general data for the studies included in this systematic review are shown in Table 1. The 6 studies found by the systematic search were published between 2017 and 2020.

Out of the articles selected, five correspond to randomised clinical trials and one corresponds to a non-randomised clinical trial. Table 2 shows the results of the assessment of the methodological quality, where five of the studies were assessed to have excellent methodological quality and one as regular. Therefore, all these studies were considered for the systematic review.

Sample characteristics

Regarding the quantity of sample studied in the interventions, two studies assessed between 40 and 42 participants[20,21], three studies between 23 and 30 participants[19,22,24] and one studied assessed[18,22].

In relation to the age and gender of the sample, some studies considered participants from both genders within the research. Lin *et*

Figure 1. Selection procedure for articles in the bibliographic searches.

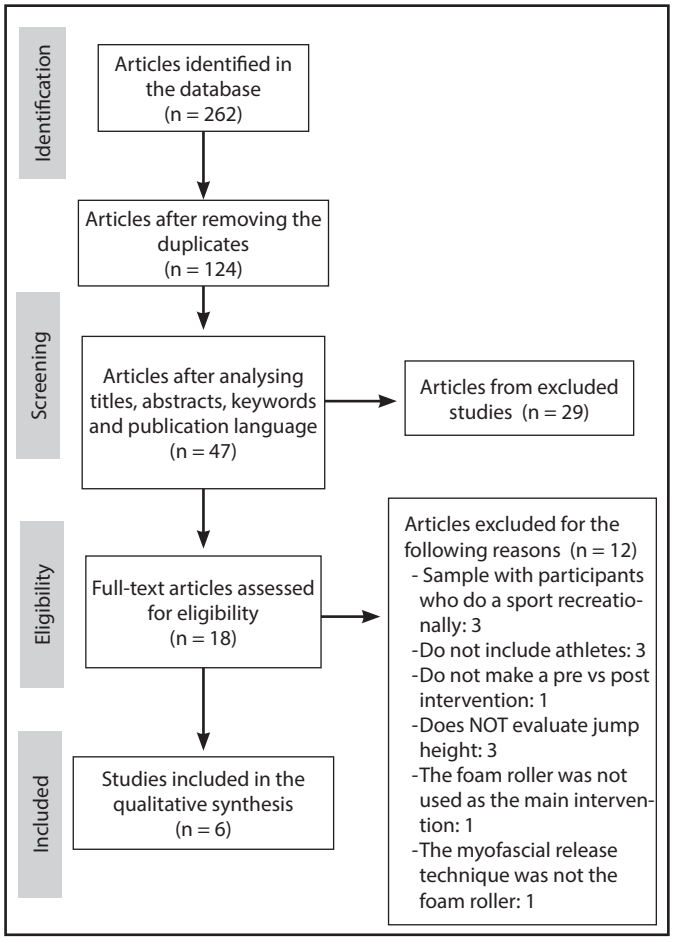

Table 1. Summary of the studies included in the systematic review.

Author	Sample	Age range	Sport	Intervention protocol	Duration of the training	Types of jumps assessed	Results
Kyranoudis *et al*. (2019).	24 male participants divided into 2 groups Control group (n=11) FR group (n=13)	20 to 22 years old	Football	Both groups warmed up for 5 minutes. FR group: Sliding along adductor, hip, quadricep, hamstring and gastrocnemius muscles. Furthermore, static stretching was included on each muscle group. Duration: 30 seconds of FR and 10 seconds of static stretching on per muscle group. It was done on both sides. Control group only did 10 seconds of static stretching on the same muscle groups as the FR group.	1 session	CMJ ABK	Control group: CMJ (cm) pre: 37.07 ± 3.12 post: 38.25 ± 5.20* Abalakov (cm) pre: 44.68 ± 4.92 post: 45.57 ± 5.19 FR group: CMJ (cm) pre: 35.36 ± 6.5 post: 36.72 ± 6.48* Abalakov (cm) pre: 43.29 ± 6.84 post: 43.79 ± 6.19

(continue)

Table 1. Summary of the studies included in the systematic review (continuation).

Author	Sample	Age range	Sport	Intervention protocol	Duration of the training	Types of jumps assessed	Results
Portilla-Dorado *et al.* (2017).	23 male participants divided into 3 groups Control group, FNP group and FR group (no information provided on participant distribution)	20 to 28 years old	Football	Weekly FR protocol: Day 1: sliding along gluteal muscles and external hip rotators, tensor fasciae latae, hamstrings, biceps femoris and quadriceps. Day 2: sliding along calf, biceps femoris, hamstrings, medial calf, peroneal and tibia muscles. Day 3: sliding along quadricep, gluteal, external hip rotator, hamstring and biceps femoris muscles. Duration: 2 repetitions of 30 seconds, 20 seconds of rest. It was done on both sides. The FNP group also performed 3 weekly sessions, with the same characteristics as the FR group on both the muscle groups and the volume of work.	8 weeks Frequency of 3 times a week	CMJ ABK	Control group: CMJ (cm) Pre: ~30 post: ~29 ABK (cm) Pre: ~35 Post: ~31 FNP group: CMJ (cm) Pre: NR post: NR ABK (cm) Pre: ~38 Post: ~39* FR group CMJ (cm) Pre: ~30 Post: ~34* ABK (cm) Pre: ~36 Post: ~39*
Romero-Franco *et al.* (2019).	30 participants (18 men and 13 women) divided into 2 groups Control group (n=15) FR group (n=15)	18 to 25 years old	Athletics (discipline not mentioned)	Both groups warmed up for 8 minutes. FR group: Sliding on hamstrings, quadriceps and triceps surae. Duration: 45 seconds for each muscle group. 15 seconds of rest. It was done on both sides.	1 session	CMJ	Immediately post intervention Control group (cm) Pre: 34.4 ± 10.4 Post: 36.4 ± 9.1* 10 min: 35.9 ± 7.7 FR group (cm) Pre: 31.6 ± 7.7 Post: 35.6 ± 8.0* 10 min: 33.3 ± 8.1*
Lin *et al.* (2020).	40 participants (25 men and 15 women) took part in 2 interventions. Dynamic stretching and vibratory FR.	20 to 30 years old	Badminton	FR protocol: sliding along quadriceps, hamstrings, gastrocnemius, rotator cuff and lumbar spinal. Duration: 20 seconds for each muscle group. It was done on both sides.	1 session	CMJ	Dynamic stretching group (cm) Pre: 37.7 ± 9.5 Post: 39.6 ± 10.5* FR group (cm) Pre: 37.4 ± 9.3 Post: 38.2 ± 9.6*
Pişirici *et al.* (2020).	42 participants (21 men and 21 women) divided into 3 groups Dynamic stretching group (n= 14) Graston instrumental manual technique group (n=14) FR group (n=14)	18 to 35 years old		Recreational running.	1 session	CMJ	Dynamic stretching group (cm) Pre: 19.85 ± 7.17 Post: 24.57 ± 9.31* Graston instrumental technique group (cm) Pre: 21.28 ± 7.40 Post: 26.57 ± 8.17* FR group (cm) Pre: 17.14 ± 5.69 Post: 20.78 ± 5.72*
Rey *et al.* (2017).	18 participants divided into 2 groups: Control group (n=9) FR group (n=9)	22 to 30 years old	Football	Both groups carried out a 60-minute football session between the pre and post assessment. FR protocol: sliding along quadricep, hamstring, adductor, gluteal and gastrocnemius muscles. Duration: 45 seconds on each muscle group, 15 second rest. It was done on both sides.	1 session	CMJ	Control group (cm) Pre: 32.33 ± 5.43 Post: 30.36 ± 4.53* FR group (cm) Pre: 31.32 ± 4.28 Post: 30.26 ± 3.34

FR: Foam Roller; CMJ: counter-movement jump; ABK: Abalakov jump.
*Significant differences ($p < 0.05$).

Table 2. PEDro scale for methodological assessment of the included studies.

Study	Criteria											Total
	1*	2	3	4	5	6	7	8	9	10	11	
Kyranoudis *et al.*, 2019.	1	0	0	1	0	0	0	1	1	1	1	5/10
Portilla-Dorado *et al.*, 2017.	1	1	0	1	0	0	0	1	1	1	1	6/10
Romero-Franco *et al.,* 2019.	1	1	1	1	1	0	1	1	1	1	1	9/10
Lin *et al.,* 2020.	1	1	0	1	0	0	0	1	1	1	1	6/10
Pişirici *et al.,* 2020.	1	1	1	1	0	1	1	1	1	1	1	9/10
Rey *et al.*, 2017.	1	1	0	1	0	0	0	1	1	1	1	6/10

*Criterion is not considered in the total score.

al., (2020)[20] included men (n = 25) and women (n = 15) with an average age of 20.35 years old, while Pişirici *et al.,* (2020)21 included participants with an average age of 22.7 years old (men n = 21; women n = 21). On the other hand, Romero-Franco *et al.,* (2019)24 also recruited participants from both genders in the sample studied with an average age of 24.5 (men n = 18; women n = 13).

Finally, three research projects considered an exclusively male sample with an average age of 21.7 years old (n = 24), 24.35 years old (n = 23) and 26.6 years old (n = 18), respectively[19,22,23].

Therefore, this review includes a total sample of 177 athletes, of whom 48 were female and 129 male.

Measuring the jumping ability

To evaluate the effects of the FR in the jumping tests, the selected studies used various instruments which quantified the height in centimetres. Two research projects used the mobile phone app My Jump[20,24], which analyses movement using video photograms. Another two studies[19,21] used the OptoJump system, which is an optical detection system comprising a transmitter and infra-red LED receiver bar that detect interruptions in a defined space. Finally, two research projects used a contact platform called Ergojump[23] and Axon jump[22], respectively.

Concerning the number of attempts, three studies made 3 attempts and selected the greatest height[20,21,24], one study reports 2 attempts[23], and two research projects do not declare the number of attempts made[19,22]. In relation to the above, two studies report 1-minute rests between attempts[20,23] and four research projects do not specify rest protocols[19,21,22,24].

Protocols for FR intervention and dosing

Regarding the duration of the interventions, five of the selected studies analysed the acute effect of the FR on the jumping ability in one intervention session[19-21,23,24]. Within these protocols, it is important to highlight the study by Rey *et al.,* (2017)[23], where, after their initial assessments, the athletes took part in a 60-minute football training session. The FR was used after this training session, and they were assessed after these activities to determine how the FR affected recovery. In turn, the research by Portilla-Dorado *et al.*, (2017)[22] lasted 8 weeks with 24 FR intervention sessions (3 sessions a week), where the jumping assessments took place before and after the 8 weeks of interventions.

The intervention protocols consisted of sliding the FR along various muscle groups. All the studies used the FR on both extremities and on most muscle groups on the lower limbs, including gluteal, tensor fasciae latae, hamstring, quadriceps and triceps surae muscles[22-24]. The study by Portilla-Dorado *et al.*, (2017)[22] used two 30-second series per muscle group, while two interventions[23,24] used one 45-second series on each muscle group. Kyranoudis *et al.*, (2019)[20] in 1 series combined sliding the FR for 30 seconds with 10 seconds of static stretching on quadriceps, hamstring, abductor and gastrocnemius muscles on each limb. In turn, Pişirici *et al*., (2020)[21] applied 1 series of FR lasting 3 minutes on hamstrings, 3 minutes on gastrocnemius and 2 minutes on the plantar fascia. Finally, the study by Lin *et al.*, (2020)[20] applied 1 series of vibrating FR bilaterally on muscles in the lower limbs, lumbar region and rotator cuff for 20 seconds on each muscle group.

Regarding the intensity, the modified Borg scale was used to control the degree of force. However, the ranges of values were not indicated[22]. The intensity was also controlled using self-regulation of force, working with the maximum tolerable intensity[20,21]. The rest of the studies did not report the intensity applied in their interventions[19,23,24].

Main results

The selected studies show that applying the FR is a technique that helps to increase the performance in jumping ability among athletes[19-22,24], and its effect can last up to 10 minutes after application[24]. Prior to the intervention, Lin *et al.,* (2020)[20] recorded an average jump of 37.4 cm and after use of FR, they measured 38.2 cm in CMJ, which was a statistically significant increase ($p < 0.05$). In turn, Kyranoudis *et al.*, (2019)[19] saw significant differences ($p < 0.05$) in the CMJ height when applying static stretches + FR (pre: 35.36 ± 6.5 cm; post 36.72 ± 6.48 cm) but not in Abalakov (pre: 43.29 ± 6.84 cm; post: 43.79± 6.19 cm). Romero-Franco *et al.,* (2019)[24], analysed the effects of FR on the CMJ height among athletes,

where the intervention with FR had major changes (pre: 31.6 cm; post: 35.6 cm) compared to the control group (pre: 34,4 cm; post 36,4 cm), where the comparison between the groups was significant. This study carried out an assessment 10 minutes after applying the FR, where it was seen that the effect on the jumping capacity was maintained in this period of time, a result that was statistically significant.

Pişirici *et al.,* (2020)[21] compared three techniques to observe changes in the CMJ height. In the three groups, significant increases were seen in the jumping height ($p<0.05$): FR (pre:17.14 cm; post 20.78 cm), dynamic stretching (pre: 19.85 cm; post: 24.57 cm) and Graston technique (pre: 21.28 cm; post: 26.57 cm). There were no significant differences ($p >0.05$) when comparing the percentage change between the three techniques. Portilla-Dorado *et al*., (2017)[22], analysed the jumping ability among football players using CMJ observing significant favourable changes ($p <0.05$) in favour of the FR protocol in the jump height (pre: 30 cm; post 34 cm) compared to the control group (pre: 30 cm; post 29 cm).

Rey *et al*., (2017)[23] analysed the effects of the FR on the jump height after a 60-minute football training session. The jump height performance does not demonstrate significant changes with the use of FR (pre: 31.32 cm; post: 30.26 cm) compared to the control group (pre: 32,33 cm; post 30,36 cm) there was a significant decrease in the jump height ($p <0.05$).

Discussion

The aim of this systematic review was to analyse the effects of applying the FR on the athletes' jumping ability. 262 studies were reviewed for this purpose and 6 met the inclusion criteria. The main finding in this review suggests that a myofascial release protocol with FR is an effective technique to increase athletes' vertical jumping performance. The intervention protocols analysed in this review are important, as 5 studies analysed the effects of the FR acutely in a single session[19-21,23,24], while only one study analysed the effect of the FR during 24 sessions over 8 weeks[22]. Four of the studies reported a statistically significant acute effect on jumping capacity ($p <0.05$) when working with FR compared to the control groups. This is relevant as other training protocols such as plyometrics[25], traditional strength and Olympic movements[26,27] must be applied for several weeks to show positive results in vertical jumping performance.

In our review, the results show that among athletes, FR use has a favourable acute effect on jumping ability performance. It has been proposed that the use of the FR, as a self-myofascial release technique, reduces rigidity in muscles and tendons, eases tissue relaxation through afferent signals to the central nervous system[28]. Therefore, like static stretching, the self-myofascial release with FR could also increase tolerance to neural stretching, causing an increase of ROM[28]. However, several research projects have demonstrated that static stretching does not improve muscle performance[29,30]. In fact, this relaxation of the muscles and neural inhibition have been presented as causes of reducing post static stretching performance. Therefore, the FR has other mechanisms which cause an increase in muscle performance. It has been demonstrated that rolling along soft tissue with an FR could increase both tissue temperature and local blood flow. This would make the tissues more elastic, which encourages the generation of explosive force in jumps that include a counter movement due to a greater accumulation and release of energy during the motor movement[31]. This explains why we believe that in the results of our review, all the studies analysed included CMJ to determine gain in vertical jump height after FR use. Furthermore, it is one of the most popular tests in intermittent and explosive sports.

The capacity of the FR to affect other factors such as the ROM can influence mechanisms leading to positive effects on jumping ability. Thirty to forty seconds of FR sliding, 3 times a week, demonstrates positive effects on the ROM[32]. It has also been reported that the FR can affect the ROM acutely, increasing the dorsiflexion of the ankle up to 60 minutes after the intervention[33]. The increase of the ROM can also influence vertical jumping height performance, as it allows the muscle-tendon unit to generate a greater quantity of force.

One limitation of this review was that it was impossible to meta-analyse the data due to the diversity of instruments and protocols used by the research projects being analysed. The strengths of this review include the use of an internationally recognised scale for the methodological quality of the studies being reviewed. Another strength of this review is that it followed the PRISMA-P recommendations and so it can ensure a comprehensive, exhaustive and structured search for the information compiled.

Conclusions

Interventions with FR produce an acute improvement in athletes' jumping ability (recreational, elite, amateur). There is a favourable trend linking the use of the FR and the increase in the ROM and performance, although the scientific evidence should go into greater depth on the mechanisms which bring about these improvements. The optimum volume of work suggested by this review is 1-2 series of sliding on each muscle group for 30-45 seconds, although protocols and durations should be standardised to maximise the results.

Conflicts of interest

The authors declare that there is no conflict of interest.

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High-intensity interval training among healthy older adults. A systematic review

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Summary

Introduction: Due to demographic changes in fertility and mortality, it is predicted that in 2050 the proportion of the world population aged 60 and over will increase from 11% to 22%.
Objective: To analyze the effects of high-intensity interval training in healthy older adults.
Material and method: A bibliographic search was carried out in the following Pubmed, Scielo and ScienceDirect databases, using the Boolean terms High-intensity interval excercise OR High-intensity interval training OR high intensity interval activity AND aged OR older adult OR elderly. The PICoR strategy was used to define eligibility criteria (P) Healthy Older Adults, (I) Use High Intensity Interval Training (HIIT), (C) be subjected to evaluation using the PEDRO scale and obtain a score equal to or greater than 6 points, (O) effect of high-intensity interval training in Adults Healthy elderly (S) studies with control groups or other interventions, published between the years 2016 to 2021.
Results: 1.516 articles were identified, but only those that met the inclusion criteria (7 studies) were included. Significant improvements in sleep quality, fatigue, and body composition were obtained by combining HIIT training with nutritional support. Other improvements were obtained in strength, anabolic hormones, blood lipids, VO2max, exercise tolerance, and systolic BP using only HIIT training.
Conclusion: The adapted HIIT training is applicable to healthy older adults and causes significant improvements in this age group.

Key words:
High-intensity interval training. Healthy older adult. Sports training.

Entrenamiento intervalado de alta-intensidad en el adulto mayor sano. Una revisión sistemática

Resumen

Introducción: Debido a los cambios demográficos de fecundidad y mortalidad se predice que en el año 2050 la proporción de la población mundial de 60 años y más, aumentará del 11% al 22%.
Objetivo: Analizar los efectos del entrenamiento intervalado de alta-intensidad en el adulto mayor sano.
Material y método: Se realizó una búsqueda bibliográfica en las siguientes bases de datos Pubmed, Scielo y ScienceDirect, con la utilización de los términos boleanos High-intensity Interval excercise OR High-intensity interval training OR high intensity interval activity AND aged OR older adult OR elderly. Se utilizó la estrategia PICoR para definir criterios de elegibilidad (P) Adultos mayores sanos, (I) Utilizar Entrenamiento intervalado de alta intensidad (HIIT), (C) ser sometidos a evaluación mediante la escala de PEDRO y obtener en esta un puntaje igual o superior a 6 puntos, (O) efecto del entrenamiento intervalado de alta intensidad en el Adulto Mayor sano (S) estudios con grupos control u otras intervenciones, publicados entre los años 2016 a 2021.
Resultados: Se identificaron 1.516 artículos, pero solo se incluyeron los que cumplieron con los criterios de inclusión (7 estudios). Se obtuvieron mejoras significativas en la calidad de sueño, fatiga y composición corporal combinando un entrenamiento HIIT con apoyo nutricional. Otras mejoras se obtuvieron en fuerza, hormonas anabólicas, lípidos en sangre, Vo2máx, tolerancia al ejercicio y PA sistólica solo utilizando entrenamiento HIIT.
Conclusión: El entrenamiento HIIT adaptado, es aplicable a adultos mayores sanos y provoca mejoras significativas en este grupo etario.

Palabras clave:
Entrenamiento intervalado de alta intensidad. Adulto mayor sano. Entrenamiento deportivo.

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Introduction

The Economic Commission for Latin America and the Caribbean (CEPAL) determines that the ageing population is a consequence of the evolving components of demographic change (fertility and mortality)[1,2]. It predicts that in 2050, the proportion of the world's population aged 60 and over will increase from 11% to 22%. Furthermore, it is said that between 2025 and 2030, the life expectancy in Latin America and the Caribbean will rise to 80.7 years old for women and 74.9 for men[3]. Likewise in Chile, it is expected that by 2025, adults aged over 60 will make up 20% of the population, exceeding the under 15 age bracket from that year onwards[4]. This change implies the challenge of healthy ageing[5], so the National Senior Service (SENAMA)[4], and the Ministry of Health (MINSAL)[6] have implemented a series of programmes to benefit older adults (OA), people who have reached the age of 60 or above. These programmes aim to promote active ageing, encouraging intergenerational encounters, creating favourable environments that provide good quality of life, delay levels of dependency and remain functional and autonomous for as long as possible[7]. It is known that functional impairment is one of the main factors influencing poor quality of life, with lethal effects on their state of health[8].

Ageing is a normal process in the life cycle, characterised by a progressive loss of functional reserve, both molecularly, cellularly and systemically, affecting the physiological capacity of maintaining homoeostasis, which causes changes at a cognitive, physiological, physical, psychological and social level[9,10]. Consequently, the World Health Organisation (WHO)[11] and other authors[12,13] agree that physical exercise during ageing has multiple benefits, including a lower mortality rate in all its causes[11], better functional health[11,14-16], and prevention or delay of cognitive deterioration[14,17].

Considering these benefits and the WHO recommendations for older adults, one striking option is high-intensity interval training (HIIT), which consists of short episodes of high-intensity exercise (>85% of VO_{2max}), alternating with low-intensity active rest or recovery periods (20-40% VO_{2max})[18]. Its main objective is to improve the maximum oxygen consumption (VO_{2max})[19]. This training method has proven to be effective among different populations and in a wide range of pathologies: children[20], teenagers[21] and young adults[22] with cardiometabolic alterations such as obesity[23], diabetes[24], hypertension[25], and metabolic syndrome[26,27]. As Abarzúa *et al*.[28] and Martín *et al*.[29] mention, HIIT induces improvements in muscular and cardiovascular aptitude and body composition among healthy teenagers. It has also proven highly effective among adults, even in heart transplant recipients by improving VO_{2peak}, maximum heart rate, and heart rate reserve[30].

In summary, we can determine that HIIT training, apart from its main objective of improving VO_{2max}, can be highly effective for other variables. However, in relation to using HIIT among older adults, López-Chicharro[19] establishes that considering the actual features of HIIT, it is not possible in physiological terms to apply a real HIIT to older adults, so it must be individualised, adapting to the characteristics of each subject, plus their behaviour, preferences and goals.

According to the above, the aim of this systematic review is to analyse the effects of HIIT training on healthy older adults.

Material and method

This systematic review was performed according to the rules determined in the PRISMA declaration[31].

Search strategy

A bibliographic search was performed in both English and Spanish, for a period between January 2016 and April 2021, using the Pubmed, Scielo, and ScienceDirect databases. The eligibility criteria were determined based on the PICoR strategy:

P (Participants/Population): healthy older adult.

I (Intervention): High-intensity Interval Exercise.

C (Comparison): with control groups or other interventions.

O (Outcomes): effect of high-intensity interval training among healthy older adults.

The search descriptors used were: *High-intensity Interval exercise AND older adult, High-intensity Interval exercise AND elderly, High-intensity Interval exercise AND aged; High-intensity interval training AND older adult, High-intensity interval training AND elderly, High-intensity interval training AND aged; High intensity interval activity AND older adult, High intensity interval activity AND elderly, High intensity interval activity AND aged.*

Selection of articles and inclusion criteria

The inclusion criteria were:

- Sample of healthy older adults.
- Experimental and quasi-experimental papers, controlled - randomised.
- No gender distinction.
- Free articles.

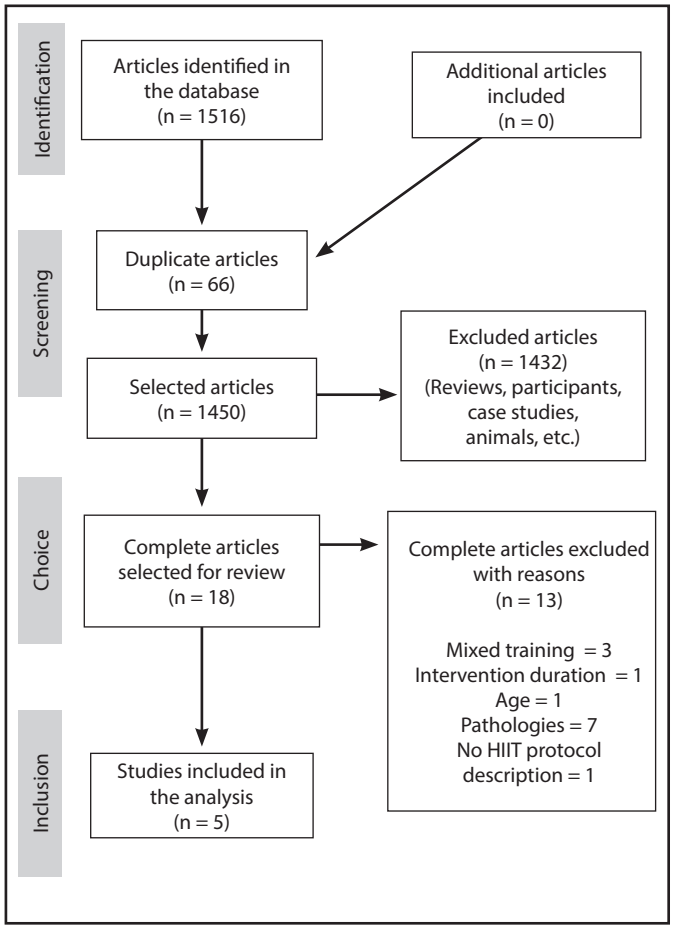
Quality assessment

The methodological quality assessment used the PEDro scale[32]. The PEDro scale is based on the Delphi list developed in the Editorial or Thesis department. The articles selected by title and abstract should meet the conditions indicated in the search strategy (inclusion criteria).

Information collection

The search for articles in the Pubmed, Scielo and ScienceDirect databases produced a total of n=1.516. Sixty-six duplicate articles were removed, and no additional articles were added to the search. From reading the titles and abstracts, 18 articles were selected. Subsequently, based on the complete reading of the articles, 13 articles were excluded for the following reasons: mixed training or combined with other training, uncontrolled pathologies, age under 60, duration of the

Figure 1. Flow chart for study selection.



intervention in years and due to not describing the HIIT intervention, finally selecting 5 articles that meet the inclusion-exclusion criteria (Figure 1) and PEDro scale.

Results

The methodological quality results for each article selected for the systematic review are presented in Table 1, which present methodological quality according to the PEDro scale between 6 and 9 points.

It is considered that studies scoring 9-10 on the PEDro scale have excellent methodological quality. Studies with a score between 6-8 have good methodological quality, between 4-5 regular quality and below 4 points poor methodological quality[33], so in general the selected articles present good methodological quality.

Table 2 presents the variables studied in the included articles. Based on the information compiled, we obtained a total studied population of 245 older adults: men (n=115) and women (n=130), aged 60 or over, who were assigned at random to groups of HIIT vs MIIC[34], HIIT v/s aerobic training[35], HIIT+CIT v/s HIIT+PLA[36], HIIT v/s GC[37], and HIIRT v/s TRT[38].

The total volume of the interventions made in the selected articles is between 2 and 12 weeks of application, with a frequency of 2 to 3 times a week, the duration of each training session varies between 16.5 min and 60 min including the warmup and cool-down (see Table 3).

The drop-out percentage among participants in the studies by Herrod and Bruseghini was 0%[35,37], while in Moro's study, although 34% dropped out, only 11% represented the HIIT group[38], as in the study by Buckinxet *et al.*[36] where the drop-out rate was lower for HIIT than in other types of training.

In relation to the outcomes (sleep quality and fatigue)[34], there were no significant differences between the HIIT and MIICT groups. However, the HIIT group did obtain significant PRE-POST differences regarding improved sleep quality and, in turn, a significant drop in their fatigue scores.

Regarding body composition and the effect of HIIT, HIIT significantly improved the body composition in the study by Buckinx *et al.*[36] which assesses the influence of ingesting proteins on the combined effect of HIIT+CIT, significantly decreasing the total fat mass and significantly increasing the lean mass, while in articles by Moro *et al.*[38] and Herrod *et al.*[37], there were slight but not significant changes. The study by Buckinx *et al.*[36] also demonstrated that HIIT combined with ingesting Citrulline would be more beneficial in obese older adults who eat less than 1 g/kg/day of protein a day as there are greater improvements in the body composition. Regarding muscle strength that is assessed in two studies, both saw a significant improvement[36,38].

In the functional abilities, HIIT scored significant improvements for all parameters (Timed up and go test, support test in chair, one-leg balance test, 6-min walking test). However, differences between groups were not significant[36]. Regarding the maximum oxygen consumption, this rose significantly after 6 weeks of HIIT, but not 4 or 2 weeks from the intervention[37]; for tolerance to the HIIT exercise, there was a significant

Table 1. PEDro scale to assess the methodological quality of the selected studies (n = 5).

Authors-year	1	2	3	4	5	6	7	8	9	10	11	Total score
Jiménez *et al.*[34]	1	1	1	1	0	0	1	1	1	1	1	9
Bruseghini *et al.*[35]	1	1	0	0	0	0	0	1	1	1	1	6
Buckinx *et al.*[36]	1	1	1	0	0	0	0	0	1	1	1	6
Herrod *et al.*[37]	1	1	0	1	0	1	1	1	1	1	1	9
Moro *et al.*[38]	1	1	1	1	0	0	0	0	1	1	1	7

Table 2. Variables studied from the included articles (n = 5).

Authors-year	Participants	Intervention	Comparison	Outcomes	Result
Jiménez *et al.*[34]	n = 73 (H = 17, M = 56) (HIIT = 26, MIICT = 24, GC = 23)	12 weeks (2/week) 45' x session, HIIT 4X4' 90-95% FCM TRX MIICT 70% FCM TRX	HIIT V/S MIICT	Sleep quality Fatigue	↑ ↓
Bruseghini *et al.*[35]	n = 24 (H = 24) (HIIT =12, Aerobic = 12)	8 weeks (3/week) HIIT Bike 7x2 85-95% VO_{2max}.	HIIT V/S Aerobic	Physical activity Energy expenditure	↑ =
Buckinx *et al.*[36]	n = 73 (H = 33, M = 40)	12 weeks (3/week) HIIT Elliptic trainer 10 x 30" (80-85%) x 90" (65%)FC_{max}.	HIIT+CIT V/S HIIT+PLA	Body composition Muscle strength Functional abilities	↑ ↑ ↑
Herrod *et al.*[37]	n = 40 (H = 21, M = 19) (HIIT = 30, GC = 10)	2-4-6 week (3/week) HIIT static bike 5 x 60" (90% -110% $POT_{max.}$) x 90" (Active)	HIIT V/S CG	Anaerobic threshold VO_{2max} Tolerance to exercise Systolic arterial pressure Diastolic arterial pressure Body composition	= ↑ ↑ ↓ = =
Moro *et al.*[38]	n = 35 (H = 20, M = 15) (HIIT = 18, TRT = 17)	16 weeks (2/week) HIIT of strength 6RM (80%) x 20" + rep to fail (80%) x 20" + 2-3 rep (80%) x 2'30"	HIIRT V/S TRT	Body composition Strength Anabolic hormones Lipids in the blood	= ↑ ↑ ↑

HIIT: High-intensity interval training; MIICT: Moderate-intensity interval training; CIT: Citrulline; PLA: Placebo; CG: Control group; HIIRT: High-intensity interval resistance training; TRT: Traditional Resistance Training.
*Statistically significant difference in HIIT/outcomes.

Table 3. Intervention characteristics.

Articles	Participants	Method/ intensity	Frequency times a week	Duration	Recovery	Total time (min)	Intervention duration (week)
Jiménez *et al.*[34]	n = 26	TRX 90-95% maximum pulse rate	2	4 x 4 min.	3 min.	48	12
Bruseghini *et al.*[35]	n = 12	Cycling 85%-95% VO_{2max}.	3	7 x 2min	2 min. 40% $VO_{2max.}$	45 - 60	8
Buckinx *et al.*[36]	n = 73 (H = 33, M = 40)	Elliptic trainer 80%-85% HR_{max}.	3	10 x 30 seg.	90 seg. 65% $FC_{max.}$	30	12
Herrod *et al.*[37]	n = 30	Cycling 90%-110% POT_{max}	3	5 x 1min.	90 s	16.5	2 4 6
Moro *et al.*[38]	n=18	6 RM 80% 1 RM	2	It is measured in repetitions x RM	20 s	45	16

interaction demonstrated in the 2, 4 and 6 weeks of training[37]; for the systolic arterial pressure (SAP) at rest, HIIT demonstrates a significant drop after 4 and 6 weeks of training, but not after 2 weeks and there were no significant differences in diastolic arterial pressure after 2, 4 or 6 weeks of HIIT training[37]. Finally, and in relation to anabolic hormones and lipids in the blood, although cortisol levels were higher in both training groups (TRT and HIIRT), this was only statistically significant in the HIIRT group; insulin only dropped significantly for the HIIRT group; the baseline level of growth hormone (GH) dropped significantly in TRT and not in HIIRT; both groups saw an improvement in their lipidic profile, but only HIIRT obtained statistically significant differences ($p < 0.05$)[38].

Another finding is that HIIT does not negatively affect the lifestyle of active older adults, as it does not reduce daily energy expenditure or increase sedentary time[34].

Discussion

The aim of this review was to assess the effects of a HIIT programme as a means of healthy training in healthy older adults (>60 years old). The studies included have demonstrated that using a well-applied and controlled HIIT among older adults effectively shows improvements in different indicators such as: sleep quality and fatigue[34],, energy expenditure[35]; functional capacity and body composition[36]; physical strength[37]; muscle strength[36,38]; tolerance to exercise[37]; anabolic hormones and lipids in the blood[38]; systolic arterial pressure and VO_{2max}[37].

When referring to sleep quality, in this aspect Štefan *et al.*[39] demonstrates that older people who report a short sleep duration are less likely to meet the physical activity recommendations for their age group. However, people who report a prolonged sleep duration and

good sleep quality are more likely to meet these same recommendations. There are also many therapeutic interventions for sleep treatment, including pharmaceutical treatments[40], however, due to their side effects, non-pharmacological interventions are recommended[41] such as physical exercise[42].

Regarding VO_{2max}, frequently used as a cardiorespiratory fitness indicator and considered fundamental to promote health[43], analysis of the results shows us that 6 weeks or more of HIIT are required to observe a significant improvement, and the same can be said for the resting SAP which requires a minimum of 4-6 weeks of intervention, in line with the study by Wen *et al.*[44] and Batacan *et al.*[45] which recommends long interval HIIT (≥2min), with high volume (≥15min) and moderate to long term (≥4-12 weeks) to maximise the effects on VO_{2max}.

It could also be seen that a combination of HIIT with nutritional support can increase the beneficial effects in the body composition of Older Adults with obesity[46].

Although the HIIT training obtained all these improvements, it is important to mention that, among the articles studied, no two protocols are alike, either in quantity of intervals, training method (TRX, cycling, elliptic trainer, static bike, RM) or total duration of the intervention, so it is difficult to determine the ideal protocol to generate significant changes in older adults. However, something important that they do have in common is the low percentage of drop-outs or injuries related to the training, even 0%[35,37], which supports the motion that HIIT is a good training strategy that stimulates adaptations in healthy older adults[47], and in other articles[34,36,38] where subjects do drop out, this refers to no more than 2 to 4 participants, and their reasons for this are not related to the HIIT training.

To adapt the participation of the Older Adults in HIIT, the scientific evidence even suggests including an adaptation period of 4 weeks[38], prior to the HIIT which involves strength exercises, and also carrying out HIIT with low impact exercises, on the static bike or elliptic trainer when working with obese and/or sedentary adults, to thereby reduce the risk of injuries and the percentage of drop-outs.

The results obtained in this review paper can be considered novel and positive, given the beneficial effects of a HIIT intervention on a healthy elderly adult, where an adapted programme can bring about significant improvements, with a minimum of 4 weeks of interventions, in maximum heart rate, systolic arterial pressure at rest, quality of sleep and tolerance to fatigue, as well as reducing the baseline insulin levels and reduction of baseline cholesterol considered as a good non-pharmacological way of improving their lifestyle, with no compensatory effects on older adults.

Conclusion

In conclusion, the 5 articles under review provide evidence that adapted HIIT can lead to significant improvements in healthy older adults, involving a minimum of 4 weeks of interventions, with improvement in maximum heart rate, systolic arterial pressure at rest, quality of sleep and tolerance to fatigue, as well as reducing the baseline insulin levels and reduction of baseline cholesterol considered as a good non-pharmacological way of improving their lifestyle, with no compensatory effects on older adults.

Conflicts of interest

The authors declare that there is no conflict of interest.

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Injuries and illnesses during the 2021 South America wheelchair basketball championships: an epidemiological study

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Summary

Introduction: Several international sports federations have implemented a standardized injury registration system during their championships. However, very few studies have included athletes with disabilities during major competitions, apart from the Paralympic Games. Therefore, the objective of this study is to evaluate the rate and characteristics of illnesses and injuries during the 2021 South America Wheelchair Basketball Championships.
Material and method: The coaching staff of the 11 participating teams (a total of 129 players) were asked to report daily all the health problems that have occurred and their characteristics in a standardized form. Prevalence and incidence rates were calculated.
Results: In this study 108 health problems were reported, equivalent to 83.7 per 100 players [95% CI: 67.9-99.5], with 8 time-loss health problems (6.2 per 100 players [95% CI: 1.9-10.5]) and a total of 74 medical attention injuries (57.4 per 100 players [95% CI :44.3-70.4]). Were reported 15 diseases, and the most affected organ systems were ophthalmologic, gastrointestinal, and genitourinary. More injuries were recorded during matches (n=43). The most affected regions were shoulder/clavicle (24.7%), hand/fingers (23.7%) and neck/cervical spine (12.9%). The most frequent conditions were muscle contractures/cramps (32.2%), and the predominant mechanism was overuse (53.8%). 2.2% of concussions produced during training were reported. Most of the recorded events were without time loss and with return to full participation between zero and one day.
Conclusion: Monitoring of health problems during competitions is essential to determine sport-specific injury risk factors, and a complex approach should be implemented for the recognition of their characteristics in wheelchair basketball players. In this way, adequate preventive measures can be developed.

Key words:
Epidemiology. Athletic injuries. Illnesses. Para-athletes. Wheelchair sports.

Lesiones y enfermedades durante el campeonato sudamericano de baloncesto en silla de ruedas 2021: un estudio epidemiológico

Resumen

Introducción: Varias federaciones deportivas internacionales han implementado un sistema estandarizado de registro de lesiones durante sus campeonatos. Sin embargo, muy pocos estudios han incorporado a deportistas con discapacidad durante los principales campeonatos, aparte de los Juegos Paralímpicos. Por lo tanto, el objetivo de este estudio es evaluar la tasa y características de las enfermedades y lesiones durante el Campeonato Sudamericano de Baloncesto en Silla de Ruedas 2021.
Material y método: Se solicitó a los cuerpos técnicos de los 11 equipos participantes (un total de 129 jugadores), que reportaran diariamente todas las afecciones ocurridas y sus características en un formulario estandarizado. Se calcularon las tasas de prevalencia e incidencia.
Resultados: Se reportaron 108 afecciones, equivalentes a 83,7 por 100 jugadores [IC 95%: 67,9-99,5], con 8 afecciones de tiempo perdido (6,2 por 100 jugadores [IC 95%: 1,9-10,5]) y un total de 74 lesiones de atención médica (57,4 por 100 jugadores [IC 95%: 44,3-70,4]). Se informaron 15 enfermedades, y los sistemas orgánicos más afectados fueron el oftalmológico, gastrointestinal y genitourinario. Se registraron más lesiones durante los partidos (n=43). Las regiones más afectadas fueron hombro/clavícula (24,7%), mano/dedos (23,7%) y cuello/columna cervical (12,9%). Las afecciones más frecuentes fueron las contracturas/calambres musculares (32,2%), y el mecanismo predominante fue el sobreuso (53,8%). Se reportó un 2,2% de conmociones producidas durante los entrenamientos. La mayoría de los eventos registrados fueron sin pérdida de tiempo y con retorno a la plena participación entre cero y un día.
Conclusión: El seguimiento de problemas de salud durante las competiciones es esencial para determinar los factores de riesgo de lesiones específicas del deporte, y se debe implementar un enfoque complejo para el reconocimiento de sus características en jugadores de baloncesto en silla de ruedas. De esta manera se podrán desarrollar medidas preventivas adecuadas.

Palabras clave:
Epidemiología. Lesiones Deportivas. Enfermedades. Paratletas. Baloncesto en silla de ruedas.

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Introduction

Wheelchair basketball (WB) is an adaptation of basketball and is played by people with different physical disabilities. It is a high-performance sport for people with disabilities and the most important competitions are the Paralympic Games (POG) and the World Championship, which are held every 4 years. While the epidemiology of injury in Olympic sports has been intensively researched[1,2], it has not been examined in so much detail in Paralympic sports[3]. However, with the growing popularity of para-sport over the past few decades, the number of publications on injuries and illnesses in this sports population has increased significantly[4].

Some of the first articles published found that basketball players have one of the highest incidences of injury among wheelchair sports[5] and during the 1992 POGs it was reported that 79% of British basketball players suffered an injury[6]. Injuries were monitored more systematically at the summer POGs in 2012[7] and 2016[8], at which WB was played. WB was reported to have an injury incidence rate of 12.0 injuries per 1,000 athlete-days [CI 95%: 8.3-16.8] in 2012 and 12.8 injuries per 1,000 athlete-days [CI 95%: 9.5-17.4] in 2016, and more traumatic injuries were reported than injuries through overuse in WB at the 2012 POGs[7]. Meanwhile, Hollander *et al*.[3] assessed the rate and characteristics of injuries during the 2018 Wheelchair Basketball World Championship (WBWC) and reported 100 injuries, which is equivalent to 75.8 per 100 athletes [CI 95%: 60.9-90.7] or 68.9 injuries per 1,000 athlete-days [CI 95%: 55.4-82.4]. In addition, 8 time loss (TL) injuries (6.1 TL injuries per 100 athletes [CI 95%: 1.9-10.3] or 5.5 TL injuries per 1,000 athlete-days [CI 95%: 1.7-9.3]) were reported and more injuries occurred during matches (n=68) than during training.

Since epidemiological analysis is the first step to developing appropriate injury prevention strategies[9], several international sports federations have implemented a standardised injury reporting system during their championships[2,3]. However, very few studies have looked into athletes with disabilities during major competitions, other than the Paralympic Games[3]. For this reason, the aim of this study is to describe the rate and characteristics of injuries and illnesses during the 2021 South America WB Championships (SAWBC) held in Buenos Aires, Argentina.

Materials and methods

Design, environment, and study participants

A prospective follow-up study of illnesses and injuries occurring during the 2021 SAWBC was conducted. The total population consisted of 11 teams from 7 different countries with a total of 129 athletes (men: 7 teams [n=81]; women: 4 teams [n=48]. The SAWBC were held from 28 November to 4 December (female) and from 6 to 13 December (male) 2021 in Buenos Aires, Argentina. During the 15 days of the championships, 31 matches were played, 10 by women's teams and 21 by men's teams. The total exposure was 310 athlete-matches and 984 athlete-days.

For the monitoring of athletic health problems during the SAWBC, the 2020 declaration of the International Olympic Committee[10] and its translation adapted to para-sport4 were used as a guide. An "athletic health problem"[11] or "complaint" was defined as any physical manifestation (illness) or musculoskeletal manifestation (injury) suffered by the athlete during the championships, irrespective of the need for medical attention or the consequences in terms of participation[12]. A contact from each team reported daily details of all health problems on a standardised illness and injury reporting form. The form was an adapted version of those used by the International Olympic Committee (IOC), the International Association of Athletics Federations (IAAF) and the International Swimming Federation (FINA) with predefined categories for location, type, cause, guidance regarding diagnosis, match/training and estimated time loss[13-15], and with items suggested for para-sport4. The functional classification (1-4.5) of the athletes was in accordance with the relevant volume of action for the WBC[16]. The reporting form for athletic health problems was completed virtually through a web platform and was available in Spanish and Portuguese.

The study was presented in written and audiovisual format by email and through social networks to the contacts in each delegation the week before the start of the SAWBC. All the teams were briefed on the purpose and logistics of the study.

During both championships, a member of the research group was present at the venue to encourage and assist with participation in cooperation with the local organising committee. Contact was also maintained by telephone with the contacts from each delegation individually in two shifts per day. Response rates and data quality were analysed daily. The duplication of data entries or reports with incongruous features were resolved by consensus between DB and RM. The confidentiality of all the information was guaranteed and it was not possible to identify any individual athlete or team. The athlete's accreditation number was used to consult the player database to find out the age, sex and nationality of the injured or ill athlete and the database was de-identified after the Championships[2]. All the authors followed the rules of the Declaration of Helsinki. The study reports in accordance with the STROBE guidelines for reporting observational studies[17].

Calculation of exposure and injury rate

The squad sizes and team match exposure were determined based on the publicly available list and schedule18. All the teams had training sessions on match and non-match days before the end of the championships. Athlete-match exposure was calculated by multiplying the number of players on the field by the number of games[12–14] and athlete-training day exposure as the number of players per team multiplied by the number of training sessions[19]. Athlete-days exposure was calculated by multiplying the number of players registered by the number of days of the SAWBC[20]. The health problem rates were calculated as the

number of problems per 100 players and per 1,000 athlete-days, and were reported with a confidence interval (CI) of 95%[3].

Statistical analysis

Descriptive statistics were used to present the data. Results are described as means with standard deviation or frequencies with percentage. The differences in location, type and mechanism of injury between groups (match vs. training and women vs. men) were analysed using chi-square tests. Significance levels of $p < 0.05$ and confidence intervals of 95% were used[21]. All the data were processed using Excel (version 2108, Microsoft Corporation) and InfoStat (version 12.0).

Results

4 women's and 7 men's teams with a total of 129 players (mean age ± SD of 32.9 ± 8.3) from 7 different countries took part in this study (Table 1). These 11 teams played 31 games and completed 62 training sessions over a total of 984 athlete-days. The exposure time and number and rates of health problems during the SAWBC are shown in Table 2. 108 health problems were reported, equivalent to 83.7 per 100 athletes [CI 95%: 67.9-99.5]. Of these, 44 problems were suffered by female players (91.7 problems per 100 players; [CI 95%: 64.6-118.8]) and 64 by male players (79.0 problems per 100 players; [CI 95%: 59.7-98.4]).

8 time loss (TL) health problems (6.2 TL problems per 100 players [CI 95%: 1.9-10.5]) were reported, 6 in women (12.5 TL problems per 100 players; [CI 95%: 2.5-22.5]) and 2 in men (2.5 TL problems per 100 players; [CI 95%: 0.0-5.9]) (Table 2).

Table 1. Characteristics of all the players taking part in the 2021 South America Wheelchair Basketball Championships.

	All the players taking part in the SAWBC	Women	Men
Number	129	48 (37.2)	81 (62.8)
Age			
Mean (SD)	32.9 (8.3)	31.6 (8.2)	33.7 (8.3)
Range	16-56	17-50	16-56
	n (%)	**n (%)**	**n (%)**
Sport classification			
1.0	24 (18.6)	10 (20.8)	14 (17.3)
1.5	7 (5.4)	1 (2.1)	6 (7.4)
2.0	17 (13.2)	7 (14.6)	10 (12.3)
2.5	16 (12.4)	6 (12.5)	10 (12.3)
3.0	14 (10.9)	6 (12.5)	8 (9.9)
3.5	10 (7.8)	3 (6.3)	7 (8.6)
4.0	27 (20.9)	9 (18.8)	18 (22.2)
4.5	14 (10.9)	6 (12.5)	8 (9.9)

SD: standard deviation; SAWBC: South America Wheelchair Basketball Championships

Comparisons between the different problems and subgroups are shown in Table 3. Significant differences were observed between injuries in matches, peri-competition activities and training with respect to location, type, mechanism of injury and the mechanism associated with the mode of injury onset ($\chi^2 = 44.83$, $p = 0.04$; $\chi^2 = 39.44$, $p = 0.02$; $\chi^2 = 8.23$, $p = 0.04$, $\chi^2 = 30.13$, $p = 0.01$, respectively; Table 3).

Table 2. Exposure, number and incidence of all health problems, time loss health problems and medical attention health problems at the 2021 South America Wheelchair Basketball Championships.

Number of	Men	Women	Total
Athletes	81	48	129
Championship days	8	7	15
Athlete-days	648	336	984
Matches	21	10	31
Athlete-matches	210	100	310
Training sessions	42	20	62
Athlete-training days	486	240	726
Health problems	64	44	108
Medical (illnesses)	7	8	15
Musculoskeletal (injuries)	57	36	93
Injuries in matches	27	16	43
Injuries in training	17	12	29
Injuries in peri-competition activities	4	5	9
Injuries in other activities	9	3	12
TL health problems	2	6	8
TL injuries in peri-competition activities	0	1	1
TL injuries in training	1	2	3
TL illnesses	1	3	4

(continuation)

Table 2. Exposure, number and incidence of all health problems, time loss health problems and medical attention health problems at the 2021 South America Wheelchair Basketball Championships *(continuation)*.

MA injuries	41	33	74
Health problems per 100 athletes (CI ± 95%)	79.0 (59.7-98.4)	91.7 (64.6-118.8)	83.7 (67.9-99.5)
Injuries in matches	33.3 (20.8-45.9)	33.3 (17.0-49.7)	33.3 (23.4-43.3)
Injuries in training	21.0 (11.0-31.0)	25.0 (10.9-39.1)	22.5 (14.3-30.7)
Illnesses	8.6 (2.2-15.0)	16.7 (5.1-28.2)	11.6 (5.7-17.5)
TL health problems per 100 athletes	2.5 (0.0-5.9)	12.5 (2.5-22.5)	6.2 (1.9-10.5)
TL injuries in matches	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
TL injuries in training	1.2 (0.0-3.7)	4.2 (0.0-9.9)	2.3 (0.0-5.0)
TL illnesses	1.2 (0.0-3.7)	6.3 (0.0-13.3)	3.1 (0.1-6.1)
MA injuries per 100 athletes	50.6 (35.1-66.1)	68.8 (45.3-92.2)	57.4 (44.3-70.4)
Health problems per 1,000 athlete-days (CI ± 95%)	98.8 (74.6-123.0)	131.0 (92.3-169.6)	109.8 (89.1-130.5)
Injuries per 1,000 athlete-days	88.0 (65.1-110.8)	107.1 (72.1-142.1)	94.5 (75.3-113.7)
Illnesses per 1,000 athlete-days	10.8 (2.8-18.8)	23.8 (7.3-40.3)	15.2 (7.5-23.0)
TL health problems per 1,000 athlete-days	3.1 (0.0-7.4)	17.9 (3.6-32.1)	8.1 (2.5-13.8)
TL injuries per 1,000 athlete-days	1.5 (0.0-4.6)	8.9 (0.0-19.0)	4.1 (0.1-8.0)
TL illnesses per 1,000 athlete-days	1.5 (0.0-4.6)	8.9 (0.0-19.0)	4.1 (0.1-8.0)
MA injuries per 1,000 athlete-days	63.3 (43.9-82.6)	98.2 (64.7-131.7)	75.2 (58.1-92.3)
Injuries in training per 1,000 athlete-days of training	35.0 (18.4-51.6)	50.0 (21.7-78.3)	39.9 (25.4-54.5)
TL injuries in training per 1,000 athlete-days of training	2.1 (1.1-3.0)	8.3 (3.6-13.0)	4.1 (2.6-5.6)
Injuries in matches per match (CI ± 95%)	1.3 (0.8-1.8)	1.6 (0.8-2.4)	1.4 (1.0-1.8)
Injuries in matches per 1,000 athlete-matches	128.6 (80.1-177.1)	160.0 (81.6-238.4)	138.7 (97.2-180.2)
Injuries in matches per 100 athlete-matches	12.9 (8.0-17.7)	16.0 (8.2-23.8)	13.9 (9.7-18.0)
Injuries in matches per 1,000 athlete-hours	192.9 (120.1-265.6)	240.0 (122.4-357.6)	208.1 (145.9-270.3)
TL injuries in matches per match	0.00 (0.0-0.0)	0.00 (0.0-0.0)	0.00 (0.0-0.0)
TL injuries in matches per 1,000 athlete-matches	0.00 (0.0-0.0)	0.00 (0.0-0.0)	0.00 (0.0-0.0)

TL: time loss; AM: medical attention; CI: confidence interval.

The injuries suffered by female and male players differed significantly in the type and mechanism associated with the mode of injury onset ($\chi^2 = 15.87$, $p = 0.04$ and $\chi^2 = 18.5$, $p = 0.002$), but not in the mechanism of injury or location ($\chi^2 = 1.28$, $p = 0.26$; $\chi^2 = 13.16$, $p = 0.21$; Table 3).

Of all the health problems reported, 49 (45,4%) new injuries and 6 (5.6%) new illnesses were recorded during the days the championships lasted. The distribution of the types of health problems is shown in Figure 1.

As for the relationships with sports activity[10], 85 (78.7%) directly related health problems, 15 (13.9%) indirectly related health problems and 8 (7.4%) health problems unrelated to sports activity were reported (Figure 2).

Injuries during the championships

During the matches, 43 injuries occurred, which equates to an incidence of 1.4 injuries per match [CI 95%: 1.0-1.8] or 138.7 injuries per match per 1,000 athlete-matches [CI 95%: 97.2-180.2] (Table 2).

The predominant locations by anatomical region of the injuries were shoulder/clavicle (23; 24.7%), hand/fingers (22; 23.7%) and neck/cervical spine (12; 12.9%) (Table 3). The most common types were muscle contracture/cramp (30; 32.3%), contusion/haematoma (14; 15.1%) and

Figure 1. Types of health problems during the 2021 South America Wheelchair Basketball Championships.

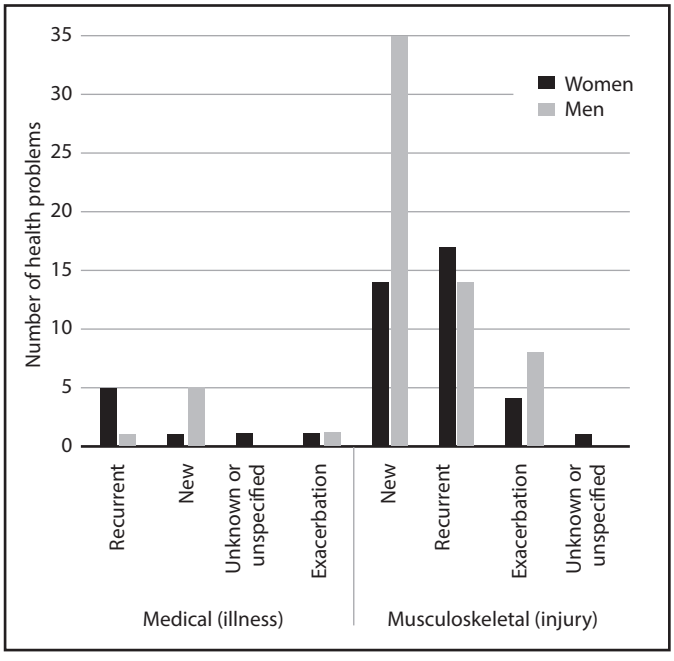
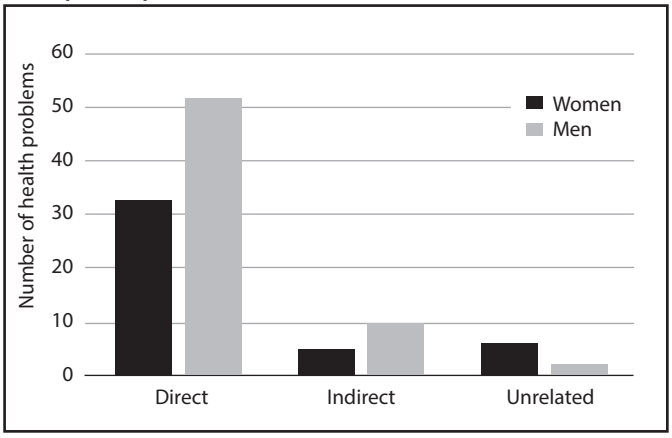


Figure 2. Relationship between the health problem and sports activity during the 2021 South America Wheelchair Basketball Championships.



tendinopathy (13; 14.0%). The most common health problems were tendinopathy in the shoulder (n=11), followed by muscle contracture in the neck and cervical spine (n=10) and sprained fingers (n=9) (Table 4). The predominant mechanisms of injury were repetitive/overuse (53.8%) with gradual onset (36.6%) and acute (46.2%) with sudden onset (43.0%) (Table 3).

4 time loss (TL) injuries were reported during the championships; 4.1 TL injuries per 1,000 athlete-days [CI 95%: 0.1-8.0], with a maximum of 3 days for full return to sport. These were concussion (with or without loss of consciousness), muscle contracture/cramp in the neck/cervical spine area, sprained fingers from direct contact with the ball, and elbow contusion from indirect contact with another player.

27 injuries were reported from contact, with 29.6% from direct contact with a moving object and 37% from indirect contact with another player (Figure 3).

Table 3. Characteristics of injuries in matches, peri-competition activities, training and other activities, and of illnesses during the 2021 South America Wheelchair Basketball Championships.

Number of injuries	Matches n = 43 n (%)	Peri-competition activities n=9 n (%)	Training n = 29 n (%)	Other activities n = 12 n (%)	Women n = 36 n (%)	Men n = 57 n (%)	Total n = 93 n(%)
Location							
Shoulder/ Clavicle	8 (18.6)	1 (11.1)	11 (37.9)	3 (25.0)	9 (25.0)	14 (24.6)	23 (24.7)
Hand/ Finger	15 (34.9)	1 (11.1)	5 (17.2)	1 (8.3)	6 (16.7)	16 (28.1)	22 (23.7)
Neck/Cervical spine	2 (4.7)	4 (44.4)	3 (10.3)	3 (25.0)	7 (19.4)	5 (8.8)	12 (12.9)
Thorax/Cervical spine	5 (11.6)	2 (22.2)	1 (3.4)	2 (16.7)	2 (5.6)	8 (14.0)	10 (10.8)
Elbow	5 (11.6)	0 (0.0)	1 (3.4)	0 (0.0)	1 (2.8)	5 (8.8)	6 (6.5)
Lumbar spine/Pelvis/Sacrum	2 (4.7)	1 (11.1)	2 (6.9)	1 (8.3)	5 (13.9)	1 (1.8)	6 (6.5)
Forearm	1 (2.3)	0 (0.0)	3 (10.3)	0 (0.0)	1 (2.8)	3 (5.3)	4 (4.3)
Arm	3 (7.0)	0 (0.0)	1 (3.4)	0 (0.0)	2 (5.6)	2 (3.5)	4 (4.3)
Knee	1 (2.3)	0 (0.0)	0 (0.0)	2 (16.7)	2 (5.6)	1 (1.8)	3 (3.2)
Head/ Face	0 (0.0)	0 (0.0)	2 (6.9)	0 (0.0)	1 (2.8)	1 (1.8)	2 (2.2)
Hip/ Pubis	1 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.8)	1 (1.1)
Type							
Contracture/ Cramp	7 (16.3)	5 (55.6)	11 (37.9)	7 (58.3)	14 (38.9)	16 (28.1)	30 (32.3)
Contusion/ Haematoma	10 (23.3)	3 (33.3)	0 (0.0)	1 (8.3)	2 (5.6)	12 (21.1)	14 (15.1)
Tendinopathy	5 (11.6)	1 (11.1)	7 (24.1)	0 (0.0)	5 (13.9)	8 (14.0)	13 (14.0)
Pain	4 (9.3)	0 (0.0)	4 (13.8)	2 (16.7)	8 (22.2)	2 (3.5)	10 (10.8)
Sprain/Joint or ligament injury	5 (11.6)	0 (0.0)	4 (13.8)	1 (8.3)	4 (11.1)	6 (10.5)	10 (10.8)
Abrasion/ Laceration	7 (16.3)	0 (0.0)	1 (3.4)	0 (0.0)	1 (2.8)	7 (12.3)	8 (8.6)
Blister	3 (7.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.8)	2 (3.5)	3 (3.2)
Bursitis/ Synovitis	2 (4.7)	0 (0.0)	0 (0.0)	1 (8.3)	0 (0.0)	3 (5.3)	3 (3.2)
Concussion (with/without unconsciousness)	0 (0.0)	0 (0.0)	2 (6.9)	0 (0.0)	1 (2.8)	1 (1.8)	2 (2.2)
Mechanism and mode of onset							
Repetitive/ Overuse	17 (39.5)	6 (66.7)	21 (72.4)	6 (25.0)	22 (61.1)	28 (49.1)	50 (53.8)
Gradual	9 (20.9)	3 (33.3)	17 (58.6)	5 (20.8)	10 (27.8)	24 (42.1)	34 (36.6)
Combination	4 (9.3)	3 (33.3)	2 (6.9)	0 (0.0)	9 (25.0)	0 (0.0)	9 (9.7)
Sudden	4 (9.3)	0 (0.0)	2 (6.9)	1 (4.2)	3 (8.7)	4 (7.0)	7 (7.5)
Acute	26 (60.5)	3 (33.3)	8 (27.6)	6 (25.0)	14 (38.9)	29 (50.9)	43 (46.2)
Sudden	25 (58.1)	2 (22.2)	8 (27.6)	5 (20.8)	12 (33.3)	28 (49.1)	40 (43.0)
Gradual	1 (2.3)	1 (11.1)	0 (0.0)	0 (0.0)	1 (2.8)	1 (1.8)	2 (2.2)
Combination	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.2)	1 (2.8)	0 (0.0)	1 (1.1)
Time loss (in days)							
0	36 (83.7.6)	6 (66.7)	24 (82.8)	7 (58.3)	25 (69.4)	48 (84.2)	73 (78.5)
1-2	5 (11.6)	2 (22.2)	5 (17.2)	4 (33.3)	7 (19.4)	9 (15.8)	16 (17.2)
3-6	2 (4.7)	1 (11.1)	0 (0.0)	1 (8.3)	4 (11.1)	0 (0.0)	4 (4.3)

(continuation)

Table 3. Characteristics of injuries in matches, peri-competition activities, training and other activities, and of illnesses during the 2021 South America Wheelchair Basketball Championships. ***(Continuation).***

Number of illnesses	Women n = 8 n (%)	Men n = 7 n (%)	Total n = 15 n (%)
Affected system and medical problem			
Ophthalmological	0 (0.0)	3 (42.9)	3 (20.0)
Conjunctivitis	0 (0.0)	2 (28.6)	2 (13.3)
Unknown or unspecified	0 (0.0)	1 (14.3)	1 (6.7)
Gastrointestinal	3 (37.5)	0 (0.0)	3 (20.0)
Diarrhoea	3 (37.5)	0 (0.0)	3 (20.0)
Urogenital	3 (37.5)	0 (0.0)	3 (20.0)
Overactive bladder	2 (25.0)	0 (0.0)	2 (13.3)
Urinary tract infection	1 (12.5)	0 (0.0)	1 (6.7)
Respiratory	1 (12.5)	1 (14.3)	2 (13.3)
Pulmonary dysfunction	1 (12.5)	0 (0.0)	1 (6.7)
Rhinorrhoea/ congestion	0 (0.0)	1 (14.3)	1 (6.7)
Dermatological	0 (0.0)	2 (28.6)	2 (13.3)
Pressure ulcer	0 (0.0)	1 (14.3)	1 (6.7)
Abrasion	0 (0.0)	1 (14.3)	1 (6.7)
Dermatological. Ophthalmological	0 (0.0)	1 (14.3)	1 (6.7)
Stye	0 (0.0)	1 (14.3)	1 (6.7)
Gastrointestinal. Haematological	1 (12.5)	0 (0.0)	1 (6.7)
Fatigue/ Overtraining Syndrome	1 (12.5)	0 (0.0)	1 (6.7)
Time loss (in days)			
0	4 (50.0)	6 (85.7)	10 (66.7)
1-2	1 (12.5)	1 (14.3)	2 (13.3)
3-4	3 (37.5)	0 (0.0)	3 (20.0)

Figure 3. Types of injury contacts during the 2021 South America Wheelchair Basketball Championships.

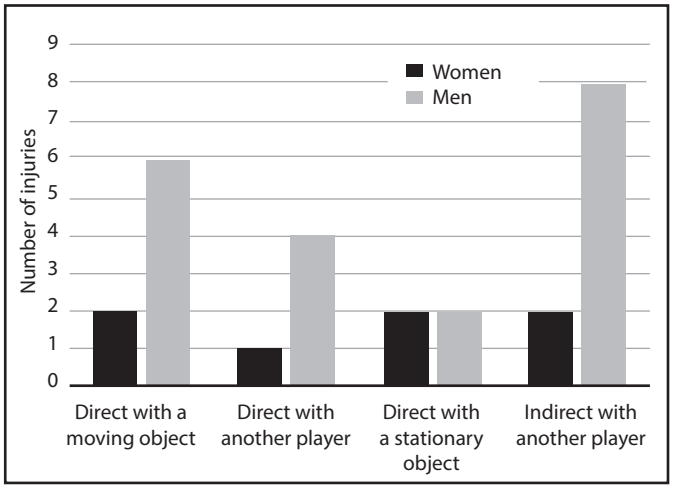
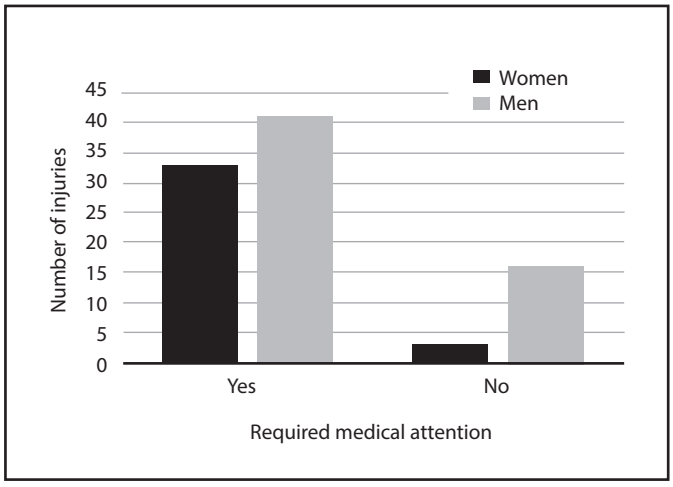


Figure 4. Medical-attention injuries during the 2021 South America Wheelchair Basketball Championships.



A total of 74 (79.6%) medical attention (MA) injuries (57.4 MA injuries per 100 players [CI 95%: 44.3-70.4] or 75.2 MA injuries per 1,000 athlete-days [CI 95%: 58.1-92.3]) and 19 (20.4%) injuries which did not require medical attention were reported (Figure 4).

Illnesses during the championships

During the championships, 15 athletes were ill: 8 women players and 7 men. The organ systems most affected were ophthalmological (n = 3; 20%), gastrointestinal (n = 3; 20%) and genitourinary (n = 3; 20%) (Table 3).

4 time loss (TL) illnesses or 4.1 TL illnesses per 1,000 athlete-days [CI 95%: 0.1-8.0], with a maximum of 4 days for full return to sport, were reported. These were nausea/vomiting, overactive bladder, urinary tract infection and conjunctivitis.

Like the items reported during the 2018 WBWC[3], data were provided on the number and rates of health problems by sport classification, and there also appear to be differences with a wide-ranging distribution over sport classification. (Table 5).

Table 4. Injured body part and types of injuries during the 2021 South America Wheelchair Basketball Championships.

Part of the body	Abrasion/ Laceration	Blister	Bursitis/ Synovitis	Concussion	Contracture/ Cramp	Contusion/ Haematoma	Pain	Sprain/ Ligament injury	Tendinopathy	Total
Head	0	0	0	2	0	0	0	0	0	2
Neck/ Cervical spine	0	0	0	0	10	0	2	0	0	12
Thorax/ Dorsal spine	0	0	0	0	4	6	0	0	0	10
Lumbar spine/Pelvis/ Sacrum	0	0	0	0	3	1	2	0	0	6
Shoulder/ Clavicle	0	0	1	0	7	0	4	0	11	23
Arm	0	0	0	0	3	1	0	0	0	4
Elbow	1	0	2	0	0	1	1	0	1	6
Forearm	0	0	0	0	3	0	0	0	1	4
Hand/ Fingers	5	3	0	0	0	5	0	9	0	22
Hip/ Pubis	1	0	0	0	0	0	0	0	0	1
Knee	1	0	0	0	0	0	1	1	0	3
Total	8	3	3	2	30	14	10	10	13	93

Table 5. Number of Injuries and injury rates during the 2021 South America Wheelchair Basketball Championships by sport classification.

Sport classification	Injuries n = 93 n (%)	Illnesses n = 15 n (%)	Women n = 44 n (%)	Men n = 64 n (%)	Total n = 108 n (%)	Health problems/ 100 athletes n = 108 IR (CI 95%)	Injuries/1,000 athlete-h n = 43 IR (CI del 95%)
1.0 (n = 24)	15 (13.9)	2 (1.9)	9 (20.5)	8 (12.5)	17 (15.7)	70.8 (37.2-104.5)	7.6 (1.5-13.6)
1.5 (n = 7)	5 (4.6)	2 (1.9)	1 (2.3)	6 (9.4)	7 (6.5)	100.0 (25.9-174.1)	20.3 (2.5-38.0)
2.0 (n = 17)	13 (12.0)	2 (1.9)	10 (22.7)	5 (7.8)	15 (13.9)	88.2 (43.6-132.9)	9.1 (1.1-17.2)
2.5 (n = 16)	15 (13.9)	1 (0.9)	3 (6.8)	13 (20.3)	16 (14.8)	100.0 (51.0-149.0)	17.1 (5.3-29.0)
3.0 (n = 14)	8 (7.4)	2 (1.9)	2 (4.5)	8 (12.5)	10 (9.3)	71.4 (27.2-115.7)	4.9 (0.0-11.7)
3.5 (n = 10)	5 (4.6)	1 (0.9)	2 (4.5)	4 (6.3)	6 (5.6)	60.0 (12.0-108.0)	2.9 (0.0-8.7)
4.0 (n = 27)	18 (16.7)	4 (3.7)	9 (20.5)	13 (20.3)	22 (20.4)	81.5 (47.4-115.5)	10.2 (3.5-16.9)
4.5 (n = 14)	14 (13.0)	1 (0.9)	8 (18.2)	7 (10.9)	15 (13.9)	107.1 (52.9-161.4)	16.7 (4.3-13.6)

CI 95%: 95% confidence interval; IR: injury rate.

Discussion

This is the first prospective epidemiological study of WB during a major South American competition in which illnesses and not only musculoskeletal injuries were recorded. The overall rate of health problems was 83.7 injuries per 100 players or 109.8 injuries per 1,000 athlete-days. Just over half of the injuries were reported as due to overuse with a gradual onset mode and a third were classified as muscle contractures, mainly in the neck and cervical spine. 47% of the injuries occurred during matches.

The mechanisms of injury were different between training sessions and matches, but not between female and male players. The differences found when the mechanism of injury was analysed in isolation compared to when it was analysed associated with the mode of onset could be explained by the recent introduction of the latter categorisation, which might still have posed difficulties of interpretation at the time of reporting. It should be clarified that, although it has been argued that peri-competition injuries should be included as training injuries 0,12, this study kept reports of injuries of this kind separately because we consider that they occur in an environment other than the situation of training and competition.

Rates and characteristics of the health problems

The injury rate during the SAWBC was substantially higher (94.5 injuries per 1,000 athlete-days [CI: 75.3-113.7]) than those reported during the 2012 POGs[7], with 12.0 (CI: 8.3-16.8) injuries per 1,000 athlete-days, and the 2016 POGs[8], with 12.8 (CI: 9.5-17.4) injuries per 1,000 athlete-days, and higher than the injury rate reported during the 2018 WBWC[3],

with 68.9 injuries per 1,000 athlete-days (CI: 55.4-82.4). These differences could result from the definitional criteria for athletic health problems applied in this study, as this is a general term which includes, but is not limited to, injuries that require medical attention[10].

The time loss (TL) injury rate (4.1 TL injuries per 1,000 athlete-days) was lower than the incidence of TL injuries reported at the 2018 WBWC (5.5 TL injuries per 1,000 athlete-days). The TL illness rate was also 4.1 TL illnesses per 1,000 athlete-days, but unfortunately illnesses were not reported during the POGs or the WBWC. In male players, 40% of these problems were new and predominant in the ophthalmological and dermatological systems; while in female players, 40% of these problems were recurrences and predominant in the gastrointestinal and genitourinary systems. In this regard, the need could also be highlighted to monitor medical problems for their impact on sports participation[22] during championships held in just a few days. In this way, sports events which have medical services could be better prepared to address and solve such problems.

Most injuries occurred to the shoulder and hand/fingers, and to the cervical and dorsal spine. This is consistent with other reports on wheelchair sports[6,23] and could be explained by the high demands placed on the upper limbs by the actions that playing WB involves[23,24].

In this study, 53.8% of the injuries occurred due to overuse. Similar data were reported during the 2018 WBWC (52%)[3]; while acute injuries were more prevalent at the 2012 POGs (65%)[7]. Both mechanisms of injury are considered to be a major problem in WB and should be addressed through prevention strategies.

In contrast to the 2016 POGs[8], where no cases of concussion were reported, despite several reported incidents of blows to the head[25], and to data reported during the 2018 WBWC, where no cases of concussion were reported[3]; in this study 2.2% of concussions (with or without loss of consciousness) occurring during training were reported. The most recent data from the POGs, which report high rates of head and face injuries, demonstrate the need to make progress in the identification of these types of problems[25]. A recent study by Herring *et al*.[26] may provide pointers regarding this initiative.

Methodological considerations and limitations

Variations in the definitions and methodologies used for previous studies of injuries in Paralympic sports cause inconsistencies in the reported data and it is difficult to compare results[27,28].

It has been mentioned that para-athletes often do not have access to a team doctor. For this reason, in this study, it was considered that the data could be reported by other health personnel or a team contact4 accompanied by a trained volunteer from the research team. We believe that daily telephone communication with each delegation and being able to report using an online form favoured daily compliance with the reports[29], but we also recognise that this could result in insufficient reports on injuries and illnesses. Therefore, this population may not be representative of all elite WB players and may not be representative of all non-elite players at regional level.

In the same vein, the term "medical attention" refers to an assessment of a player's medical condition by a qualified physician[12]. This study recorded injuries that required medical/physiotherapeutic attention, defined as any orders given or therapeutic measure indicated by anyone who is involved in the health care of the athletes and implements an action plan to improve their health[14].

For the surveillance of recurrent problems or exacerbations, it is necessary to have monitored previous injuries and illnesses, and used similar indexing before the start of the championships. All the technical staff also need to have experience in reporting[10]. In para-sport, this is especially relevant as para-athletes may have a greater number of recurrent problems[4].

With regard to exposure times, in order to simplify analysis[30], training and match days were documented at team level[13] and, therefore, injury rates in training and matches may have been underestimated if individual players missed a training session or did not participate in any matches. The female teams had to play more matches during the tournament compared to the male teams, which increased the female players' match exposure.

Like the study during the 2018 WBWC[3], the sample size of this study was not big enough for an in-depth analysis of the effect of sport classification on injury risk. The reasons for the differences between the health problem rates in different competition settings and the patterns of health problems between the different sport classifications call for more detailed analysis[29]. In the future, studies on WB should consider including sport classification as a relevant factor[31].

Although mental health problems in athletes are very relevant[32,33] and some teams anecdotally reported certain manifestations, such as anxiety, stress and sleep disorders, this study did not cover problems of this kind. Future studies could include aspects related to mental health using recognition tools as a guide to identify athletes at risk[34]. With the same criteria, as Bittencourt *et al*.[35] propose, a more complex approach should be implemented with respect to the dynamic interaction of risk factors and their recognition techniques to improve the prediction and prevention of health problems.

Conclusion

This study found a higher injury rate than those reported in the POGs and the WBWC. A more detailed analysis of the characteristics of health problems revealed a large number of problems without time loss and with a return to full participation of between zero and one day. Most of the injuries were directly related to sports activity, primarily during matches, and were mostly seen on the shoulder and hand/fingers. Just over half of the injuries were reported as due to overuse with a gradual onset mode and a third were classified as muscle contractures, especially in the neck and cervical spine. Eight time loss problems and no serious injuries were reported.

As for the mechanisms of injury, these were different between training sessions and matches, but not between female and male players. Among the acute injuries, the sudden onset mode by indirect contact

with another player and direct contact with a moving object proved the most prevalent.

Regarding medical problems, in male players, new conditions with predominance in the ophthalmological and dermatological systems were mainly observed, while in female players the problems were recurrences with predominance in the gastrointestinal and genitourinary systems. It is necessary to highlight the importance of monitoring medical problems for their impact on sports participation during championships held in just a few days. In this way, the technical bodies and sports events which have medical services could be better prepared to address and solve such problems.

Epidemiological studies are fundamental when it comes to protecting the health of para-athletes. Well-designed health problem surveillance and precise data collection followed by careful analysis are elementary building blocks for the prevention of athletic health problems. Greater precision in the records can be achieved by continuing with the implementation of systematised follow-ups of health problems manifested by para-athletes at local level and including trained professionals in technical bodies.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Formation of medical information model for rehabilitation of highly qualified athletes

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Summary

Introduction: Each development stage of the healthcare system and medicine is associated not only with the emergence of new integrated areas of knowledge, but also with radical changes in the technology of the doctor's work with the patient, algorithms, methods for collecting, processing information, and making decisions. Also, many postulates need revision, activation of existing reserves, certain concepts also require a new interpretation.
Objective: To form a high-quality medical model for the rehabilitation of highly qualified athletes.
Material and method: The paper proposes a model for constructing a quality assessment of rehabilitation of athletes based on probabilistic methods. The novelty of the study underlies the transition from a qualitative to a quantitative assessment of health, which has become a new direction in the assessment and management of health.
Results: The authors present a model of a qualitative increase in the managerial process by the rehabilitation of highly qualified athletes. The paper proves that it is necessary to determine the ability to measure and express the basic properties of any organism in conditionally qualitative proportions – the ability to withstand various stressful effects and adverse environmental influences.
Conclusion: The practical significance of the study is determined by the fact that it is necessary to search for evaluative health criteria, and in the individual's ability to carry out biological and social functions. The perfection of these functions in humans can also be described quantitatively, by reserves of energy, plastic, and regulatory support of functions.

Key words:
Rehabilitation. Athlete. Model. Dynamics. Information.

Formación de modelo de información médica para la rehabilitación de atletas altamente calificados

Resumen

Introducción: Cada etapa de desarrollo del sistema de salud y de la medicina está asociada no solo al surgimiento de nuevas áreas integradas del conocimiento, sino también a cambios radicales en la tecnología del trabajo del médico con el paciente, algoritmos, métodos de recolección, procesamiento de información, y tomando decisiones. Asimismo, muchos postulados necesitan revisión, activación de las reservas existentes, ciertos conceptos también requieren una nueva interpretación.
Objetivo: Formar un modelo médico de alta calidad para la rehabilitación de atletas altamente calificados.
Material y método: El artículo propone un modelo para la construcción de una evaluación de la calidad de la rehabilitación de deportistas basado en métodos probabilísticos. La novedad del estudio subyace en la transición de una evaluación cualitativa a una cuantitativa de la salud, que se ha convertido en una nueva dirección en la evaluación y gestión de la salud.
Resultados: Los autores presentan un modelo de incremento cualitativo en el proceso gerencial por la rehabilitación de atletas altamente calificados. El documento demuestra que es necesario determinar la capacidad de medir y expresar las propiedades básicas de cualquier organismo en proporciones condicionalmente cualitativas: la capacidad de resistir diversos efectos estresantes e influencias ambientales adversas.
Conclusión: La importancia práctica del estudio está determinada por el hecho de que es necesario buscar criterios evaluativos de la salud, y en la capacidad del individuo para realizar funciones biológicas y sociales. La perfección de estas funciones en humanos también se puede describir cuantitativamente, por reservas de energía, plástico y soporte regulador de funciones.

Palabras clave:
Rehabilitación. Atleta. Modelo. Dinámica. Información.

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Introduction

Rehabilitation in medicine is a system of state, socio-economic, psychological, medical, professional, pedagogical measures aimed at restoring a person's health, ability to work, and social status. It is based on biological, socio-economic, psychological, moral, ethical and scientific method foundations[1]. The main objectives of rehabilitation are: maximum possible restoration of health; functional recovery (full or compensation in case of insufficiency or lack of recovery); return to everyday life; involvement in the labour process. Rehabilitation is based on the use of biological and social mechanisms of adaptation, compensation, and is conditionally combined into three interrelated types: medical, social, and professional[2]. They are aimed at eliminating the three main consequences of disease: deviation from the norm in morphological status; decreased performance; social maladaptation.

Medical rehabilitation is the main type of rehabilitation treatment of the patient, the effectiveness of which depends on the use of other types of rehabilitation, their duration and scope[3]. The leading methods of medical rehabilitation are restorative therapy and reconstructive surgery with subsequent prosthetics (if necessary)[4]. Restorative therapy is carried out, first of all, with the help of medical treatment, physical activation (remedial gymnastic, massage, physiotherapy, occupational therapy), psychological methods (group and individual psychotherapy). The ultimate purpose of rehabilitation treatment is the elimination or reduction of the manifestations of the disease, including prevention of its complications[5].

Medical rehabilitation aims to restore the physical, psychological, and social status of a person after serious illnesses, injuries, complex surgical interventions so as to avoid disability or have the least degree of disability, to ensure integration into society with the achievement of maximum possible social and economic independence[6]. In the rehabilitation of patients, priority is given to medical rehabilitation. Experts, educators, psychologists, sociologists, lawyers, representatives of social welfare agencies, trade unions, and enterprises actively take part in this process together with medical workers[7]. There is much concern about training of rehabilitation specialists, rehabilitation therapists, and paramedical workers who have the scientific foundations and practical skills of complex rehabilitation treatment: methods of physiotherapy, massage, remedial gymnastic, mechanotherapy, occupational therapy, and other rehabilitation means[8]. Their importance especially increases during the modern pharmacological boom[9].

The means used in medical rehabilitation are diverse and unequal at various stages of rehabilitation. Rehabilitation most often begins with active treatment, where pathogenetic drug therapy or surgical treatment is predominant, aimed at eliminating or reducing the activity of the pathological process[10]. It is gradually being replaced by supportive pharmacotherapy and various non-drug therapies[11]. The role of non-drug rehabilitation means gradually increases in the subsequent stages of rehabilitation and is appointed with the aim of accelerating recovery, achieving long-term remission, recovery of disability, preventing disability, returning the patient to society[12].

The most common non-pharmacological means of medical rehabilitation are: protective regime; medical nutrition; physical rehabilitation: physiotherapy, natural physical factors, cold water treatment; physical therapy, massage, mechanotherapy, traction therapy, manual therapy, occupational therapy; reflexology, phytotherapy, aromatherapy; psychotherapy: general and special psychotherapy, psychotherapeutic measures, bioethics, music therapy, vocal therapy, dance therapy; disease prevention, health education, healthy lifestyle[13].

The purpose of the presented article is to form a high-quality medical model for the rehabilitation of highly qualified athletes. The study was conducted according to the classical scheme of evidence-based medicine, multicenter, randomized, controlled trials were organized, and experiments were conducted.

Literature review

A living organism is a multi-level, self-regulating system with a dynamic control hierarchy. The reaction of the body in the process of interaction with environmental factors proceeds in different ways: depending on the strength, duration of exposure and the adaptive capacity of the body[14]. Adaptation of the body to the effects of inadequate environmental factors occurs through the mobilization and expenditure of functional reserves. Assessment of the adaptive capabilities of the body is considered as one of the important criteria of health. The stock of functional reserves is information, energy and metabolic resources, the costs of which are accompanied by constant recovery[15].

Adaptation as one of the fundamental properties of living matter is the result and means of resolving internal and external contradictions, it exists and is formed on the verge of life and death, health and disease due to their collision and adoption of the transition. Adaptation costs depend on the body's reserve capacity[16]. The cost that goes beyond the biosocial budget, requires new efforts from the body, leading to the breakdown of the adaptation mechanism[17]. This is not only biological, but also social in nature and is sometimes achieved at the cost of certain injuries, a certain disharmony as against the norm[18].

The problem of assessing the level of health is primarily associated with the development of methods for prenosological diagnostics[19]. The decrease in the adaptive capacity of the body is an almost unfavourable sign and one of the leading causes of the onset and development of diseases[20]. This condition occurs gradually, long before the first signs of the disease are detected, and is difficult to diagnose[21]. Medicine is not able to predict and prevent diseases, but only passively expects a healthy person to become a patient[22]. The main task of the health problem is its prognostic direction – the need to predict an individual trajectory of movement from health to disease, which, in accordance with the health criteria of highly qualified athletes, relates to strategic ones[23]. There are various opinions regarding the application of preventive rehabilitation. It necessitates early diagnosis of health deviations and the use of means to prevent and eliminate them.

Material and method

The research methodology was based on the analysis, systematization, identification of general patterns and factors influencing physical rehabilitation, the development of additional diagnostic methods, monitoring and evaluation of the effectiveness of rehabilitation mea-

sures. When conducting research, the requirements of the experiment were adhered. To register studies, a special map was created, which was characterized by uniformity and maximum preparedness for subsequent computer processing. The registration cards presented research areas, analysed indicators and data processing methods.

Creation of the information system involved over 1,680 blood pressure measurements, followed by recording and analysis of waveforms. The experiment was attended by 566 people (235 men and 331 women) who were practically healthy and with health deviations. Patients were examined using a clinical, instrumental, laboratory, or special examination. Homogeneous material was selected for the analysis. To form the control and main groups, a table of random numbers was used for each group of patients.

To assess the state of adaptive reserves of the body, we used the determination of the level indicator of regulation of individual mechanisms with correlation; we used methods of correlation and cluster analysis. The quantitative component of the experimental part of the study is presented in Table 1.

For the preparation of information technologies to assess the state of the cardiovascular system by peripheral blood circulation, about 1,600 measurements of blood pressure were carried out, followed by recording and analysis of oscillograms. The experiment involved 566 people (235 men and 331 women) aged 11 to 75 years, almost healthy and with deviations in health status. Upon research, the requirements of the experiment were adhered to. Oscillograms were recorded:

- at rest: 446 people aged 18-75,
- before and after physical load (Ruthier test 75 people, physical exercises according to the Qigong method – 46 people),
- before and after exposure to thermal factors (dry and wet baths – 42 people, "winter swimming" – 25 people),
- before and after psychological audiovisual influences – 31 people,
- before and after the massage procedure (manual – 47 people, Nuga Best – 19 people, Reiki session – 65 people).

The oscillograms were subjected to morphological, temporal, spectral analysis according to the methods introduced for the analysis of electrocardiograms. A cluster analysis of the obtained indicators is carried out. Norm indicators were selected based on the analysis of oscillograms of 127 healthy individuals.

To prepare the information system for the physical rehabilitation process, literary sources were studied and our personal practical experience in organizing and conducting physical rehabilitation were generalized. Algorithmic modelling of the general process of prescribing and conducting remedial gymnastic and massage was carried out, along with their use in some of the most socially significant diseases (myo-

Table 1. The quantitative component of the experimental part of the study.

Research area	Research objectives	Research methods
The rationale for the analysis of arterial oscillograms	To study the reaction of the cardiovascular system to compression of the vessels of the shoulder at rest and under the influence of physical, thermal, audio-visual factors	Methods of morphological, temporal, spectral, fractal analysis of oscillograms
Analysis of the adaptive response of the cardiovascular system to the load	To develop an information technology for constructing and evaluating correlation portraits of CVS indices in healthy people and in some pathological conditions at rest and after various influences	Methods of correlation and cluster analysis
The state of the cardiovascular system	Comparative analysis of synchronously recorded electrocardiograms and arterial oscillogram	Methods of time, spectral, fractal analysis
Analysis of the impact of differential massage	To investigate the degree of the target control procedure	Methods of time, spectral, autocorrelation analysis of an electrocardiogram and arterial oscillogram
The effectiveness of remedial gymnastic algorithm	To study the effectiveness of the algorithm of remedial gymnastic in patients who suffered a violation of blood supply in the middle cerebral artery basin (stationary stage of treatment)	Methods of time, spectral, correlation analysis of an electrocardiogram and arterial oscillogram
Informational content of clinical indicators	Assessment of the information content of the Kerdo index in determining the level of autonomic regulation disorders in patients with osteochondrosis of the cervical spine	Statistical and experimental research methods
The information content of the Ruthier test	The information content of the Ruthier test in assessing the physical condition	Oscillography methods and statistical research methods
Informational content of clinical indicators	To study the informativeness of the indicators of fractal dimension of the ECG to assess the effects of massage	Fractal analysis method
Justification for the use of multimedia tools in rehabilitation	System-analytical justification for the use of a multimedia environment for the prevention and rehabilitation of various diseases	T. Saati hierarchy analysis method
Optimality assessment in the branching of microvascular nodes	To assess the optimality in the branches of microvascular nodes, which is compared with the data of studies of literary sources	Mathematical modelling methods

cardial infarction, cerebrovascular accident, neurological syndromes of cervical spine osteochondrosis, osteoporosis).

The existing information technology were applied. Electrocardiogram was analysed with the following purposes:

- to determine the impact of rehabilitation on the physical condition of individual athletes after unsuccessful medical treatment;
- to investigate the informative value of the fractal portrait of patients with neurological syndromes of cervical spine osteochondrosis.

The information content of the Kerdo index for patients with neurological manifestations of cervical spine osteochondrosis was analysed (based on literature and analysis of the results of scientific studies of other authors). The fractal dimension of rheoencephalograms was analysed (based on literature and analysis of the results of scientific studies of other authors). To this end, a correlation approach was developed to justify the optimal branching patterns of microvascular nodes and an expert diagnostics system was applied to analyse the patient's condition and choose a set of treatment methods using the approaches of traditional Chinese medicine.

The result of research was the creation of information systems in medical (physical) rehabilitation, a software environment for data analysis; diagnostic and treatment information system in the Wuxing health improvement system; psychomodulating multimedia environment. The instrumental examination method involved a typical electrocardiograph with an additional program to study the effect of differential massage on the state of the autonomic nervous system, and to assess the information content of the Kerdo index and evaluate the information content of fractal dimension values. The study of changes in the state of the cardiovascular system at large and peripheral vessels in particular under the influence of various factors was carried out with the use of an electronic blood pressure meter that can record cuff pressure values during the compression growth period and export the obtained values for further analysis of the arterial oscillogram. The results of laboratory research methods were applied to assess the objectivity of the Kerdo index in patients with cervical spine osteochondrosis (containing adrenaline and noradrenaline in daily urine and acetylcholinesterase activity in capillary blood).

Results and discussion

To analyse the biosignals in the frequency spectrum, methods of fast Fourier transformation (FFT) were used. The discrete Fourier transformation for a vector x consisting of N elements has the form:

$$\vec{X} = \hat{A}x,$$

the $\hat{A}$ matrix elements have the form:

$$a_N^{mn} = exp\left(-2\pi i \frac{mn}{N}\right).$$

If *N* is paired, then FFT can be rewritten as follows:

$$X_m = \sum_{n=0}^{N-1} x_n a_N^{mn} = \sum x_{2n} a_N^{2nm} + \sum_{n=0}^{\frac{N}{2-1}} x_{2n+1} a_N^{(2n+1)m}.$$

Coefficients a_N^{mn} and $a_N^{(2n+1)m}$ can be rewritten as follows:

$$M = N/2: a_N^{mn} = exp\left(-2\pi i \frac{mn}{N}\right) = exp\left(-2\pi i \frac{mn}{N/2}\right) = a_M^{mn},$$

$$a_N^{(2n+1)m} = exp\left(-2\pi i \frac{m}{N}\right) a_M^{mn} .$$

As the result, we shall get:

$$X_m = \sum_{n=0}^{M-1} x_{2n} a_M^{mn} + exp\left(-2\pi i \frac{m}{N}\right) \sum_{n=0}^{M-1} x_{2n+1} a_N^{nm}.$$

That is, the discrete Fourier transformation of a vector consisting of N samples are reduced to a linear composition of two FFTs of $N/2$ samples, and if N^2 operations are required for the initial task, then for the resulting composition - $N^2/2$. If M is a power of two, then this separation can be recursively continued until we reach the two-point Fourier transformation, which is calculated according to the following formulas:

$$X_0 = x_0 + x_1 X_1 = x_0 - x_1.$$

To study the local indicators of the frequency and phase in the spectrum of biosignals, we used the Hilbert-Huang transformations (HHT), understood as the method of empirical mode decomposition (EMD) for nonlinear and non-stationary processes and Hilbert spectral analysis (HAS). HHT is a time-frequency data analysis and does not require an a priori functional transformation basis. Instantaneous frequencies (Ifs) are calculated from the derivatives of the Hilbert phase functions by transforming the basic functions.

The next step of the Hilbert-Huang transformation is the Hilbert transformation. Conversion for each IMF allows to obtain the value of the instantaneous frequency and amplitude for each point in time. We shall describe the application of the Hilbert transformation in more detail. It is applied to every IMF $c_j(t)$ to get $H[c_j(t)]$:

$$H\left[c_j(t)\right] = \frac{1}{\pi} \int_{-\infty}^{+\infty} \frac{c_j(\tau)}{t-\tau} d\tau,$$

and we can build an analytical signal $Z_j(t)$

$$Z_j(t) = c_j(t) + iH\left[c_j(t)\right] = a_j(t) exp\left(i\theta_j(t)\right).$$

This is how the amplitude function $a_j(t)$ and the phase function $\theta j(t)$ change in time:

$$\alpha_j(t) = \sqrt{c_j^2(t) + H^2\left[c_j(t)\right]},$$

$$\theta_j(t) = arctan \frac{H\left[c_j(t)\right]}{c_j(t)}.$$

The instantaneous value of the frequency of a non-stationary signal can be calculated as follows:

$$\omega_j(t) = \frac{d\theta_j(t)}{dt}.$$

The spectral methods for the analysis of arterial oscillograms are used directly for the values of the pressure change in the cuff upon shoulder compression, without the pressure component that the compressor creates in the cuff. For a curve that reflects the mechanical activity of the arterial wall upon shoulder compression, a visual analysis is applied for quantitative characteristics, localization, and the presence of small fluctuations. Also, these methods are applied for electrocardiograms, pulsograms, and rheograms, the signal itself and the intervalograms between various extrema. In the above-described

biosignals and intervals calculated from them, the methods of spectral analysis are applied in the following aspects:

- The fast Fourier transformation of the oscillogram is used to estimate the spectrum power according to the spectral analysis criteria adopted in the ECG in the range from 0 to 0.4 Hz (HF: 0.15-0.40 Hz; LF: 0.04-0.15 Hz; k = LF/HF; VLF: 0.003-0.04 Hz; Total <0.40 Hz; <0.003 Hz) and in the following ranges: Delta – 0-4 Hz, Theta – 4-8 Hz, Alpha – 8-13 Hz, Beta – 13-25 Hz, 25 Hz and more. For analysis, the arterial oscillogram itself is used, and not the intervals between the waves, as in the spectral analysis of the ECG.
- Application of the Hilbert-Huang (S-Hil) method to analyse the oscillogram in order to estimate the local frequency by determining the areas (Delta (S-Hil-Delta) 0-4 Hz, Theta (S-Hil-Theta) 4-8 Hz, Alpha (S-Hil-Alpha) 8-13 Hz, Beta (S-Hil-Beta) 13-25 Hz, (S-Hil-25-60Hz) 25-60 Hz, (S-Hil-60 Hz) 60 Hz or more). The same frequency intervals were used to calculate the area of the instantaneous phase.

In the arterial oscillogram, depending on the degree of compression, five of its parts are distinguished (until the diastolic pressure is reached, from the moment of appearance of diastolic pressure – up to 70% of the amplitude, from 70% to 100% of the amplitude, from 100% to the appearance of systolic pressure, from the appearance of systolic pressure until the end of measurement).

Spectral analysis is applied to the arterial oscillogram itself, and not to the intervals between the waves, as it is upon the spectral analysis of the ECG. The use of fast Fourier transformation of the oscillogram for assessing the spectrum power according to the criteria of the CVS functional state assessment method by the heart rhythm registered in the ECG in the range from 0 to 0.4 Hz and in the following ranges: Delta 0-4 Hz, Theta 4-8 Hz, Alpha 8-13 Hz, Beta 13-25 Hz, 25 Hz or more.

The Hilbert-Huang method was used to analyse the oscillogram for estimating the instantaneous frequency by determining the areas (Delta 0-4 Hz, Theta 4-8 Hz, Alpha 8-13 Hz, Beta 13-25 Hz, 25-60 Hz, 60 Hz and more). The instantaneous phase is also calculated in the above time intervals of the arterial oscillogram in frequency intervals up to 15 Hz and more than 15 Hz.

Fractal analysis was used to create a fractal portrait of the subject based on an analysis of the modulation levels of the recorded biosignal and intervalogram. A fractal provides an opportunity to study and evaluate the degree of harmonization of biorhythms of the entire organism and individual organs and systems that have an effect on the systems, organs or tissues under study. The use of fractal analysis methods allows to identify functional and pathological changes, assess the immune status, energy resources, level of psychoemotional and physical activity, the prognosis of changes in the patient's health status for the next day and a relatively long period (up to 10 days). Research in the mode of dynamic observation allow to monitor the functional state of the patient and evaluate the effectiveness of various methods of therapy in application of therapeutic and preventive measures.

To determine the fractal dimension, the Hurst exponent was calculated as follows:

$$\frac{R}{S} = (\alpha N)^H,$$

from which

$$H = \frac{log(R/S)}{log(\alpha N)},$$

where H is the Hurst indicator; S root mean square deviation of a series of observations; R is the size of an accumulated deviation; N is the number of observation periods; α constant of correlation and cluster analysis of oscillograms and assessment of the state of the cardiovascular system and peripheral vessels.

The method for determining the level of interaction of regulatory mechanisms and the correlation portrait (for marking loads and pathological processes) was based on methods of linear correlation and cluster analysis (k-means method). In probability theory and mathematical statistics, correlation is the dependence of two random values. With that, a change in one or several of these values leads to a systematic change in one or several other values. The correlation coefficient is a mathematical measure of the correlation of two random values.

The correlation can be positive and negative (a situation of the absence of a statistical relationship is also possible – for example, for independent random values). Negative correlation is a correlation where an increase in one value is associated with a decrease in another, while the correlation coefficient is negative. A positive correlation is a correlation where an increase in one value is associated with an increase in another, while the correlation coefficient is positive. We shall consider the algorithm for determining the correlation coefficient. If X,Y are random values with mathematical expectation μ_X and μ_Y. Their correlation coefficient is designated $as\rho(X,Y)$ and equates to:

$$\rho(X,Y) = \frac{Cov(X,Y)}{\sigma_X,\sigma_Y} = \frac{E((X-\mu_X)(Y-\mu_Y))}{\sigma_X,\sigma_Y},$$

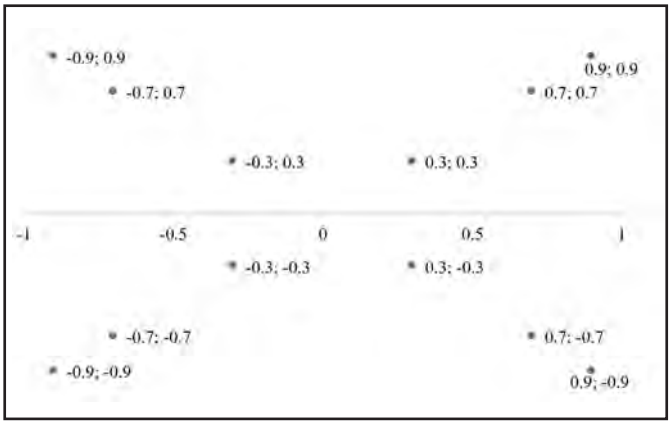
where $Cov(X,Y)$ is a covariation of X,Y values, σ_X,σ_Y is a standard deviation of X,Y values, E is a mathematical expectation operator.

Cluster analysis is the task of splitting a given sample of objects (situations) into subsets called clusters, so that each cluster consists of similar objects, and objects of different clusters differ significantly. Formal definition of clustering. Let X be the set of objects, Y – the set of numbers (names, marks) of clusters. The distance function between objects ρ(x,x') is set. There is a finite selection of objects $X^m=\{x_1,...,x_m\}$. It is necessary to break the sample into extraordinary subsets called clusters, so that each cluster consists of objects similar in matrixρ, and the objects of different clusters are significantly different. With that, the cluster number y_i is assigned to each object $x_i \in X^m$.

The clustering algorithm is a function $a: X \rightarrow Y$, which associates a cluster number $y \in Y$ with any object $x \in X$. The set Y in some cases is known in advance, but more often the task is to determine the optimal number of clusters from the standpoint of a certain clustering quality criterion. The selected correlation values were subjected to cluster analysis (k-means method), where the calculated correlation values were grouped separately within one experiment and between all indicators before and after the experiment in 12 clusters with the following centroid coordinates (Figure 1).

Data analysis was carried out for grouped data, by type of experiment, or its stage, between persons without complaints on health status and persons who had various diseases. The proposed algorithm was used to determine the level of interaction of regulatory mechanisms and a correlation portrait for marking loads and pathological processes for analysing the adaptation mechanisms of patient groups. In turn, clustered correlates, which were in the range from 0.85 to 1 and

Figure 1. Centroid forms of correlation values.



-0.85 to -1 (significant), were sorted by the following criteria – components of the correlation portrait:

- In the experiments that were carried out, the values of correlations in the cluster did not go beyond the limits of one cluster and were not sensitive to acting factors.
- In the experiment, the cluster values were unique (specific) up to a certain factor from the entire list of experiments.
- In the study of certain types of effect, the general and unique correlates were studied at various stages of research.
- The number of significant correlates before and after the experiment.
- The number of direct and inverse correlates.
- Comparison of the correlation portrait of an individual measurement grouped by certain attributes (weighting factors).
- The study of general correlates for experiments.

To identify the mechanisms involved in the adaptation process in a single study, the following algorithm was used. To evaluate and identify a single recorded biosignal, the following algorithms were implemented in the program "biosignal analysis":

- Evaluation of mechanisms and the strength of interrelations upon adaptation (correlation and cluster analysis) in a single analysis in the middle of the signal.
- Between synchronously (conditionally synchronously) registered signals of the same nature (ECG, pulsograms, rheograms, etc.).
- Between synchronously (conditionally synchronously) registered signals of various nature (ECG, pulsograms, rheograms, etc.).

Mathematical models (to study the effect of differential massage on a patient, a massage therapist, and upon constructing an algorithm for a massage procedure and its dosage). Mathematical modelling is a method of researching processes or phenomena by creating their mathematical models and researching these models. To build a mathematical model of differential massage, we used a system of linear differential equations. A differential equation is an equation connecting the independent variable X, the unknown function y and the derivatives of the unknown function $y`y''y(n)$. The general form of the differential equation is

$$F\left(x, y, y, Y, y(n) = 0.\right.$$

The solution of the differential equation is the function $Y = y(x)$, which, when substituted into the equation, turns it into an identical equation.

Pontryagin's maximum principle (PMP) for solving problems with phase constraints to optimize the process of bone tissue reconstruction. A correlation expressing the necessary conditions for a strong extremum for the nonclassical variational problem of optimal control of a mathematical theory was formulated in 1956 by L. S. Pontryagin. The accepted assertion of PMP relates to the following optimal control problem. A system of ordinary differential equations

$$x = f(x,u),$$

is given where $x \in R^n$ is a phase vector, $u \in R^p$ is a control parameter, f is a vector function, continuous in the aggregate of variables and continuously differentiable in x.

In the space, the set of admissible values U of the control parameter i is given; in phase space points x_0 and x_1 are given; fixed initial moment of time t_0. Let us assume that control is carried out by any continuous function $u(t), t_0 \leq t \leq t_1$ with values in the set U. It is said that an admissible control $u = u(t)$ transfers the phase point from position x^0 to position x^1 ($x^0 \rightarrow x^1$). Among all admissible controls that transfer the phase point from position x^0 to position x^1, we need to find the optimal control – the function $u^*(t)$, minimizing the functional:

$$j = \int_{t_0}^{t_1} f^0\left(x(t), u(t)\right)dt\,.$$

here $f^0(x,u)$ is a given function in the same class as the components $f^0(x,i)$, $x(t)$ is the solution of system[1] with the initial condition $x(t_0) = x^0$, which corresponds to the control $u(t), t_1$ – the time of passage of this solution through the point x_1.

By solving the problem, we mean a pair consisting of the optimal control $u^*(t)$ and the corresponding optimal trajectory $u^*(t)$. It follows from the above system, that

$$H(\psi, x, u) = (\psi, f(x,u)),$$

scalar (Hamiltonian) function of variables y, x, u

$$\psi = (\psi_0, \psi^1) \in R^{n+1},\ \psi_0\ R^1,\ \varphi^1 \in R^n,\ = (f^0,\ f).$$

Functions $H(y, x, u)$ are assigned to the canonical (Hamiltonian) system (relative to y, x)

$$\frac{dx}{dt} = \frac{\partial H}{\partial \psi}, \frac{d\psi}{dt} = -\frac{\partial H}{\partial x}.$$

The first of these equations is a system. Let

$$M(\psi, x) = sup\{u \in U\}.$$

Pontryagin's maximum principle: if $uu^*(t)$, $x^*(t)$ ($t \in [t_0, t_1]$) is a solution of the optimal control problem, ($x^0 \rightarrow x^1$, $u \in U$), then there exists such a nonzero absolutely continuous function $y(t)$, while the triple of functions $y(t)$, $x^*(t)$, $u^*(t)$, satisfies the system on $[t_0, t_1]$ and for almost all the maximum condition is performed.

$$H(\psi(t), x^*(t), u^*(t)) = M(\psi(t), x^*(t)),$$

and at the final moment t_1, the conditions

$$M(\psi(t_1), x^*(t_1)) = 0, \psi_0(t_1) \leq 0$$

If the functions $y(t)$, $x(t)$, $u(t)$ satisfy the correlations, (that is, $x(t)$, $u(t)$), form an extremum of S.M. Pontryagin, then the condition

$$M(t) = M(\psi(t), x(t)) \equiv const;\ \psi_0(t_1) \equiv const.$$

This statement implies the maximum principle for the performance problem $f^0 = 1, j = t_1 - t_0$, this statement can be naturally generalized to non-autonomous systems, problems with moving ends of trajectories, and problems with a restriction on phase coordinates (condition $x(t) \in X$, where X is a closed set of phase space R^n, satisfying some additional restrictions).

Saati hierarchy analysis method (to justify the use of a psycho-moderating multimedia environment for the prevention and rehabilitation of various diseases). The hierarchy analysis method contains a procedure for synthesizing priorities calculated on the basis of subjective judgments of experts (in our work, in connection with the need to construct a complex multi-criteria problem that requires judgments from different areas of knowledge, judgments from different branches were involved, with a weighted assessment of judgments from directly professional branch, related, and remote field of expertise). The number of opinions can be measured in dozens or even hundreds. Mathematical calculations for tasks of small dimension can be performed manually or using a calculator, however it is much more convenient to use software for entering and processing judgments. The procedure for applying the hierarchy analysis method:

The construction of a qualitative model of the problem in the form of a hierarchy that includes a purpose, alternative options for achieving the goal and criteria for assessing the quality of alternatives:

- prioritization of all elements of the hierarchy using the method of pairwise comparisons;
- synthesis of global priorities of alternatives by linearly convolving the priorities of elements in the hierarchy;
- verification of judgments for consistency;
- making decisions based on the results.

Methods of variational and alternative statistics (methods for testing statistical hypotheses were used to analyse changes in the indicators of an experimental study). The experiments were carried out by comparing the measured parameters before and after the experiment. The number of participants in one type of experiment ranged from 10 to 96, the number of experiments is 23.

The choice of the law of distribution. To determine the type of distribution law according to statistical data, a histogram is built. Histogram is a graph of statistical density of a random value in the form of a stepped polygon. It is constructed as follows: on the abscissa axis, the intervals χ_i are plotted. A rectangle with an ordinate is constructed on each of them, which is equal to the value of the studied quantity x. By combining the ordinates of the centres of the intervals χ_i, we obtain the polygon of the corresponding indicator (statistical density curve). Comparing these curves in appearance with the corresponding theoretical curves, factoring in the nature of the occurrence of failures, the hypothesis on this law of probability distribution is accepted.

The validity of the selected theoretical law (the consistency of the experimental and theoretical curves) is verified according to the matching criteria, of which the most common are Kolmogorov's and Pearson's χ^2 criteria. Kolmogorov's criteria are used when the distribution parameters are known prior to the experiment and after the experiment it is necessary to verify the consistency of the theoretical and experimental distributions. Pearson's χ^2 criterion is used when the distribution parameters are unknown. The algorithm for using χ^2 in assessing the consistency of theoretical and statistical distributions taking into account the statistical values of the frequencies χ^2 (Table 2) provides for:

Definition of discrepancy:

$$x^2 = m\sum_{i=1}^{k} \frac{(v_i^* - v_i)^2}{v_i},$$

where χ_1 is a theoretical frequency; χ_1^* is a statistical frequency of a random variable in ith interval; k is the number of intervals into which the observation time is divided; m is the sample size.

Finding the number of degrees of freedom:

$$r = k - (s + 1),$$

where s is the number of parameters of theoretical distribution.

The theoretical frequency and the number of degrees of freedom depend on the type of theoretical distribution law (Table 2). A decision was made on the consistency of experimental and theoretical distribution laws.

The calculated value of χ^2 is compared with the tabular value (Critical values of the statistics of χ^2 criterion), which correspond to the selected confidence probability χ = (0,9; 0,95; 0,99). If the tabular values are greater than the calculated ones, then the hypothesis of the correctness of the selected distribution law is accepted, otherwise they are rejected. Statistical hypotheses are hypotheses related to the type or individual distribution parameters of a random variable.

We shall describe the terminology used in this case. Let $f(X,\theta)$ be the distribution law of a random variable X with a certain parameter θ. Then:

– H_0 (null hypothesis) – $\theta = \theta_0$,

– H_1 (alternative or competing hypothesis) – $\theta = \theta_1$.

Table 2. The number of degrees of freedom and theoretical frequency when calculating the χ^2 criterion.

Theoretical distribution law	Number of degrees of freedom	Theoretical frequency
Normal law: $f(x) = \frac{1}{\sigma_x\sqrt{2\pi}} exp[-(x-\bar{x})^2/(2\sigma_x^2)]$	$r = k - 3$	$v_i = \Phi\left(\frac{x_i - \bar{x}}{\sigma_x}\right) - \Phi\left(\frac{x_{i+1} - \bar{x}}{\sigma_x}\right)$
Exponential law: $f(x) = \lambda e^{-\lambda x}$	$r = k - 2$	$v_i = e^{-\lambda x_i} - e^{-\lambda x_{i+1}}$
Weibull's Law: $f(x) = \frac{\beta}{z_x} x^{\beta-1} e^{-\left(\frac{x}{z_x}\right)^\beta}$	$r = k - 3$	$v_i = e^{-\left(\frac{x_i}{z_x}\right)^\beta} - e^{-\left(\frac{x_{i+1}}{z_x}\right)^\beta}$

Φ – Laplace's function; χ_i – initial value of a random variable in the ith sample; χ_{i+1} – ultimate value of a random variable in the i^{th} sample.

H_0 is rejected when the probability that it is true falls below a certain level called the significance level. When analysing hypotheses, two kinds of errors are possible:

- H_0 is rejected when it is true.
- H_0 is accepted when H_1 is true.

Reducing the significance level, we reduce the probability of an error of the first kind, but at the same time, the probability of an error of the second kind increases. Therefore, the concept of the power of a criterion is introduced, which represents the probability of a deviation of H_0. Since this probability changes when the parameters of the population change (for example, the sample size), a power curve is usually considered.

Hypothesis testing usually goes through the following steps.

- Definition of the used statistical model. Here, a certain set of prerequisites is put forward regarding the law of distribution of a random variable and its parameters. For example, the distribution law is normal, the values are independent.
- H_0 and H_1 are formulated.
- A criterion (criterial statistics) is selected suitable for the advanced statistical model.
- A significance level is selected, depending on the required reliability of the findings.
- The critical area for testing H_0 is determined. If the value of the criterion falls into this area, then H_0 is rejected. Provided that H_0 is correct, the probability of falling into the critical area equals a. The type of this area (one-sided or two-sided) depends on the adopted H_0.
- The value of the selected statistical criterion for the available data is calculated.
- The calculated value of the criterion is compared with the critical (sometimes called tabular) value and then a decision is made to accept or reject H_0.

When choosing a criterion, it is always necessary to proceed from the applied statement of the problem and the nature of the data. The sequence of operations when choosing a criterion:

- Formulation of the problem. Possible classes of problems are given above. In this part, we consider problems associated with verification of any parameters of the distribution law.
- Definition of the class of criteria used. A choice must be made between parametric and nonparametric criteria for testing hypotheses.
- Definition of additional conditions for the selection of criteria. Many criteria require the performance of additional conditions, without which their use would be incorrect.
- The choice of a specific criterion. For many situations, there are several roughly equivalent criteria suitable for testing a hypothesis.

Student's statistical hypothesis test for normally distributed data. The boundaries of the confidence interval for small samples (n≥30 is limited by the coefficient tα, which was proposed in 1908 by the English mathematician and chemist V. S. Gosset, who published his work under the pseudonym "Student". Later this coefficient was called the Student's coefficient – specially designed tables with consideration of the sample size). It is advisable to adhere to such a sequence of preliminary processing of the observation results at n≥30:

- The observation results are recorded in a table.
- The average value of $\bar{X}$ is calculated fromn observations:

$$\overline{X = \frac{1}{n}\sum_{i=1}^{n} X}.$$

- The errors of individual observations are determined:

$$\Delta X_i = \bar{X} - X_i \text{ and their squares } (\Delta X_i)^2.$$

- The observations that are sharply different from others are filtered out. For this, the following are found:
- Mean square error:

$$\Delta\sigma_x = \sqrt{\frac{\sum_{i=1}^{n}\Delta x_i^2}{n}}.$$

- The error value α = 0,95 is set.
- The student coefficient t_α=(n) is determined for a given reliability P and the number of observations n.
- The boundaries of the confidence interval (errors of the observation results) are found:

$$\Delta X = t_\alpha(n)\Delta\sigma_x, X = \bar{X} \pm \Delta X.$$

- Relative error of sampled data is calculated:

$$\varepsilon = \frac{\Delta x}{x} * 100\%.$$

The Wilcoxon criterion is one of the most famous tools for nonparametric statistics (along with such statistics as Kolmogorov-Smirnov and rank correlation coefficients). The properties of this criterion and the tables of its critical values are addressed in many monographs on mathematical and applied statistics. We shall introduce some notation. Let the button be the function inverted to the distribution function $F(x)$. It is defined on the segment [0; 1]. Let us assume that

$$L(t) = G(F - 1(t)).$$

Since $F(x)$ is continuous and strictly increasing, $F^{-1}(t)$ and $L(t)$ have the same properties. An important role in the subsequent presentation will play the value of unused $a = P(X < Y)$. As it is easy to show,

$$a = P(X < Y) = \int_0^1 tdL(t).$$

We shall also introduce:

$$b^2 = \int_0^1 L^2(t)dt - (1-a)^2, g^2 = \int_0^1 t^2 dL(t) - a^2.$$

Then the mathematical expectations and variances of the Wilcoxon and Mann-Whitney statistics are expressed in terms of the introduced values:

$$E(U) = mna, E\left(S = mn + \frac{m(m+1)}{2} - E(U) = mn(1-a) + \frac{m(m+1)}{2}\right),$$

$$D(S) = D(U = mn[(n-1)b^2 + (m-1)g^2 + a(1-a)]).$$

When the volumes of both samples grow infinitely, the distributions of the Wilcoxon and Mann-Whitney statistics are asymptotically normal with the parameters given by formulas[33]. If the samples are completely homogeneous, that is, their distribution functions coincide, the following hypothesis is fair:

$$if\ H_0: F(x) = G(x)\ for\ all\ x,$$

then $L(t) = t$ and $a = 1/2$.

Substituting into formula[37], we obtain:

$$E(S) = m(m+n+1)/2, D(S) = mn(m+n+1)/12.$$

Consequently, the distribution of normalized and centred Wilcoxon statistics:

$$T = (S - m(m+n+1)/2)(mn(m+n+1)/12) - 1/2,$$

as sample sizes increase, it approaches the standard normal distribution (with a mathematical expectation of 0 and a variance of 1).

Conclusions

The decision rules and the table of critical values for the Wilcoxon criterion are constructed under the assumption that the hypothesis of complete homogeneity described by the formula is valid. To implement the information system of medical (physical) rehabilitation and the software environment for the analysis of biosignals of athletes during rehabilitation. We have proposed a decision-making methodology for choosing a set of patient treatment methods. This approach provides the choice of a set of physiotherapeutic methods, which is optimal in efficiency and balanced in time of application and load on the patient. The proposed structure will allow doctors to determine supportive treatment plans for patients receiving drug therapy or recovering from surgery.

Ethical standards

The article does not contain experiments conducted with the participation of humans or animals.

Conflict of interest

The authors do not declare a conflict of interest.

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X JORNADAS INTERNACIONALES DE MEDICINA DEL DEPORTE

El trabajo en equipo en medicina del deporte

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Oral communications / Comunicaciones orales

kinanthropometry - Training / Cineantropometría - Entrenamiento

003. Distribución del genotipo ACTN3 R577X en jugadores profesionales de bádminton

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Introducción: El gen ACTN3 codifica la proteína alfa-actinina-3 que se encuentra exclusivamente en las fibras musculares de tipo II. Este gen tiene un polimorfismo, el R577X (rs1815739) que produce que las personas con el genotipo XX no expresen alfa-actinina-3. Además, diversos estudios han encontrado una mayor prevalencia del genotipo RR en los deportes de potencia y velocidad. El objetivo de este estudio ha sido analizar la frecuencia del genotipo ACTN3-R577X y su distribución alélica en jugadores profesionales de bádminton para establecer si este polimorfismo está relacionado con el rendimiento en el bádminton.
Material y método: Participaron voluntariamente 53 jugadores profesionales de bádminton que se encontraban disputando el campeonato de Europa. 31 fueron hombres (26,2±4,4 años) y 22 mujeres (23,4±4,5 años). Se utilizó una Chi-cuadrado para analizar las diferencias en la distribución de los genotipos (RR, RX y XX) entre diferentes categorías de nivel según la posición alcanzada en el Ranking Mundial y entre hombres y mujeres.
Resultados: El genotipo RR fue el más frecuente en los jugadores de bádminton (RR=49%, RX=23% y XX=28%) con una prevalencia de este genotipo superior a los valores de referencia registrados en la población europea, donde el predominio pertenece al genotipo RX (41-51%). Ninguno de los jugadores que había alcanzado el top-10 en el ranking mundial mostró un genotipo XX (RX=60%, RR=40%) lo que nos indicaría que la deficiencia completa de la proteína alfa-actinina-3 puede condicionar el rendimiento en un deporte que se caracteriza por sus movimientos explosivos. La distribución de los genotipos fue similar entre los hombres y las mujeres.
Conclusiones: El polimorfismo R577X del gen ACTN3 puede determinar el rendimiento en los jugadores de bádminton de élite ya que se ha encontrado una prevalencia del genotipo RR en los jugadores analizados y ningún jugador que haya alcanzado el top-10 mostró el genotipo XX.
Palabras clave: Badminton. Rendimiento. Alfa-actinina-3. Genética. ACTN3.

009. Masa grasa relativa e índices de adiposidad. Relación con la composición corporal obtenida por bioimpedancia

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Introducción: Cada vez se usa más la bioimpedancia eléctrica (BIA) para la obtención de los porcentajes de masa grasa (MG) y masa músculoesquelética (MME) en la determinación de la composición corporal de los deportistas y de la población en general. Así mismo, hay múltiples trabajos y referencias que usan índices antropométricos para esta valoración y la estratificación del riesgo cardiovascular. Nuestro objetivo es establecer cuál es el índice antropométrico que mejor se ajusta a los datos de composición corporal obtenidos por BIA.
Material y método: Hemos valorado a 73 deportistas aficionados (29% mujeres). Edad media 31±8,1 años (entre 18 y 49 años). Tras obtener el consentimiento informado se les midió la talla en bipedestación (SECA®), los perímetros de cintura y cadera (HOLTAIN) y se determinó la masa total y los kilos y porcentajes de MG y MME con una báscula de BIA (INBODY®). Hemos correlacionado (r Pearson), en la población total, y separados por sexo, los valores obtenidos por BIA con el Índice de Masa Corporal (IMC), la relación cintura/cadera (C/C), la relación cintura/talla (C/T) y la masa grasa relativa (MGR) obtenida con la fórmula de Woolcott y Bergman de 2018 [MGR= 64 – (20 × (talla/cintura)) + (12 × sexo); varones=0; mujeres=1].
Resultados: MGR tiene una alta correlación positiva con el porcentaje MG (r=0,83, p=0,000) y negativa con el de MME (r=0,80, p=0,000). C/C discrimina entre varones y mujeres, no muestra relación con la MG en la población global, pero sí separados por sexo (% varones p=0,007

y % mujeres p=0,034). Los Kg de MME de las mujeres no muestran relación con ningún índice. IMC tiene correlación negativa con % MME y positiva con % MG.
Conclusión. Las relaciones entre índices y porcentajes dependen del sexo. El índice que mejores correlaciones muestra es la MGR y la mayor dispersión aparece en la relación C/C.
Palabras clave: Composición corporal. Masa músculo-esquelética. Masa grasa.

014. Relación entre masa muscular y fuerza prensil con la tolerancia a la hipoxia en paracaidistas

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Introducción: La tolerancia a la hipoxia es la capacidad de respirar en ambientes con una proporción de oxígeno disminuida. Los paracaidistas realizan saltos a gran altitud por lo que se ven sometidos a condiciones de hipoxia. En la tolerancia a respirar en estos ambientes influyen distintos factores como la edad, el sexo o la genética. El objetivo es analizar la relación entre la masa muscular (MM) y la fuerza de prensión manual (FPM) sobre la tolerancia a la hipoxia en paracaidistas.
Material y método: 21 paracaidistas profesionales (14.29% mujeres) realizaron un test de tolerancia a la hipoxia normobárica (TTHN) (simulador iAltitude Trainer v2.7®) a 5050 m. El test finalizaba a los 10 minutos de duración o al alcanzar un valor de saturación arterial de oxígeno ($SatO_2$) inferior al 83%. Se dividió a la población en dos grupos: completo (G1; n=8) e incompleto (G2; n=13) según finalizasen o no el TTHN, respectivamente. La $SatO_2$ se medía con un pulsioxímetro Nonin® 3018LP colocado en la oreja izquierda del sujeto. Antes de la prueba de hipoxia se midió la FPM (dinamómetro manual Psymtec® T.K.K-5001) en ambas manos y se realizó la media. La MM se midió previa a la sesión de hipoxia con la báscula Omronv Healthcare 511.
Resultados: La MM media del G1 fue de 37,11±3,22% y del G2 de 37,05±4,43% no existiendo diferencias significativas entre grupos (p=0,487). El G1 obtuvo una FPM de 49,44±7,08N y el G2 48,46±8,67N no existiendo diferencias entre ambos (p=0,396). Existe una correlación positiva entre la FPM y la MM (p=0,001), pero no entre el tiempo del TTHN y la MM (p=0,518) así como tampoco entre la FPM (p=0,906) y el tiempo del TTHN.
Conclusión: el porcentaje de MM y la FPM no influye en la tolerancia a la hipoxia en una población paracaidista.
Palabras clave: Hipoxia. Fuerza prensil. Masa muscular. Composición corporal.

021. Influencia de la competición sobre la ansiedad y variabilidad de frecuencia cardiaca en tenistas adolescentes

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Este estudio tuvo como objetivo analizar el efecto de la competición sobre la ansiedad y la variabilidad de la frecuencia cardiaca (VFC) en tenistas. En la investigación se incluyeron 30 tenistas (15 chicos y 15 chicas). Los chicos presentaban una edad media de 14,53 ± 2,42 años, 169,2 ± 14,05 cm y 60,60 ± 17,2 Kg mientras que en las chicas la media fue de 13,60 ± 1,4 años, 164,07 ± 5,1 cm y 54,33 ± 7,69 Kg. Se midió la ansiedad competitiva mediante el Inventario de Ansiedad Competitiva-2 (CSAI-2) y el Cuestionario de Ansiedad Estado Rasgo (STAI), así como la VFC. Estas mediciones se realizaron en dos momentos distintos, momentos antes de un entrenamiento y momentos antes de una competición, manteniendo ambas veces las mismas condiciones para los participantes. Se realizó una prueba T para muestras repetidas para analizar el efecto de la competición sobre las variables estudiadas y una prueba T para muestras independientes para comparar entre sexos. Además, se calculó el coeficiente de correlación de Pearson para analizar la asociación entre variables. La ansiedad somática y la ansiedad estado fueron significativamente mayores en el momento previo a la competición comparado con el momento previo al entrenamiento ($p<0,05$). Por el contrario, el resto de las variables no presentaron diferencias significativas entre las condiciones ($p>0,05$). Por otro lado, no se observó ninguna correlación entre la ansiedad y la variabilidad de la frecuencia cardiaca ni antes de competición, ni antes de entrenamiento. Se observaron diferencias significativas entre hombres y mujeres en la ansiedad estado y la frecuencia cardiaca, siendo superior siempre en mujeres ($p<0,05$). La competición afecta negativamente a la ansiedad somático y estado a tenistas adolescentes, siendo mayor este efecto en las chicas. Por otro lado, no se observa efecto fisiológico medido a partir de la VFC.
Palabras clave: Ansiedad. Variabilidad de frecuencia cardiaca. Deportista. Competición. Rendimiento.

022. Análisis de las diferencias de masa grasa en función de las ecuaciones de estimación en adolescentes de baloncesto y piragüismo

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Introducción: Los métodos y ecuaciones para la valoración de la composición corporal son muy variados en la literatura. Aunque existen documentos de consenso entre especialistas en la materia que aconsejan su uso en determinadas poblaciones, a menudo se pueden encontrar comparaciones antropométricas realizadas desde diferentes procedimientos. Es el caso de la estimación de la masa grasa mediante técnicas antropométricas, dónde se pueden observar diferentes ecuaciones para su valoración incluso en la misma población. Podría

hipotetizarse que en deportes con más o menos implicación de las extremidades superiores, el tipo de ecuación podría influir en el resultado final. El objetivo de esta investigación fue analizar las diferencias de masa grasa deportistas de baloncesto y kayak usando las dos ecuaciones recomendadas en adolescentes.

Material y método: Cuarenta y ocho deportistas (12 kayakistas hombres, 12 kayakistas mujeres, 12 jugadores de baloncesto y 12 jugadoras de baloncesto) adolescentes (15,31 ± 1,63) fueron valorados antropométricamente. Para la estimación de la masa grasa, las ecuaciones de Slaughter *et al.*, (1988), fueron usadas a partir la medición de los pliegues cutáneos de todos los participantes por parte de un atropometrista nivel II. El análisis estadístico se realizó mediante pruebas t emparejadas y el nivel de significación se estableció en p <0,05.

Resultados: Podemos ver los resultados en la Tabla 1.

Tabla 1. Porcentaje de masa grasa de kayakistas y jugadores y jugadoras de baloncesto mediante las fórmulas de Slaughter (1988) para adolescentes.

	% Masa grasa (Tri + Pr Med) Media ± DE	% Masa grasa (Tri + Subes) Media ± DE	valor p
Kayak hombres (n=12)	15,50 ± 3,13	14,65 ± 3,40	0,877
Kayak mujeres (n=12)	22,25 ± 4,63	20,31 ± 4,27	0,546
Baloncesto hombres (n=12)	16,19 ± 4,59	14,74 ± 2,98	0,382
Baloncesto mujeres (n=12)	21,37 ± 6,80	18,88 ± 5,02	0,354

Conclusiones: Las dos ecuaciones propuestas por Slaughter *et al*., (1988) se diferencian en los distintos pliegues que se tienen en cuenta para su obtención. Sin embargo, los resultados de esta investigación en deportes tan diferentes como el baloncesto y el kayak, muestran que entre ambas ecuaciones no existen diferencias significativas.

Palabras clave: Masa grasa. Estimación. Ecuación. Pliegues cutáneos.

027. Efectos del método Tabata en deportistas profesionales y personas físicamente activas. Revisión sistemática

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Introducción: El principal objetivo de este trabajo de revisión bibliográfica fue la búsqueda de artículos científicos que reportasen evidencia alguna sobre los beneficios del método Tabata como herramienta para trabajar la resistencia en deportistas profesionales y personas físicamente activas.

Material y método: Se ha seguido una metodología cualitativa no interactiva. A través de diversos motores de búsqueda como Redalyc, Project Muse, Dialnet, Teseo, Google Académico, Pubmed y Web os science. Se incluyeron clinical trials cuyos participantes fueran deportistas o personas físicamente activas que realizaran un protocolo HIIT. Entre los métodos de exclusión, todos aquellos artículos que no estuviesen en inglés o español.

Resultados: Se han encontrado un total de 30 artículos, los cuales han valorado los efectos de distintos métodos de *High Intensity Interval Training* (en adelante HIIT) y en concreto del Método Tabata, en deportistas profesionales y sujetos físicamente activos. En este sentido, Foster et al. (2015) valoraron los efectos de tres métodos de entrenamiento HIIT en sujetos físicamente activos, entre ellos el método Tabata, observando un aumento de rendimiento del ejercicio aeróbico y anaeróbico. También, se han encontrado estudios que analizan y valoran positivamente el efecto de un entrenamiento HIIT en diferentes deportes, como futbol, natación, judo, atletismo y baloncesto (Sánchez y Carranque, 2016; Agudelo-Velásquez *et al.,* 2016; Aschendorf *et al.* 2018; y Gardachal 2020). Además, según Ben-Zeev y Okun (2021) mejora los marcadores de salud, como la salud cardiovascular, la salud metabólica y la función cognitiva en cualquier actividad física y modalidad deportiva, siendo una de las mejores opciones para la mejora del VO_{2max} (Narváez 2022).

Conclusiones: El método Tabata podría contribuir a la eficiencia de la preparación física de los deportistas y personas físicamente activas, pues se trata de un método entrenamiento rápido, efectivo e intenso, que requiere un gran esfuerzo concentrado en un intervalo de tiempo muy corto.

Palabras clave: Condición física. Deportistas. HIIT. Método Tabata. Personas físicamente activas. Resistencia.

Official communications / Comunicaciones oficiales

001. Entrenamiento de fuerza y flexibilidad, solos o combinados, efecto sobre la flexibilidad en adolescentes

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Introducción: Algunas evidencias sugieren que el entrenamiento de fuerza también puede mejorar la flexibilidad. Sin embargo, no está claro hasta qué punto el entrenamiento de fuerza es comparable al estiramiento. Se evaluó el efecto de un programa de fuerza y estiramiento, aislado o combinado, sobre la flexibilidad activa de estudiantes de secundaria durante las clases de educación física (EF).

Material y método: Una muestra de 206 estudiantes de secundaria (54,6% mujeres) de entre 14 y 16 años de edad pertenecientes a ocho grupos naturales fueron asignados aleatoriamente a un grupo de flexibilidad (n = 43), a un grupo de fortalecimiento (n = 61), a un grupo de fortalecimiento + flexibilidad (n = 46) o a un grupo de control (n = 56). Durante las clases de EF, los estudiantes de los grupos experimentales realizaron un programa de estiramiento de 2 minutos, fortalecimiento de 2 minutos o de fortalecimiento + estiramiento (1 min +1 min) dos veces por semana en días no consecutivos durante un total de 36 semanas. Los estudiantes del grupo control realizaron las mismas clases de EF pero no siguieron ningún programa de fortalecimiento y/o estiramiento. Se evaluó la flexibilidad activa (estimada por la prueba de sentarse y alcanzar) al principio y al final del programa de intervención.

Resultados: Los resultados del modelo lineal multinivel sobre las puntuaciones de la prueba de sentarse y alcanzar mostraron un efecto de interacción estadísticamente significativo (- 2LL = 2410,746; F = 6,780; p <0,001). Posteriormente, las comparaciones por pares entre grupos con el ajuste de Bonferroni mostraron que los estudiantes de los grupos experimentales tenían puntuaciones estadísticamente significativas más altas que los del grupo control (p <0,05). Por último, las comparaciones por pares dentro del grupo para los alumnos de los grupos experimentales mejoraron de forma estadísticamente significativa sus puntuaciones en la prueba de sentarse y alcanzar (p <0,001; d = 0,19/0,33/0,32).

Conclusiones: La flexibilidad de los estudiantes de secundaria puede mejorarse realizando estiramientos, entrenamiento de fuerza o combinando estiramientos y entrenamiento de fuerza.

Palabras clave: *Sit and Reach.* Flexibilidad. Fuerza. Estiramiento.

005. Efectos de las contracciones isométricas voluntarias intermitentes en el rendimiento y la cinemática de la región de estancamiento en el press de banca

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El propósito de este este estudio era analizar el rol de un protocolo de potenciación del rendimiento isométrico en el rendimiento y analizar los efectos que éste tenía sobre las características de la región de estancamiento. 21 participantes (edad 26,4 ± 5,42 años; masa corporal 79,4 ± 9,7 kg; altura 176,2 ± 6,9 cm; 1RM en press de banca 97,4 ± 19,8 kg) pasaron por dos protocolos de investigación en orden aleatorio: un protocolo tradicional (TRAD), que consistía en una sola serie de una repetición de press de banca al 93% 1RM y un protocolo isométrico experimental (ISO), que consistía en 15 contracciones isométricas voluntarias máximas de 1s de duración con 1s de descanso entre ellas en la región de estancamiento del press de banca. Solo el protocolo ISO mejoró el rendimiento en la fase inicial de la subida (la región previa a la región de estancamiento) de 0,298 a 0,38 m/s (p <0,001; ES = 0,67), mejoró el pico máximo de velocidad de 0,51 a 0,57 m/s (p = 0,005; ES = 0,71) y el pico mínimo de 0,47 a 0,51 m/s (p = 0,025; ES = 0,38) de la región de estancamiento, mientras que el protocolo TRAD no mostró mejoras ni en el pico máximo (de 0,49 a 0,52 m/s; p = 0,457; ES = 0,37) ni en el pico mínimo (de 0,41 a 0,49; p = 0,125; ES = 0,85) de velocidad. Los resultados de este estudio sugieren que las contracciones isométricas voluntarias de corta duración, intercaladas con breves periodos de descanso, mejoran la velocidad del levantamiento en la zona previa a la región de estancamiento, mejorando así sus características y facilitando el levantamiento.

Palabras clave: Calentamiento. Entrenamiento de fuerza. Rendimiento deportivo.

007. Funcionalidad y fuerza de aductores en jugadores de hockey patines de alto nivel

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Introducción: Las lesiones inguinales son un problema complejo en el mundo del deporte debido a su alta tasa en disciplinas multidireccionales, como futbol o hockey. El principal factor de riesgo descrito es haber padecido una lesión inguinal previamente. Esto es de vital importancia en poblaciones jóvenes ya que evitar un episodio inicial previene la aparición futura de lesiones en esta zona. Los objetivos fueron evaluar la fuerza de los músculos aductores y la funcionalidad en jugadores de hockey sobre patines de alto nivel y su relación con sufrir el padecimiento de una lesión inguinal en la temporada anterior.

Material y método: Se registraron los valores de fuerza mediante el *"Squeeze Test"* de 5 segundos (5SST), y la funcionalidad de la cadera e ingle mediante el cuestionario *"Hip and Groin Outcome Score"* (HAGOS) en una población de 11 jugadores de hockey sobre patines de alto nivel.
Resultados: La prevalencia de lesión inguinal fue del 18,2%. La fuerza media para el 5SST fue de 254,68N (3,25 Nm/Kg) y la funcionalidad alcanzó los 90/100 puntos en el cuestionario HAGOS para toda la muestra. La fuerza muscular fue similar entre jugadores que habían sufrido lesión con pérdida de tiempo durante la última temporada y jugadores sanos en (p= 0,261-0,948; g: 0,04-0,85). Se encontraron diferencias significativas en las siguientes subescalas del cuestionario HAGOS: Dolor, actividades deportivas y recreacionales, y calidad de vida entre ambos grupos (p= 0,005-0,042; g: 0,34-2,65; r: 0,3-0,61).
Conclusiones: Un quinto de los jugadores llegó a detener su actividad por lesión inguinal. La funcionalidad medida a través del HAGOS se erigió como el principal indicador que mostró diferencias entre grupos. Basándonos en estudios previos de nuestro grupo de investigación y de los de este estudio piloto, se recomienda el uso del HAGOS en la evaluación de deportistas con sospecha de esta lesión.
Palabras clave: Adolescente. Dolor Inguinal. *Squeeze test*. Hockey. Traumatismos en atletas.

008. Depresión, ansiedad e historia lesional en futbolistas con lesiones graves y muy graves

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Introducción: En los procesos de rehabilitación de las lesiones deportivas ha quedado patente la importancia que determinados factores psicológicos tienen en una recuperación exitosa. Las variables psicológicas y los indicadores de salud mental parecen jugar un papel preponderante, como la depresión y la ansiedad. El objetivo de este estudio es relacionar la historia de lesiones de los futbolistas lesionados con el nivel de depresión y de ansiedad manifestado; y, establecer la relación entre la depresión y la ansiedad manifestadas por los jugadores.
Material y método: La muestra estuvo formada por 22 futbolistas varones lesionados en el momento de la investigación. La edad media era 20,32±. Todos los participantes se habían lesionado de gravedad moderada o grave y no presentaban ninguna enfermedad crónica ni trastorno psiquiátrico. Se evaluó la historia de lesiones (2 temporadas anteriores), la depresión con el Inventario de Depresión de Beck-II (BDI-II) y la ansiedad con la escala Ansiedad Rasgo del Inventario de Ansiedad Rasgo-Estado de Spielberger.
Resultados: Los resultados indicaron que un 22,7% del grupo de jugadores que no manifestó depresión tampoco sufrió lesión. Sin embargo, del grupo que manifestó un nivel de depresión leve, los jugadores que no se lesionaron fue un 18,1%, y solo un 4,5% del grupo que manifestó depresión moderada. Por otro lado, los jugadores sin depresión mostraron valores más bajos de ansiedad (M = 18,6 ± 8,00, 95% IC [13,64, 23,56]), siendo mayores para el grupo de depresión leve (M = 28,25 ± 10,96, 95% IC [20,65, 35,85]), y aún mayores para el grupo de depresión moderada (M = 39,75 ± 6,34, 95% IC [33,63, 45,86]).
Conclusiones: Los jugadores con niveles de depresión leve o moderada se lesionaron más que los jugadores que no manifestaron depresión. Además, el nivel de depresión se relacionó positivamente con los niveles de ansiedad de los jugadores lesionados.
Palabras clave: Lesión. Fútbol. Depresión. Ansiedad.

010. Análisis de la carga interna y externa en la caza al salto

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Introducción: La práctica de la caza es una actividad que se alarga en el tiempo y conlleva una implicación global, así como ocupa el tiempo de ocio con una percepción lúdica y deportiva (Gamonales & León, 2014). Por tanto, la caza ha evolucionado notablemente, y se concibe a la práctica de la caza como actividad físico-deportiva, término que engloba tanto al ejercicio físico como al deporte (Feu, 2003; Gamonales, León & Muñoz-Jiménez, 2016). Por ello, este trabajo tiene como objetivo analizar la carga interna y externa de los cazadores de la modalidad al salto.
Material y método: La muestra estuvo formada por dos grupos de cazadores (grupo de edad 35-44 y grupo de edad 45-54), durante una jornada de caza al salto. Las variables analizadas fueron: Variables antropométricas (edad, altura, peso e IMC), variables de carga interna (hr max, hr avg, %hr max, pl y pl/min.), variables de carga externa (distancia, max. *speed, avg. speed,* aceleraciones, deceleraciones, acc./min., y secel. /min.), y Variable independiente (categoría (edad 35-44 años y edad 45-54 años)). Para recoger los datos, cada cazador fue equipado con un dispositivo inercial modelo WIMUTM (RealTrack Systems, Almería, Spain), el cual fue fijado mediante un arnés anatómicamente adaptado a cada deportista. Se realizó análisis descriptivo y de diferencias en función de la Categoría de edad de los cazadores.
Resultados: En la Tabla 1, se muestran los resultados relacionados con la carga interna y externa de los cazadores de la modalidad al salto.

Tabla 1. Análisis descriptivo y diferencias en función de la categoría de edad de los cazadores.

Variable	Edad 35-44		Edad 45-54		t de student	
	M	DE	M	DE	t.	p.
HR Max	106,11	9,76	111,6	13,35	39,48	0,00
HR Avg	76,89	4,78	79,00	7,53	53,20	0,00
%HR Max	38,40	2,40	39,50	3,77	53,20	0,00
PL29,53	6,9	30,60	7,82	17,79	0,00	
PL/min	0,20	0,03	0,21	0,03	27,78	0,00
Distancia	7386,88	1623,38	7657,42	1607,76	20,28	0,00
Max. Speed	9,07	1,91	8,71	2,11	19,31	0,00
Avg. Speed	2,96	0,25	2,96	0,31	46,18	0,00
Aceleraciones	243,88	144,83	330,33	141,98	8,40	0,00
Deceleraciones	222,33	107,53	267,55	103,18	9,78	0,00
Acc./min.	1,63	0,90	2,29	1,11	8,01	0,00
Decel/min	1,47	0,61	1,85	0,81	9,78	0,00

Conclusiones: La carga interna y externa que presentan los deportistas depende de diferentes factores relacionados con la propia modalidad al salto. Además, es un estudio pionero en la caza como actividad físico-deportiva como consecuencia de utilizar dispositivos inerciales para conocer la carga interna y externa.

Palabras clave: Salud. Actividad física. Deporte.

020. Síndrome doloroso del trocánter mayor (SDTM): enfoque multifactorial actualizado

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Introducción: Si bien el SDTM es una patología eminentemente clínica y mal definida, los avances en pruebas de imagen y el interés de la medicina deportiva han llevado a una mejor comprensión de los síntomas. Es una patología multifactorial que cursa con dolor en cara lateral en cadera y muslo.

Causas musculares: Tendinopatía de los tendones glúteo medio y menor, en su inserción con el trocánter mayor del fémur. El glúteo medio se lesiona a causa de micro y/o macro traumatismos de cadera y pelvis, mientras el glúteo menor se lesiona por pérdida de función del glúteo medio. Procesos de reparación fallidos a nivel tendinoso, aumento de adiposidad en el musculo, sedentarismo, aumento del índice de masa corporal, escoliosis, disimetrías y en la práctica deportiva errores en el entrenamiento por alta intensidad.

Causas morfológicas: Factores morfológicos de la pelvis femenina menor área de inserción del trocánter mayor, ángulo femoral menor de 134º, mayor desplazamiento trocantérico hacia coxa vara y aumento del ángulo Q. Se correlacionan con una mayor compresión de los tendones glúteos sobre el trocánter mayor en mujeres de mediana edad.

Causas biomecánicas: La combinación de insuficiencia abductora trocantérica, el aumento de la contribución de los tensores de banda iliotibial y uso excesivo de la aducción funcional puede representar un factor de riesgo biomecánico para los tendones glúteos que están expuestos a la carga combinada de compresión y tracción en estos pacientes.

Material y método: revisión bibliográfica actualizada de los enfoques etiológicos relacionados al desarrollo del SDTM.

Conclusiones: por todo ello, se evidencia la necesidad de reconocer los posibles factores de riesgo que permitan diseñar un tratamiento eficaz para restablecer la funcionalidad perdida y disminuir el dolor síntoma clínico por excelencia del SDTM.

Palabras clave: SDTM. Tendinopatía glútea. Alteración de la marcha. Morfología pelviana.

Physical activity and health / Actividad física y salud

002. Influencia del ciclo menstrual en el rendimiento físico y cognitivo en mujeres eumenorreicas

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Introducción: Las hormonas sexuales femeninas propias del ciclo menstrual no solo tienen funciones reproductivas, también influyen en otros sistemas fisiológicos pudiendo afectar al rendimiento deportivo y cognitivo. El propósito del presente estudio ha sido evaluar distintos aspectos como la composición corporal, la resistencia, la fuerza muscular y algunas capacidades cognitivas en diferentes etapas del ciclo menstrual.

Material y método: En el estudio participaron ocho mujeres jóvenes eumenorreicas (edad=23,1±4,4 años) con ciclos menstruales regulares. Se realizó una prueba de densitometría y una bioimpedancia para estudiar la composición corporal, una prueba de memoria visual a corto plazo y un test de tiempo de reacción para evaluar habilidades cognitivas y se analizaron características del músculo (grosor y rigidez del recto anterior y fuerza muscular) junto a una prueba de esfuerzo para evaluar el rendimiento durante las fases folicular media (FF) y lútea media (FL) del ciclo menstrual de las participantes.

Resultados: Durante la fase folicular las participantes registraron un mayor tiempo total (FF=488,5±93,18 s vs. FL=468,6±81,29s; p=0,015) y una frecuencia cardiaca inicial menor (FF=83,3±10,23 pulsaciones por minuto (PPM) vs. FL=92,9±7,67 PPM; p=0,034) en la prueba de esfuerzo. Además, Respecto a las habilidades cognitivas, en la fase folicular se obtuvieron mejores resultados en el tiempo de reacción tanto con la mano derecha (FF=0,426±0,082 s vs. FL=0,453±0,087 s; p=0,036) como con la mano izquierda (FF=0,435±0,096 s vs. FL=0,466±0,077 s; p=0,034). Por otro lado, se encontró un mayor porcentaje de grasa (FF=27,3±5,1% vs. FL=27,9±5,0%; p=0,041) en la fase lútea.

Conclusiones: El rendimiento en resistencia y en aspectos cognitivos como es el tiempo de reacción fue mejor en la fase folicular mientras que se observó un mayor porcentaje de grasa en la fase lútea. Sin embargo, la memoria, la fuerza y las características musculares no se vieron afectadas por las fluctuaciones hormonales propias del ciclo menstrual.

Palabras clave: Ciclo menstrual. Mujer. Rendimiento deportivo. Composición corporal. Actividad física.

004. Niveles objetivos de actividad física habitual en pacientes con fibromialgia: influencia del codiagnóstico del síndrome de fatiga crónica

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Introducción: La Fibromialgia (FM) y el Síndrome de Fatiga Crónica (SFC) son dos enfermedades frecuentemente codiagnosticadas, que presentan muchas similitudes, como la escasa tolerancia a la actividad física habitual (AFH); particularmente en las personas con SFC. Aunque el ejercicio les es frecuentemente recomendado, existe poca literatura que reporte mediciones objetivas y cómo afecta el codiagnóstico de SFC. Los objetivos de la investigación fueron: a) Valorar mediante acelerometría posibles diferencias en los niveles objetivos de AFH y sedentarismo en pacientes con FM, con y sin SFC, en relación a un grupo de referencia (RG) de mujeres de la misma edad no diagnosticadas con FM. b) Conocer si la realización de programas supervisados de ejercicio (PSE) influye sobre los niveles objetivos de AFH y sedentarismo, tanto en ausencia como en presencia del codiagnóstico con SFC.

Material y método: Utilizando un acelerómetro durante 7 días consecutivos, evaluamos objetivamente los parámetros de AFH y sedentarismo en dos grupos experimentales: FM (N=15) y FM+SFC (N=15). Posteriormente, evaluamos dichos parámetros de forma diferencial en las mujeres que nos reportaron realizar PSE o no, en ambos grupos experimentales.

Resultados: Se observó un menor recuento de golpes de actividad tanto en el grupo FM (62,5±10,2) como en el FM+SFC (64,4±8,1) con respecto al RG (95,9±13,3) (p<0,05). Ambos grupos experimentales presentaron menor tiempo de ejercicio moderado-vigoroso (min) (FM:1160,5±189,1/FM+SFC:1264,8±155,9) con respecto al RG (1951,7±277,9) (p<0,01). Un mayor recuento de golpes de sedentarismo fue observado en FM (131,72±8,1) y en FM+SFC (139,1±11,5) frente al RG (110,2±8,96) (p<0,05). No se encontraron diferencias significativas entre los grupos FM y FM+SFC en ninguno de los anteriores parámetros. Sorprendentemente, no se hallaron diferencias significativas en ninguno de los parámetros objetivos de AFH y sedentarismo entre las pacientes que realizaban o no PSE, en ninguno de los dos grupos experimentales.

Conclusiones: Las pacientes con FM presentaron menores niveles de actividad física diaria que el grupo de referencia de mujeres sin FM. Ni el codiagnóstico del SFC ni la realización de programas supervisados de ejercicio influyeron en los niveles de actividad y sedentarismo en las pacientes con FM.

Palabras clave: Fibromialgia. Síndrome de fatiga crónica. Actividad física.

011. Influencia de la higiene oral en deportistas con discapacidad intelectual

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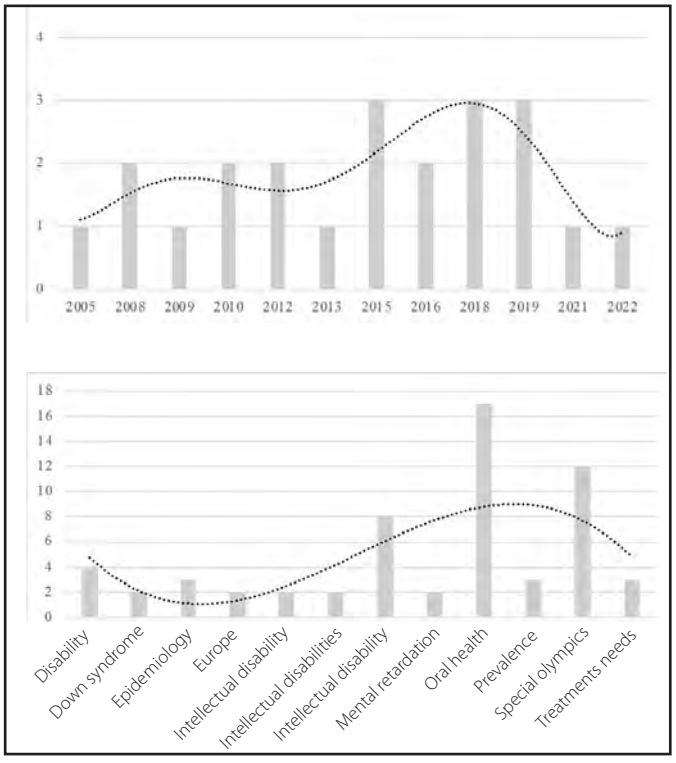
Introducción: Los hábitos de higiene bucodental, en especial los adquiridos durante la primera infancia, van a determinar la salud oral de la persona para toda vida. Las personas con discapacidad intelectual presentan más problemas bucodentales, debido en parte a la poca adaptación e individualización que se da en el tratamiento y apoyo de su salud oral. La salud bucodental tiene un fuerte impacto en la salud y en la calidad de vida. Además, puede afectar negativamente al rendimiento deportivo. El presente trabajo tiene por objetivo desarrollar una revisión sistemática, basada en los resultados encontrados en torno a los términos Salud Oral y Olimpiadas Especiales, competición deportiva en la que participan deportistas con discapacidad intelectual.

Material y método: Para llevar a cabo la búsqueda, se emplearon las palabras clave: *"Oral Health"* y *"Special Olympics"*. Los documentos fueron recopilados en la base de datos electrónica Web of Science. Con la finalidad de ajustar la búsqueda al objeto de estudio, se establecieron una serie de criterios de inclusión: i) Seleccionar cualquier tipo de documento científico, ii) Describir al menos alguna característica de la influencia de la Salud Oral en los deportistas de Olimpiadas Especiales (mínimo 50 palabras), iii) Estar escrito en inglés, portugués o español, y, iv) Tener acceso al texto completo.

Resultados: Del total de 37.052 documentos encontrados en la primera fase de búsqueda se seleccionaron un total de 15 documentos que cumplían con los criterios de inclusión. En la Figura 1, se recoge la caracterización de los documentos seleccionados en función del año de publicación y palabras clave.

Figura 1.



Conclusiones: Los documentos sobre la Salud Oral en atletas que participan en Olimpiadas Especiales muestran un estado de salud bucodental inferior al resto de la población y ponen de manifiesto la necesidad de promover y fomentar programas de tratamiento y prevención para este grupo de población.

Palabras clave: Salud oral. Olimpiadas especiales. Higiene oral. Discapacidad intelectual.

012. Propuesta de canicross como herramienta de mejora para la salud de personas con síndrome de down

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Introducción: Las personas con síndrome Down pueden presentar una restricción en la participación en actividades físico-deportivas. Por otro lado, las terapias basadas en el contacto con animales se están desarrollando de manera significativa en las últimas décadas, incluyendo las que se desarrollan durante la práctica de actividades físicas. El presente trabajo pretende mostrar los beneficios de combinar actividad física de personas con Síndrome de Down con el contacto con animales, en concreto perros, puesto que no hay constancia de que se haya planteado con anterioridad.

Material y método: El Canicross adaptado es una actividad terapéutica cuya finalidad es aumentar la motivación y participación en actividades físico-deportivas de las personas con síndrome Down. Gracias a la interacción con los perros, puede mejorar la estabilidad socioemocional, fomentando los sentimientos de empatía y respeto, junto con todos los beneficios de la práctica deportiva en el medio natural. Ayudaría a mejorar las capacidades físicas y a disminuir el estrés.

Resultados: La propuesta de adaptación del Canicross permite conocer a los profesionales de las Ciencias de la Actividad Física y del Deporte nuevos campos de actuación en la intervención de personas con síndrome Down, a través del contacto directo con los animales y el medio ambiente. Además, aporta un enfoque alternativo a las actividades convencionales.

Conclusiones: El programa de intervención planteado en este trabajo es muy aplicable. Combina la práctica deportiva del Canicross con las propiedades físicas y psicológicas de las actividades físicas acompañadas de animales, con la finalidad de dotar a las personas con síndrome Down de una mejor interacción social, habilidad corporal y control postural, además de permitir una mayor relación e interacción con el entorno y las personas que les rodean, que en definitiva, puede contribuir a mejorar su calidad de vida.

Palabras clave: Calidad de vida. Actividad física. Innovación deportiva.

015. Efecto de natación a 38ºc sobre respuesta motora y de estrés en ratones obesos C57BL/6J

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Introducción: La obesidad tiene asociada desregulaciones neuroendocrinas que frecuentemente subyacen en un estado de ansiedad/estrés, provocando, además, una peor respuesta de coordinación motora. La natación voluntaria en agua mineromedicinal hipertérmica podría ser utilizada como tratamiento no farmacológico para mejorar estos parámetros en individuos obesos. El objetivo de este estudio fue valorar el efecto de un protocolo de ejercicio de natación en agua mineromedicinal a 38ºC sobre la capacidad motora y estado de estrés/ansiedad en un modelo murino de obesidad.

Material y método: Se utilizaron ratones C57BL/6J de 6-8 semanas de edad que realizaron un protocolo de dieta hiperlipídica durante 18 semanas. Las dos últimas semanas de dieta realizaron un programa de natación voluntaria en agua mineromedicinal a 38 ºC, 30 minutos/día. Antes y después del protocolo fue evaluada la respuesta motora y el estado de estrés/ansiedad mediante pruebas comportamentales estandarizadas y validadas: prueba de la tabla, barra (respuesta motora), laberinto en cruz elevado, campo abierto y tablero de agujeros (respuesta de estrés/ansiedad).

Resultados: El protocolo de ejercicio mejoró la respuesta motora, observándose un aumento en el porcentaje de animales que llegaban al final de la tabla (50% vs. 90,9%, p <0,01) o que realiza al menos 1 segmento (68,2% vs. 100%, p <0,01) en dicha prueba. Por el contrario, aumentó el estado de estrés/ansiedad, reflejado en una disminución del tiempo que pasaban los animales en los brazos abiertos del laberinto en cruz (11,5 s. vs. 1,5s., p <0,05) o la disminución de la deambulación interna realizada en la prueba del campo abierto (11,6 cuadrantes vs. 7 cuadrantes, p <0,05), entre otros parámetros.

Conclusiones: El protocolo de natación a 38ºC, aunque mejora la respuesta motora en animales obesos, empeora la de estrés/ansiedad, generando un aumento en los valores de ansiedad/estrés por ejercicio físico en ratones obesos, que ya parten de un estado más elevado en estos parámetros.

Palabras clave: Obesidad. Ejercicio. Natación. Estrés. Ansiedad. Respuesta motora.

025. Efectos de un programa mixto (marcha nórdica +entrenamiento inspiratorio) sobre condición física y composición corporal de adultos mayores activos: estudio piloto

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Introducción: La marcha nórdica (MN) ha mostrado beneficios en amplitud y frecuencia del paso (1), condición física y calidad de vida (2) de los adultos mayores (AM). Sin embargo, se desconoce el efecto de combinar MN y entrenamiento inspiratorio, objeto de este piloto en un grupo de AM activos y sanos.

Material y método: Dieciocho AM fueron evaluados de composición corporal, fuerza inspiratoria dinámica y condición física (fuerza extremidad inferior: 5STS; fuerza prensil: HG; y aptitud cardiorrespiratoria: 200 m). El programa duró 7 semanas (MN supervisada: 3 sesiones/semana de 60min; al menos 7 de trabajo respiratorio autónomo, seguido con planillas). Trece AM (71,61±6,48 años, 11 mujeres) superaron el 70% de adherencia a las sesiones de MN. Se compararon medias para muestras relacionadas (prueba T o Wilcoxon) y se calcularon los deltas (Δ%).

Resultados: Masa grasa (Δ:0,05), índice cintura-cadera (ICC; Δ:0,03) y aptitud cardiorrespiratoria (Δ:6,32) mejoraron significativamente (p<0,05).

Conclusiones: Siete semanas de entrenamiento fueron suficientes para mejorar la aptitud cardiorrespiratoria de estos AM, que a pesar de ser activos presentaban presión arterial e IMC elevados, e ICC de riesgo cardiovascular (3) al inicio de la intervención. Incidir en el aprendizaje técnico de la MN (4) junto al trabajo respiratorio pudo potenciar sus beneficios. Al acabar la intervención, los AM presentaron valores de fitness superiores a grupos similares (5), y fuerza en la media para su grupo de edad (7,8). Nuevos estudios deben analizar la ausencia de cambios significativos en fuerza, pues mejorar la técnica implica mayor uso del tren superior (9), pero debe reducir la fuerza de prensión al andar. Igualmente, los bastones pueden reducir el efecto de los impactos y la carga sobre miembros inferiores (10) mejorando la aptitud cardio-respiratoria en base a otros parámetros.

Palabras clave: Envejecimiento activo. Entrenamiento técnico. Fuerza. Velocidad de la marcha.

Exercise Physiology-COVID Sport-Biomechanics / Fisiología Esfuerzo-COVID deporte-Biomecánica

013. ¿Es fiable la medición ecográfica de la vena cava inferior para monitorizar la deshidratación?

Ucin J, Esnal H, Tramullas A.

Erronka Kirol Medikuntza. Zumaia. Gipuzkoa.

Introducción: Pese a tener consecuencias muy importantes en la salud y el rendimiento de los deportistas, los métodos actuales no han demostrado ser fiables para la monitorización de la deshidratación. En la práctica clínica se han relacionado diferentes parámetros de la vena cava inferior (VCI), medida por ecografía, con los cambios de la volemia. Nuestra hipótesis fue que la medición de estos parámetros se relacionaba con el porcentaje de pérdida de peso corporal y, por tanto, con la deshidratación.

Material y método: Se realizó un estudio prospectivo en un equipo ciclista profesional durante la Vuelta a España de 2022. Se obtuvieron imágenes ecográficas de la VCI en el eje largo del plano subxifoideo antes y después de cada etapa. Se midió el diámetro mínimo y máximo de la VCI tras un ciclo respiratorio y se calculó el índice de colapsabilidad. También se registraron los pesos corporales antes y después de cada etapa.

Resultados: En total se analizaron 48 mediciones. De media los corredores perdieron 1,4% del peso corporal (IC 95% -0,93; -1,85). Los ciclistas que perdieron más del 1,4% del peso corporal presentaron un mayor cambio en el diámetro inspiratorio y espiratorio que aquellos que perdieron menos del 1,4% (-6,3 mm vs -2,3 mm diámetro inspiratorio, p 0,04; -2,3mm vs -0,16 mm diámetro espiratorio, p 0,03). Mientras que el índice de colapsabilidad después de la etapa no mostró cambios significativos en los dos grupos (0,62 vs 0,45; p 0,054), la diferencia del índice de colapsabilidad antes y después de la etapa fue mayor en los ciclistas que perdieron más peso (0,28 vs 0,06; p 0,03).

Conclusiones: A falta de más estudios, la medición ecográfica de la VCI parece ser una medida fiable, directa, rápida y reproducible para la monitorización de la hidratación en deportistas de resistencia.

Palabras clave: Hidratación. Ecografía. Vena cava inferior. Deporte de resistencia.

016. Comparación de la respuesta inflamatoria y niveles de actividad física según el patrón de gravedad por la infección por SARS-CoV2

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Introducción: En todo el mundo, la salud y la calidad de vida de millones de personas se han visto afectadas por la pandemia de la enfermedad por coronavirus 2019 (COVID-19). Varios factores están asociados con un mayor riesgo de hospitalización y mortalidad en pacientes con COVID-19. Estos factores tienen un estado subyacente de inflamación crónica de bajo grado asociado con la gravedad de la enfermedad. Las vías de señalización del receptor Toll Like 4 (TLR4) desempeñan un papel crucial en la producción de citoquinas inflamatorias y pueden ser altamente reguladas por la actividad física. El objetivo de este estudio fue comparar las vías de inflamación, citoquina anti y pro infamatorias y los niveles de actividad física, según el patrón de gravedad de la infección por SARS-CoV2.

Material y método: 18 pacientes COVID-19 (9 fueron hospitalizados y 9 requirieron cuarentena), se les extrajo una muestra sanguínea para la cuantificación de citoquinas anti y proinflamatorias mediante ELISA, extracción de células mononucleares periféricas de la sangre para realizar Western-Blot y también se realizó cuestionario internacional de actividad física (Ipaq).

Resultados: Los pacientes hospitalizados tienen mayor IL-1Ra comparado a los que realizaron cuarentena, además de niveles más bajo de expresión de TLR4. También, los pacientes hospitalizados tienen menores niveles de actividad física modera vigorosa (MVPA) y tienden a menor niveles actividad vigorosa (VPA).

Conclusiones: Los pacientes COVID-19 hospitalizados tenían menores niveles de actividad física previa a la infección por SARS-CoV2, además poseen una respuesta menor a la expresión de TLR4 y mayor producción de IL-1Ra.

Palabras clave: Covid-19. Actividad física. Inflamación.

017. Edema pulmonar intersticial en ciclistas profesionales durante una gran vuelta

Ucin J, Esnal H, Tramullas A.

Erronka Kirol Medikuntza. Zumaia. Gipuzkoa.

Introducción: El edema pulmonar intersticial (EPI) inducido por el ejercicio ha sido descrito anteriormente en deportistas de resistencia como una entidad subclínica y con rápida resolución. El objetivo fue describir por primera vez la incidencia del EPI, su gravedad y el tiempo de resolución en ciclistas profesionales durante una Gran Vuelta.

Material y método: Se realizó un estudio prospectivo en un equipo ciclista profesional durante la Vuelta a España de 2022. Se obtuvieron imágenes ecográficas pulmonares en busca de artefactos en cola de cometa determinantes de EPI antes y después de cada etapa. Se determinó la gravedad en leve, moderada o grave en función de la cantidad de artefactos en cola de cometa detectados (5-15 leve; 15-30 moderado; >30 grave).

Resultados: De los 8 ciclistas que participaron en el estudio, 6 desarrollaron EPI en algún momento (75%). 2 ciclistas lo desarrollaron de una forma leve (33,3%), 3 llegaron a presentarlo de forma moderada (50%) y 1 de forma grave (16,6%). De las 306 exploraciones realizadas, 243 fueron normales (79,4%). En 63 ocasiones se encontró algún grado de edema pulmonar (20,6%), siendo 41 leves (65%), 20 moderados (31,8%) y 2 graves (3,2%). Los ciclistas que presentaron EPI antes de la etapa tuvieron significativamente un mayor riesgo de seguir padeciéndolo que aquellos que no lo presentaron a la mañana (RR 5,75; IC95% 2,02-16,36).
Conclusiones: La aparición del EPI es común en los ciclistas durante una Gran Vuelta. Además, en aquellos casos en que no se recupera antes de la próxima etapa, es más probable que sigan padeciéndolo. Aunque quede por determinar las implicaciones que puede tener el EPI en la salud, recuperación y rendimiento de los ciclistas, cobran gran importancia las medidas a tomar después de las etapas y durante los días de descanso, con el objetivo de reducir su incidencia.
Palabras clave: Edema pulmonar intersticial. Ejercicio. Artefacto en cola de cometa. Deportistas de resistencia.

018. Concentraciones de elementos traza tóxicos en deportistas: diferencias entre sexos

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Introducción: El cadmio (Cd) y el plomo (Pb) son elementos tóxicos para el organismo humano. Aunque es creciente el número de estudios que abordan cómo el ejercicio físico afecta a las concentraciones de estos elementos, son casi inexistentes los trabajos que analizan qué ocurre en población deportiva femenina.
Material y método: Por ello, planteamos como objetivo analizar las diferencias en las concentraciones de Cd y Pb en deportistas de ambos sexos.
Un total de 138 futbolistas, divididos por sexo (masculino (M) n=68; 20,61±2,66 años y femenino (F) n=70; 23,37±3,95 años) participaron en el presente estudio. Se evaluaron la composición corporal, la ingesta nutricional y la condición física. Se determinaron las concentraciones de Cd y Pb, mediante espectrometría de masas de plasma acoplado inductivamente (ICP-MS), en diferentes matrices biológicas (orina, plasma y eritrocito). Posteriormente, se realizó análisis estadístico comprobándose la normalidad de las muestras y aplicándose el T-Test para muestras independientes.
Resultados: En cuanto a los resultados, se observan diferencias entre sexos en la ingesta de energía total (M 1796,0±420,1 kcal/día vs F 1.531,3±521,6 kcal/día, p<0,05), sin encontrarse diferencias significativas en la ingesta de Cd y Pb. Respecto al Cd, el grupo femenino presentó mayores concentraciones en plasma (M 0,08±0,03 µg/L vs F 0,43±0,29 µg/L, p<0,05), eritrocitos (M 2,03±1,04 µg/L vs F 2.63±1.62 µg/L, p<0,05) y plaquetas (M 0,51±0,19 µg/L vs F 0,69±0,51 µg/L, p<0,05). En cuanto al Pb, las deportistas mostraron mayores concentraciones en plasma (M 0,34±0,14 µg/L vs F 0,52±0,51 µg/L, p<0,05) y plaquetas (M 5,86±1,26 µg/L vs F 6,93±2,25 µg/L, p<0,05), en comparación con el grupo masculino.
Conclusiones: Podemos concluir qué a pesar de presentar ingestas similares, las concentraciones de Cd y Pb son diferentes entre hombres y mujeres deportistas. Estas diferencias nos hacen pensar que el metabolismo de estos elementos tóxicos se ve influenciado por el sexo en sujetos deportistas.
Palabras clave: Elementos tóxicos. Deportistas. Mujeres.

023. Análisis biomecánico en el *cheerleading* de la técnica de lanzamiento directo a una mano *"cupie"*

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Introducción: En *cheerleading* se realizan técnicas de alto riesgo para sistemas óseo y muscular, perjudicando articulaciones y musculatura involucrada para los deportistas. Se pretende analizar ejecución del gesto de cupie para determinar variables de riesgos de lesión.
Material y método: Se estudiaron 13 *cheerleaders* de alto rendimiento de Selección Colombia, 8 hombres (28,1 ± 5,6 años) 5 mujeres (28,20 ± 6,2 años). Se determinan 5 fases de estudio (inicial, ascenso, permanencia, descenso y final). Se hace observación miocinematica subjetiva de los músculos inmersos en el movimiento. Se graban planos frontal y sagital, para análisis en Kinovea versión 0.9.5. Se localizan puntos anatómicos de referencia en ejes X y Y. Se procesan datos con *software* SPSS Statistics V22.
Resultados: Se obtuvieron datos de tiempo (2,59 ± 0,22s), distancia (2,89 ± 0,22 m), velocidad media (1,69 ± 0,12m/s) velocidad máxima promedio (4,60 ± 0,66m/s), aceleración media (-0,93 ± 1,39m/s^2), aceleración positiva (6,55 ± 0,87m/s^2) y máxima desaceleración promedio (-17,9 ± 3,09 m/s^2); en *flyer*. Se determina en *flyers* índice de correlación (r= 0,72) entre peso y distancia recorrida en (51,7%) de ellas. A su vez (r= -0,51) entre porcentaje muscular y aceleración media. Se infiere subjetivamente la musculatura involucrada en el gesto.
Conclusiones: Se determina alto índice de velocidad máxima antes que flyer llegue al suelo con máxima desaceleración cuando talón impacta contra el piso afectando probablemente tobillo y tejidos que lo componen. Entre más peso de *flyer* mayor distancia total recorrida al tener IMC bajo y porcentaje de masa muscular adecuado y a su vez mayor aceleración media. Se requiere metodologías de fortalecimiento en articulaciones de cadera, rodilla y tobillo al declararse factor de riesgo de lesión por repetición de fuertes impactos contra el suelo. Se construye protocolo de análisis biomecánico para la acrobacia en estudio y como propuesta para futuras investigaciones en este deporte.
Palabras clave: *Cheerleading. Cupie.* Análisis biomecánico.

024. Comparación de efectos hipotensores en única sesión de ejercicios aeróbicos, anaeróbicos y mixtos en bicicleta

Niño O[1], Ortega G[1], Hernández C[1], Maldonado R[1], Amaya J[1], Reina J[2], Peña C[3], Rodríguez L[1].

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Introducción: La hipotensión posterior al ejercicio físico se ha evaluado en distintos ejercicios e intensidades de forma separada, sin embargo, es necesario seguir ahondando en este tema para lograr una adecuada dosificación del ejercicio físico en busca de la salud.

Material y método: Estudiantes de educación física, hombres sanos y físicamente activos, aleatorizados para conformar dos grupos; el grupo 1 (22,9±1,44 años) realizo un ejercicio incremental para determinar las intensidades de trabajo, posteriormente, ejercicios de predominancia aeróbica; al 50%, 55% y 60%. El grupo 2 (23,2±2,21 años) ejercicios de predominancia anaeróbica; Wingate, ejercicios de alta intensidad y corta duración y el test de umbral de potencia funcional. Los ejercicios se realizaron en el laboratorio de fisiología del ejercicio en bicicleta estática con medición de tensión arterial, vatios, frecuencia cardiaca y escala de Borg, además, monitorización antes, durante y después de hasta 60 minutos de descanso.

Resultados: al comparar la tensión arterial sistólica en reposo frente a la tensión arterial en descanso (10-60 minutos), todos los ejercicios con sus intensidades evidenciaron diferencias significativas entre el minuto 30-60 del descanso, y, en especial al 60%; minuto 20 con -12,9 mmHg y p = 0,001, minuto 30 con -13,5 mmHg y p = 0,001, minuto 40 con -14,4 mmHg y p = 0,001, minuto 50 con -16,5 mmHg y p = 0,001, y minuto 60 con -15,5 con p = 0,001.

Conclusiones: El ejercicio físico en bicicleta estática al 60% de la carga, determinada a través de un ejercicio incremental, tiene efectos hipotensores agudos, evidenciando los mayores valores de cambio, frente a otros ejercicios de predominancia aeróbica y anaeróbica a diferentes intensidades, de esta forma, para lograr una adecuada dosificación de las intensidades del ejercicio físico en busca de la salud, se deben plantear entrenamientos con adecuados métodos de determinación de la intensidad a trabajar, así como mecanismos de control y seguimiento.

Palabras clave: Hipotensión. Ejercicio en bicicleta. Tipos de ejercicios.

026. Recuperación de la lesión renal inducida por dos modalidades de ejercicio físico

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Introducción: El ejercicio físico extremo puede causar lesión renal aguda. Entre los factores que pueden facilitar esta lesión se encuentra hidratación insuficiente, la reducción de flujo plasmático renal o la lesión parenquimatosa causada microtraumatismos. Pese a los mecanismos propuestos, el proceso y la rapidez con la que dicho daño se recupera no han sido adecuadamente descritos.

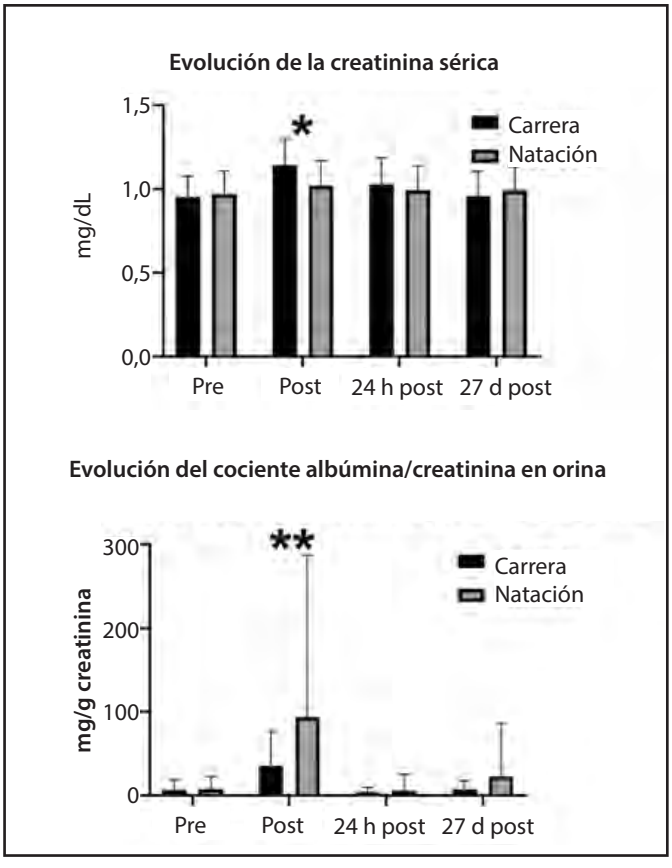
Material y método: Incluimos una muestra de 40 voluntarios sanos. Los participantes realizaron dos pruebas físicas (carrera continua 10 km, en adelante "carrera", y natación 1.5km, en adelante "natación"). Ambas pruebas se separaron entre sí al menos 14 días. Se obtuvieron muestras de sangre y orina inmediatamente antes (Pre) y después (Post), así como 24 h y 7 días tras las pruebas. Se obtuvo consentimiento informado de todos los participantes. El proyecto fue financiado por la Consejería de Sanidad, Junta de Castilla y León (GRS1732/A/18).

Resultados: La mediana de edad de los participantes fue de 33 años. Un 35% de los atletas eran mujeres. La media del índice de masa corporal en la muestra fue de 23.1±2.3 kg/m^2. La duración media de la carrera continua fue de 48±6 minutos, mientras que en el caso de la natación fue de 36±9 minutos.

La Figura 1 resume la evolución de las cifras de creatinina sérica y cociente albúmina/creatinina urinaria.

La carrera provocó un mayor aumento en la creatinina sérica en comparación con la natación. Ésta, sin embargo, parece inducir un aumento mayor del cociente albúmina/creatinina urinaria, aunque dicha diferencia no alcanzó significación en comparación con la carrera.

Figura 1.



Conclusiones: Ambas pruebas asociaron cambios en la función renal que se corrigieron en las primeras 24h, no mostrando cambios transcurridos 7 días después. Los resultados parecen sugerir que, independientemente del tipo de afectación renal inducida por el ejercicio, ésta se recupera completamente en un plazo de tiempo muy corto.
Palabras clave: Función renal. Proteinuria. Recuperación.

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