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Summary / Sumario

Prevention is better than cure

Prevenir es mejor que curar

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Universidad de Castilla-La Mancha. Facultad de Ciencias del Deporte. Toledo. Presidente de la Conferencia Española de Decanos en Ciencias de la Actividad Física y del Deporte.

The old adage confirms the wisdom of our forebears when it came to encapsulating acquired scientific knowledge in words.

The report on *Physical inactivity and sedentary lifestyle in the Spanish adult population*,[1] issued by Fundación España Activa and published in 2019, warned that physical inactivity was responsible for 13.4% of all annual deaths in Spain, claiming more than 52,000 lives. Such a negative statistic also represents an economic burden for the country of more than €1,560 million, of which 70.5% is covered by taxes.

Faced with this situation not only in Spain but in the rest of the industrialised world, WHO launched the Global Strategy for the Prevention and Control of Noncommunicable Diseases in 2013 and its regional office for Europe prepared the Physical Activity Strategy for the WHO European Region (2016-2025) in 2015.

Clearly, both PHYSICAL EXERCISE, properly done, and EATING more smartly will help bring down these lamentable mortality figures. With the plausible goal of lowering the levels of physical inactivity in the world, the World Health Organization suggested that we walked at least 15,000 steps a day (about 8 km). This is "better than nothing", of course, but it is by no means the solution. For several decades, we have known that the benefit of exercise depends less on the volume (metres, repetitions, steps, etc.) and more on the intensity at which it is carried out.

We sometimes see people joining group sessions at the gym who are unaware of the intensity at which exercise is able to deliver them any benefit. We can see, for instance, everyone from sporty twenty-year-olds to pensioners who were "just passing by" taking part in the same indoor cycling session and working at the same intensity. A lack of commitment to and actually giving up exercise are in part the result of a failure to identify the right intensity; the one at which we can make progress and see our efforts rewarded. How often have we heard someone we know say "I'm done with the gym. I've been going for a month and haven't shed an ounce."? The Spanish State owes the population a debt for failing until now to take any kind of legislative initiative to regulate the sports professions, something which would help reduce this lack of commitment to exercise and raise life expectancy.

Physical exercise is a miracle pill which can make us more productive and fitter, while also alleviating the emotional stress many of us suffer as a result of work, the pace of life or personal disenchantment. There is no reason why exercise should cost money. We have everything available from low-cost council facilities to groups of friends who meet up to go running or cycling in their local neighbourhoods or villages under the direction of an expert in sports science. Money is no excuse for not doing exercise. Is there a cheaper pill available in the pharmacies?

What is important is to differentiate between "physical activity" and "physical exercise". WHO defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure[2]. This includes activities undertaken while working, playing, carrying out household chores, travelling and engaging in recreational pursuits. Exercise, however, calls for the correct planning of objectives, embodied in tasks which respect the programmed intensity and are carried out systematically over time. For this, a professional is needed in order to determine the right workload. When somebody has a medical condition, their doctor prescribes exercise and a sports science professional defines the contents and intensity of the exercise prescribed.

Countless scientific papers and research projects confirm the need for exercise and controlling eating habits for a healthy life and, maybe more importantly, for active and healthy aging. Although from the standpoint of life expectancy at birth, Spain has the second longest-living population in the world, we grow old with a very high incidence and prevalence of comorbidities, which not only means health problems for the population but also a massive health bill with a significant pharmaceutical component. Experts encourage us to take up sports not only as a way to enhance our health but also for educational purposes. Unlike general physical exercise, sport exponentially increases the benefits described above and favours commitment. There are individual and group sports for everyone and for all ages. You just have to seek advice from your doctor and a sports science expert.

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Since the 1980s, sports professionals have speculated on the expediency of muscle strength training to improve health, well-being and quality of life. In the last decade, sports science researchers have concluded that sport, and particularly strength training, is a "wonder drug" when it comes to preventing cardiovascular diseases and physical and mental deterioration. Aware of this, primary care physicians have of late been telling their patients to "do some exercise".

Physical exercise has a great impact on the body mass index and, therefore, on the development of overweight/obesity, one of the main causes behind the development of comorbidities over the years and, consequently, unhealthy aging. Marked differences clearly exist between individuals in terms of the effect of exercise on the mobilisation of adipose tissue, hence some people with moderate or even low workloads being less at risk of obesity than others with high workloads. This difference in response to exercise can probably be explained with reference to genetic variations between individuals, primarily in gene polymorphisms which define different characteristics associated with sporting performance and the type of exercise for which the person is best equipped, and some of these genetic variants modulate the effect of exercise on the functionality of the brain or the prevention of overweight and obesity[3].

There is one rather uninspiring variable in our current understanding of sport; it is "in fashion", and fashions are ephemeral. Innumerable software applications and social network prophets organise training programmes for us and offer advice on nutrition, without the slightest reference to the people they are addressing, thereby creating stressful satiations for their followers due to their ineffectiveness. The world of fitness training, a market which currently moves millions of euros in Spain is no exception. Not to mention all the non-pharmaceutical products which can be purchased online without any kind of control and pose a danger in themselves, we are also faced with a legion of ill-prepared personal trainers who may be able to design a host of exercises for us, but pay little mind to the intensity each person requires. Remember that according to a number of regional laws passed in different autonomous communities, personal trainers must have a degree in physical activity and sports science before they can practise.

In conclusion, we can say that, in order to live a healthy life and age actively, it is essential to do exercise consistently and under the supervision of a specialist in the field, adapt our eating habits to our energy requirements and reduce stress to the extent that it becomes a positive factor as our lives move on.

Bibliography

1. Fundación España Activa. Termómetro del sedentarismo en España. Madrid. Centro de Investigación del deporte. Universidad Rey Juan Carlos (2019).
2. O.M.S. Estrategia Mundial para la Prevención y Control de Enfermedades No transmisibles. Disponible en https://www.who.int/dietphysicalactivity/pa/es/
3. López Farré A. *et al*. Los genes de la alimentación y del deporte. Madrid. Ed. Complutense (2019).

Original article

Split versus full-body strength training workouts in untrained people. A randomised study

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Summary

Introduction: There are numerous scientific studies in which the components of resistance training load have been analyzed, as well as many variables that condition the development of muscular strength. However, only a few studies compared the effectiveness of full body workouts and split body routines. The purpose of the present investigation was to determine which of them is more effective in increasing both muscular strength levels and kinanthropometric parameters.
Methods: 28 male university students without previous experience in strength training were finally included in the present study. They were randomly assigned to two different training groups: Full body workout group (GECC) and split body routine group (GERD). Intra- and inter-group differences in percentage changes (pre-post) were assessed using non-parametric tests.
Results: After the completion of an 8-week intervention period, significant improvements in body fat percentage (p = 0.028), levels of muscular strength on the upper body (p=0.008) and on the lower body (p=0.043) were observed in the GECC. Similarly, significant improvements in body fat percentage (p=0.006), lean body mass (p=0.011) and upper body (p=0.031) and lower body levels of muscular strength (p=0.048) were reported in the GERD. However, no significant differences between groups were found neither in the strength tests performed, nor in the Kineanthropometric parameters evaluated.
Conclusion: Both split and full body routines are useful to improve strength levels and kinanthropometric parameters in college students with no previous experience in strength training. However, neither of the two structures is significantly more effective than the other one when it comes to improving the above-mentioned parameters.

Key words:
Training. Strength. Split body routine. Full body workout.

Entrenamiento de fuerza mediante rutinas divididas versus rutinas de cuerpo completo en personas desentrenadas. Un estudio aleatorizado

Resumen

Introducción: Existen numerosas investigaciones científicas en las que se han analizado los componentes de la carga del entrenamiento de fuerza, y las numerosas variables que condicionan el desarrollo de esta capacidad. En cambio, son pocos los estudios en los que se ha contrastado la eficacia de los entrenamientos de cuerpo completo frente a las rutinas divididas. El objetivo del presente estudio fue determinar cuál de los dos es más eficaz a la hora de mejorar los parámetros de fuerza y cineantropométricos.
Material y métodos: 28 estudiantes universitarios de sexo masculino sin experiencia previa en el entrenamiento de fuerza fueron finalmente incluidos en este estudio y asignados aleatoriamente a dos grupos de entrenamiento de fuerza diferentes: Entrenamiento de cuerpo completo (GECC) y entrenamiento con rutina dividida (GERD). Se compararon los porcentajes de cambio (pre-post) intra e intergrupo mediante pruebas no paramétricas.
Resultados: Finalizada la intervención de ocho semanas, el GECC mejoró de forma significativa el porcentaje de grasa (p=0,028), y la fuerza en el tren superior (p=0,008), e inferior (p=0,043). En el GERD se produjeron mejoras significativas en el porcentaje de grasa (p=0,006), en el tejido magro (p=0,011), y en la fuerza en el tren superior (p=0,031), e inferior (p=0,048). Sin embargo, no existieron diferencias significativas entre ambos grupos en ninguna de las mejoras alcanzadas en los parámetros de fuerza y cineantropométricos evaluados.
Conclusión: Tanto las rutinas divididas como las de cuerpo completo permiten mejorar los niveles de fuerza y los parámetros cineantropométricos en estudiantes universitarios sin experiencia previa en el entrenamiento de fuerza. Sin embargo, ninguna de las dos estructuras de entrenamiento es significativamente más eficaz que la otra a la hora de mejorar los mencionados parámetros.

Palabras clave:
Entrenamiento. Fuerza. Rutina dividida. Rutina de cuerpo completo.

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Introduction

Strength training is very important in the field of physical activity. In elite sport, increases in strength have a positive impact on the performance of athletes by improving their motor skills. They also reduce the risk of injury[1]. At a recreational and functional level, strength training helps improve the health and quality of life, while decreasing the risk of certain diseases and medical conditions[2-4]. Such benefits have been verified by numerous studies, which have also established the proper dose of strength training each population group needs in order to achieve adaptations which result in improved athletic performance or, where applicable, health[5].

Adequate handling of the components of the training load and appropriate management of certain variables (contraction regime, selection and order of exercises, speed of execution and weekly training frequency) determine the strength adaptations which each subject can achieve. There is a considerable degree of consensus regarding these parameters in the scientific literature[6,7]. This makes it possible to prescribe effective training programmes.

That said, there is one relevant aspect on which consensus is yet to be reached[8] and that is the structuring of the sessions themselves. This point, which has not been researched in any depth, conditions variables such as the number of exercises per muscle group performed in each session, the number of weekly sessions that stimulate a particular muscle group and the recovery time for each muscle group between one training session and the next.

Kraemer & Ratamess[9] and Heredia *et al*[10] inform us that there are three ways of structuring strength training sessions:

- *Full-body workouts:* exercises which stimulate the body's main muscle groups in the same training session. Normally, one exercise is carried out for each major muscle group.
- *Upper-/lower-body split workouts:* the muscles of the upper body are stimulated in one session and those of the lower body in the next.
- *Muscle-group split workouts:* exercises aimed at strengthening specific muscle groups are performed in each session.

Bodybuilders, and generally those seeking a certain degree of hypertrophy, tend to use split workouts. Fitness enthusiasts, athletes and weightlifters prefer workouts which address the entire body[11].

Various studies have demonstrated that both split and full-body routines are effective at improving strength levels. It has not, however, been established which of these is most useful in achieving certain adjustments. Choosing a specific training structure often responds to such factors as the personal objectives of each subject, the number of weekly training sessions devoted to strength training, the length of those sessions and personal preferences[10]. Within this context, the purpose of this study was to verify which of the two ways of structuring strength training workouts was more effective at improving strength levels and kinanthropometric parameters, full-body workouts or split workouts.

Materials and methods

Participants

The initial sample consisted of 39 subjects, all male. They belonged to Prince Sultan University in Riyadh (Saudi Arabia) and were enrolled in the "Beginner Weight Training" module. This meant that it was possible to fully monitor the intervention process, which was carried out in the fitness room at the university. 11 subjects were excluded from the research for failing to keep to the training programme, because they did not complete 85% of the sessions. The final sample, therefore, consisted of 28 subjects. None of them did physical activity in a structured manner and they had no previous experience of strength training. Neither did they have any injuries or diseases which would prevent them from carrying out the tests and activities involved normally. Participation in the study was voluntary and all the subjects were suitably informed of the benefits and risks of taking part. The research project observed the ethical principles of the Declaration of Helsinki and was approved by the Institutional Review Board of the Committee for Bioethics at Prince Sultan University.

Kinanthropometric measurements

A Seca digital column scale (Hamburg, Germany) was used to measure weight, height and BMI. The weight was recorded to the nearest 0.1 kg and height to an accuracy of 0.1 cm. The measurements were taken by the same researcher with the subjects barefoot. The body fat percentage was obtained using the following equation12: % fat = [(Σ of the abdominal, suprailiac, subscapular, triceps, quadriceps and medial calf folds) x 0.143] + 4.56. The caliper used to measure the folds of fat was an FG1056 Harpenden Skinfold Caliper (Sussex, UK). Lean mass was calculated with the following formula: lean mass = total mass (kg) - fat mass (kg).

Measuring strength

Before carrying out the tests, the participants in the study did the following warm-up:

Stage I: Activation: Five minutes of aerobic exercise.

Stage II: Joint muscle mobility: Mobilisation of the main joints in cephalocaudal order.

Stage III: Specific warm-up. A series of five repetitions of the following exercises at 50% estimated 1RM: Squat, bench press, hand grips.

Then the following tests were performed:

Lower-body strength: Lower-body strength was measured using a Takei Strength dynamometer T.K.K. 5402 Back D (Japan). The protocol was as follows: the participants placed their feet on the platform with their knees slightly bent (130º-140º). The bar was held with a backhand grip on the right hand and a forehand grip on the left hand. In this position, keeping the back straight, the subjects tried to straighten their knees, applying as much force as possible. Each subject had two tries13.

Bench press: As the study participants had no previous experience in strength training, 1RM was measured indirectly using the Epley formula[14,15]: 1RM = Weight lifted in the test x [1+ (0.003 x No. of repetitions to failure)]. This test was used to measure upper body strength. The muscles involved in this exercise are the pectoralis major (agonist) and the anterior fascicle of the deltoid and elbow extensors (which act as synergists). The test was performed using 80% of the estimated 1RM for each subject, using a Hammer Strength bench, an Olympic bar and Olympic plates. The participants adopted a supine position on the bench with head and hips neutral. The bar was held across the shoulders. The participants were told that they had to do as many repetitions as possible with a full range of motion, i.e. starting with the elbows fully stretched, they had to lower the bar until it made contact with the chest and then lift it back to the starting position. Each subject had one try and only repetitions performed correctly were recorded[16,17].

Hand-grip strength (kg): Hand strength or grip was measured using a Takei Grip Strength Dynamometer T.K.K. 5401 Grip-D (Japan). The measuring protocol was as follows: the participants, in standing position and with arms outstretched along the body, held the dynamometer with their dominant hand in such a way that the screen was visible to the researcher at all times. They were then told to apply the greatest force they could trying to grip their thumb and the rest of their fingers together without moving their arm. The score obtained was recorded to an accuracy of 0.1 kg. Each subject had two tries[13].

Intervention and design

A randomised test was conducted to compare the changes between before (pre) and after (post) the two conditions: full-body workout (FBW group) and split workout (SW group). Before starting the procedure, the subjects were asked not to alter their diets during the study. Over the two weeks prior to application of the intervention design, all the participants did identical strength training twice a week to familiarise them with the exercises (Table 1). They were then randomly assigned to one of the two experimental groups: FBW group [n = 12; age = 21.17 (1.70)] and SW group [n = 16; age = 21.12 (1.36)]. The eight-week intervention period, in which the participants did strength training workouts twice a week, then began (Table 1). The training sessions were conducted each week between 9:30 a.m. and 10:30 a.m. on Monday and Wednesday.

During the intervention, the training methods used and the weekly training load were identical for both groups. On Monday, however, the SW group only performed exercises to stimulate the muscles of the upper body and on Wednesday they did exercises to strengthen the upper body, while the FBW group did full-body workouts in all the sessions over the period. The strength exercises carried out by both groups were the same each week (Table 1). The training intensity was increased every two weeks to prevent stagnation.

The training programme used was designed and supervised by a sports training specialist. The recommendations of the American College of Sports Medicine for beginner strength training was followed. In short, three sets of between 6 and 12 repetitions were completed per exercise with a rest lasting from 60 seconds to two minutes. Free-weight exercises and exercises with weight machines were included. In each workout, the exercises to strengthen the larger muscle groups preceded those for the smaller muscle groups and the multi-joint exercises preceded the single-joint ones[18].

Table 1. Training methods and strength exercises used with the FBW group and SW group during the familiarisation and intervention periods.

	Training methods used by the two groups (FBW and SW)	Strength exercises used by the FBW group	Strength exercises used by the SW group
Familiarisation period	I: 56%; S: 3; Rep: 14: R: 1'; EL: Two repetitions not done.	Vertical press, seated cable row, ab crunch on machine, back extension on machine, leg extension on machine, seated leg curl, seated calf raise on machine, shoulder press	Vertical press, seated cable row, ab crunch on machine, back extension on machine, leg extension on machine, seated leg curl, seated calf raise on machine, shoulder pres
Intervention period: 1st and 2nd weeks	I: 62%; S: 3; Rep: 12: R: 1'; EL: Maximum number of repetitions possible per set	*Monday:* Bench press, behind the neck jerk, seated cable row, dumbbell fly, reverse fly, dumbbell side lateral raise, triceps extension with pulley, triceps kickbacks, dumbbell curl, Scott bench biceps curl. *Wednesday:* Leg press, quadriceps extension on machine, seated leg curl, lying leg curl, ab crunch with machine, pelvic lift, back extension on machine, back extension on roman chair, seated calf raise on machine, standing calf raise on machine.	*Monday:* Bench press, seated cable row, quadriceps extension on machine, seated leg curl, ab crunch with machine, back extension on machine, seated calf raise on machine, dumbbell side lateral raise, triceps extension with pulley, dumbbell curl. *Wednesday:* Leg press, behind the neck jerk, lying leg curl, dumbbell fly, pelvic lift, back extension on roman chair, standing calf raise on machine, reverse fly, triceps kickbacks, Scott bench biceps curl.
Intervention period: 3rd and 4th weeks	I: 62%-67%-72%; S: 3; Rep: 12-10-8; R: 1'30"; EL: Maximum number of repetitions possible per set		
Intervention period: 5th and 6th weeks	I: 72%; S: 3; Rep: 8: R: 2'; EL: Maximum number of repetitions possible per set		
Intervention period: 7th and 8th weeks	I: 78%-72%-78%; S: 3; Rep: 6-8-8; R: 2'; EL: Maximum number of repetitions possible per set		

I: Intensity; S: Sets; Rep: Repetitions; R: Rest; EL: Exertion levelperiod.

Statistical analysis

The data are presented with calculation of the arithmetic mean and standard deviation for all the variables. The distributions of the data were checked using the Shapiro-Francia test and the D'Agostino K-squared test. Since the groups were of different sizes and some variables showed irregular variances and non-normal distributions, non-parametric tests were used. The intragroup differences between pre-test and post-test were calculated using the Wilcoxon signed-rank test for related samples. In order to estimate a measurement of the practical effect adjusted by the previous values for each subject, the percentage changes were calculated between pre-test and post-test using the formula: 100 (post-test – pre-test) / pre-test. 95% confidence intervals (CI) were calculated for the percentage changes and those which did not cross zero were considered statistically significant. The percentage changes seen in the two groups were then compared using the Wilcoxon-Mann-Whitney test. The significance level was set at 0.05. All the calculations were made using Stata 13.1 (Stata Corp, College Station, Texas, USA).

Results

As can be seen in Table 2, the FBW group saw a reduction in body fat percentage (p = 0.028), indicating a loss of 5.07% (95% CI = 0.19 to 9.95). Looking at the strength variables, a statistically significant increase was observed in this group in the bench press exercise (p=0.008), representing an average improvement of 23.9% (95% CI = 5.29 to 42.52). Although significant differences were also observed in lower-body strength between pre-test and post-test (p = 0.043), the effect size exhibited great variability and did not confirm improvement in relative values: 24.34% (95% CI = -3.51 to 52.19). Significant differences were not observed in this group for the other variables analysed.

The SW group, however, not only experienced a slightly higher reduction in body fat percentage (p = 0.006), indicating a loss of 6.76% (95% CI = 2.75 to 10.77), it also saw a significant increase in lean body mass (p = 0.011), with a percentage change of 1.94% (95% CI = 0.68 to 3.21). Looking at the strength variables, there were also significant differences between pre-test and post-test in the SW group both on the bench press (p = 0.031) and with the back dynamometer (p = 0.048). The improvement seen on the bench press was 9.22% (95% CI = 1.41 to 17.04) and on the back dynamometer it was 23.33% (95% CI = -3.85 to 50.5). As with the FBW group, no significant differences were observed in the SW group on the other tests performed.

As for intergroup differences, no statistically significant differences were found in the relative improvements achieved by each group for any of the variables analysed and the effect sizes were also seen to be small (Table 2).

Discussion

The results verify that the two training structures lead to improvements in strength levels and body composition. Both the FBW group and the SW group significantly improved their performance on the back dynamometer and the bench press. They did not, however, achieve any significant improvement on the hand grip dynamometer. We understand that this responds to the specificity of training principle, since the intervention process did not involve any exercises to strengthen the forearm muscles (Table 1). As for kinanthropometric variables, only the SW group showed significant increases in its lean mass percentage. The body fat percentage of both groups, however, fell significantly. The results of this study, therefore, are consistent with previous research in

Table 2. Comparison of results between the FBW group and SW group

	FBW group (n=12)				SW group (n=16)				p	d
	Pre	Post	p	% [CI 95%]	Pre	Post	p	% [CI 95%]		
Height (cm)	176.6 (4.6)	176.6 (4.6)	–	–	178 (6.7)	178 (6.7)	–	–	–	–
Weight (kg)	80.1 (24.1)	79.6 (23.1)	0.340	-0.23 [-1.67, 1.2]	82.6 (27.6)	82.9 (27.9)	0.283	0.29 [-0.51, 1.1]	0.378	-0.31
BMI (kg/m2)	25.7 (7.3)	25.6 (6.9)	0.705	0.15 [-1.52, 1.81]	25.9 (7.9)	26 (8)	0.278	0.31 [-0.46, 1.08]	0.642	-0.17
Lean mass (kg)	63.6 (12.8)	64.5 (13)	0.103	1.42 [-0.12, 2.96]	65.3 (14.8)	66.8 (16.2)	0.011	1.94 [0.68, 3.21]	0.781	-0.10
Fat (%)	18.6 (7.6)	17.4 (6.5)	0.028	-5.07 [-9.95, -0.19]	18.6 (8)	17.3 (7.5)	0.006	-6.76 [-10.77, -2.75]	0.403	0.34
Hand-grip strength (kg)	39.2 (7.5)	40.4 (8.4)	0.519	3.91 [-7.14, 14.97]	37.4 (9.5)	38.2 (7.3)	0.522	6.85 [-7.34, 21.03]	0.889	0.05
Lower-body strength (kg)	108.6 (26.8)	130.2 (36.2)	0.043	24.34 [-3.51, 52.19]	109 (35.8)	124.4 (31.5)	0.048	23.33 [-3.85, 50.5]	0.889	0.05
Bench press (kg)	51.6 (16.1)	61.2 (14.1)	0.008	23.9 [5.29, 42.52]	59.5 (26.9)	63.7 (24.8)	0.031	9.22 [1.41, 17.04]	0.242	0.51

The pre- and post-test data show the mean (standard deviation). The pre- and post-test percentage changes are presented with a confidence interval of 95%

which strength training led to improvements in body composition, both in subjects with experience in strength training[19] and the untrained[20].

Meanwhile, no significant differences were observed between the two groups in either the kinanthropometric parameters analysed or the strength tests carried out. As for strength levels, these results are consistent with those obtained in the research conducted by Calder *et al*.[21] with young women and Campbell *et al.*[22] with older people. In both studies, the subjects had no previous experience in strength training and it was possible to verify that the two types of workout led to similar increases in strength. Schoenfeld *et al*.[23], in a study conducted with university students with previous experience in strength workouts, also found that the two ways of structuring training sessions led to similar improvements in strength levels. They also noted that full-body workouts were more effective than split workouts in increasing muscle mass. In our study, however, the split workout resulted in a greater increase of lean tissue, although it is also true that the body fat percentages of both the FBW and SW groups fell significantly. This discrepancy should be analysed in subsequent research.

Be that as it may, according to the results of the present study and the three studies which analysed the subject before it[21-23], it can be argued that neither of the two ways of organising strength training sessions is clearly better than the other, irrespective of the subjects' age, sex or level of physical activity. We understand that this is because both types of workout have pros and cons. The advantages of split workouts are[21]: a) the training sessions do not have to be too long; b) the fatigue accumulated from the earlier exercises in the session does not prevent the exercises at the end of it from being carried out at the desired intensity; c) they result in greater muscle stress, because the number of sets per muscle group in each workout is high, in turn increasing acute hormonal secretions, cellular inflammation and muscle ischemia; d) they are less fatiguing. By contrast, the advantages of full-body routines are: a) they allow you to work each muscle group at least twice a week, leading to greater strength gains through hypertrophy[24]; b) the release of anabolic hormones is directly related to the amount of muscles used in workouts[25,26].

Certain factors which condition the suitability of each type of workout do, however, need to be borne in mind: individuals who wish to do more than three strength training sessions a week should not do full-body workouts. This is because the recovery time between moderate-intensity training sessions should be no less than 48 hours and at least 72 hours for intense workouts[27,10]. Nor is it advisable to do a very high number of exercises or sets per session, since it has been shown that shorter strength workouts are more effective in improving levels of hypertrophy and obtaining neuromuscular adaptations[28]. The main advantage of full-body workouts is that they are more suitable if you want to combine strength training with other physical ability or motor skill training. Dedicating fewer days per week to building strength means that other training stimuli can be applied on the recovery days[21]. Conversely, with split workouts, the subjects or athletes can do more than three strength training sessions per week because just a small number of muscle groups are stimulated in each session. The importance of respecting the functional unit training principle, however, need also be remembered[29]. This means that the number of muscle groups working in each training session should not be too limited because human beings are made up of a set of interrelated systems that work together in synchronisation.

Regarding the limitations of the study, it would have been desirable to conduct the research with three experimental groups instead of two, with one group doing full-body workouts, another doing upper/lower-body split workouts and the third doing split workouts based on muscle groups. However, this was not possible because workout splits focusing on muscle groups best involve people with some degree of experience in strength training and this was not the case with the subjects who were recruited to take part in this study. Moreover, their schedules meant that it was not possible for them to do three sessions per week.

Conclusion

Both split workout and full-body workouts over an eight-week period are useful for improving strength levels in university students without previous experience of strength training. Both types of workout help reduce the body fat percentage, the split system being more effective for increasing lean tissue. Neither of the approaches, however, is significantly more effective than the other when it comes to increasing strength levels or improving kinanthropometric parameters. .

Conflict of interest

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

Bibliography

1. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The importance of muscular strength: training considerations. *Sport Med*. 2018;48:765-85.
2. Silva NL, Oliveira RB, Fleck SJ, Leon AC, Farinatti P. Influence of strength training variables on strength gains in adults over 55 years-old: a meta-analysis of dose-response relationships. *J Sci Med Sport*. 2014;17:337-44.
3. Kraschnewski JL, Sciamanna CN, Pogera JM, Rovniak LS, Lehman EB, Cooper AB, *et al.* Is strength training associated with mortality benefits? A 15 year cohort study of US older adults. *Prev Med.* 2016;87:121-7.
4. Ambrose KR, Golightly YM. Physical exercise as non-pharmacological treatment of chronic pain: Why and when. *Best Pract Res Clin Rheumatol.* 2015;29:120-30.
5. Fisher J, Steele J, Bruce-Low S, Smith D. Evidence-based resistance training recommendations. *Med Sport*. 2011;15:147-62.
6. Ratamess N, Alvar BA, Evetoch TK, Housh TJ, Kibler WB, Kraemer WJ. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc.* 2009;41:687-708.
7. Schoenfeld BJ. The mechanisms of muscle hypertrophy and their application to resistance training. *J Strength Cond Res.* 2010;24:2857-72.
8. Fleck SJ. Periodized strength training: a critical review. *J. Strength Cond. Res.* 1999;13:82-9.
9. Heredia JR, Chulvi Medrano I, Isidro Donate F, Soro J, Costa MR. Determinación de la carga de entrenamiento para la mejora de la fuerza orientada a la salud (Fitness muscular). *PubliCE Standard.* 2007;21:17.
10. Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. *Med Sci Sports Exerc.* 2004;36:674-88.

11. Fleck SJ, Kraemer WJ. Designing resistance training programs. 4th Edition. Champaign. *Human Kinetics;* 2014. p. 225.
12. González Gallego J, Sánchez Collado P, Mataix Verdú J. *Nutrición en el deporte y ayudas ergogénicas y dopaje*. Madrid. Editorial Díaz de Santos; 2006. p. 273.
13. Santana Pérez FJ, de Burgos Carmona M, Fernández Rodríguez EF. Efecto del método Pilates sobre la flexibilidad y la fuerza y resistencia muscular. *EFDeportes.com*, Revista Digital. 2010;148.
14. Cummings B, Finn KJ. Estimation of a one repetition maximum bench press for untrained women. *J. Strength Cond. Res*. 1998;12:262-5.
15. Ware JS, Clemens CT, Mayhew JL, Johnston TJ. Muscular endurance repetitions to predict bench press and squat strength in college football players. *J. Strength Cond. Res.* 1995;9:99-103.
16. Chulvi Medrano I, Díaz Cantalejo A. Eficacia y seguridad del press de banca. Revisión. *Rev int med cienc act fís deporte*. 2008;32:338-52.
17. Travis TN, Brown V, Caulfield S, Doscher M, McHenry P, Statler T, *et al.* NSCA Strength and conditioning professional standards and guidelines. *Strength Cond J.* 2017;39:1-24.
18. American College of Sports Medicine. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc.* 2009;41:687-708.
19. Orquín Castrillón FJ, Torres-Luque G, Poncede León F. Efectos de un programa de entrenamiento de fuerza sobre la composición corporal y la fuerza máxima en jóvenes entrenados. *Apunts. Medicina de l'Esport.* 2009;44:156-62
20. Lee H, Kim IG, Sung C, Kim JS. The Effect of 12-Week Resistance Training on muscular strength and body composition in untrained young women: Implications of exercise frequency. *J Exerc Physiol Online*. 2017;20:88-95.
21. Calder AW, Chilibeck PD, Webber CE, Sale DG. Comparison of whole and split weight training routines in young women. *Can J Appl Physiol.* 1994;19;185-99.
22. Campbell WW, Trappe TA, Jozsi AC, Kruskall LJ, Wolfe RR, Evans WJ. Dietary protein adequacy and lower body versus whole body resistive training in older humans. *J Physiol*. 2002;542:631-42.
23. Schoenfeld BJ, Ratamess NA, Peterson MD, Contreras B, Tiryaki-Sonmez G. Influence of resistance training frequency on muscular adaptations in well-trained Men. *J Strength Cond Res.* 2015;29:1821-9.
24. Schoenfeld BJ, Ogborn D, Krieger JW. Effects of resistance training frequency on measures of muscle hypertrophy: A systematic review and meta-analysis. *Sports Med.* 2016;46:1689-97.
25. Kraemer WJ. Endocrine responses to resistance exercise. *Med Sci Sports Exerc*. 1988;20:152-7.
26. Kraemer WJ, Ratamess NA. Hormonal responses and adaptations to resistance exercise and training. *Sports Med.* 2005;35:339-61.
27. McLester JR, Bishop PA, Smith J, Wyers L, Dale B, Kozusko J, *et al*. A series of studies-a practical protocol for testing muscular endurance recovery. *J Strength Cond Res.* 2003;17:259-73.
28. Häkkinen K, Kallinen M. Distribution of strength training volume into one or two daily sessions and neuromuscular adaptations in female athletes. *Electromyogr Clin Neurophysiol.* 1994;34:117-24.
29. Granell JC, Cervera VR. *Teoría y planificación del entrenamiento deportivo*. Badalona. Paidotribo; 2006. p. 16

Anthropometric characteristics and somatotype profile in *amateur* rugby players

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Summary

Introduction: It has been proposed that body composition plays an essential role in sport performance. However, there are few studies that have analyzed body composition in amateur rugby players.
Objective: The purpose of the present study was to examine the anthropometric characteristics, somatotype profile, fat and muscle components in rugby players from an amateur Spanish team.
Material and method: Height, body mass, diameters, perimeters and skinfolds from thirty-one rugby players were measured. Fat and muscle components and somatotype profile were determined. Proportionality was determined with the z-phantom strategy. Descriptive statics (mean ± SD) and *t*-student were used.
Results: Mean body mass was 85.32 ± 14.36 kg, mean fat mass percentage was 12.35 ± 3.46%, mean muscle mass percentage was 50.29 ± 7.74% and mean somatotype was 4.50-5.80-0.95. The sum of six skinfolds was 92.92 ± 32.95 mm. Significant differences were observed between forwards and backs in body mass (95.24 *vs* 77.15 kg; p<0.001), in sum of six skinfolds (107.67 *vs* 80.77 mm; p=0.021), in body fat percentage (13.90 *vs* 11.07%; p=0.021), in muscle mass percentage (45.16 *vs* 54.54%; p=<0.001) in endomorphy (5.31 *vs* 3.76; p=0.013) and in ectomorphy (0.62 *vs* 1.33; p=0.002). Regarding proportionality, differences were found in function on the position in on the field.
Conclusion: Anthropometrical measures would be an adequate instrument to evaluate body composition in rugby. Anthropometric profile in rugby could be related to the specific position the field, although further studies would be necessary to confirm this idea. The level of professionalism could affect to the anthropometrics characteristics in rugby players.

Key words:
Muscle. Fat. Anthropometry. Body composition. Somatotype.

Características antropométricas y somatotipo en jugadores *amateur* de rugby

Resumen

Introducción: Se ha propuesto que la composición corporal juega un papel esencial en el rendimiento deportivo. Sin embargo, hay pocos estudios que hayan analizado la composición corporal en jugadores amateurs de rugby.
Objetivo: El objetivo del presente estudio fue examinar las características antropométricas, el somatotipo, el compartimento muscular y de grasa en jugadores amateurs de rugby de nacionalidad española.
Material y método: Se midió la altura, el peso, los diámetros, los perímetros y los pliegues corporales de treinta y un jugadores. Se analizó los componentes de grasa y músculo y el somatotipo. Se determinó la proporcionalidad con el z-phantom. Se utilizaron métodos estadísticos descriptivos (mean ± SD) y *t*-student.
Resultados: El peso medio fue 85,32 ± 14,36 kg, el porcentaje de grasa medio fue 12,35 ± 3,46%, el porcentaje medio de masa muscular fue 50,29 ± 7,74% y el somatotipo medio fue 4,50-5,80-0,95. La suma de los seis pliegues corporales fue 92,92 ± 32,95 mm. Se observaron diferencias entre jugadores de ataque y defensa en el peso (95,24 *vs* 77,15 kg; p<0,001), en la suma de los seis pliegues corporales (107,67 *vs* 80,77 mm; p=0,021), en el porcentaje de grasa corporal (13,90 *vs* 11,07%; p=0,021), en el porcentaje de masa muscular (45,16 *vs* 54,54%; p=<0,001) en la endomorfia (5,31 *vs* 3,76; p=0,013) y en la ectomorfia (0,62 *vs* 1,33; p=0,002). En cuanto a la proporcionalidad, se observaron diferencias en función de la posición de los jugadores en el campo.
Conclusión: Las medidas antropométricas serían un adecuado instrumento para evaluar la composición corporal en rugby. El perfil antropométrico en rugby podría estar relacionado con la posición ocupada en el campo de juego, aunque serían necesario más estudios para confirmar esta idea. El nivel de profesionalismo podría afectar a las características antropométricas de los jugadores de rugby.

Palabras clave:
Músculo. Grasa. Antropometría. Composición corporal. Somatotipo.

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Introduction

It has been well described that body composition plays a crucial role in sport performance[1]. Consequently, several methods have been used to study body composition in sports such as anthropometric analysis[2], bioelectrical impedance[3] or dual X-ray absorptiometry[4].

In particular, anthropometry determines the size, the proportionality, the composition, the form and the body function in athletes. Anthropometry relates body measures of form, proportions and compositions with specific function in sport[5]. Measures included in anthropometric analyses are body mass, height, wingspan, skinfolds, perimeters, diameters and lengths. From these data, it is possible to study body fat mass, body composition and somatotype[6]. Somatotype determines body composition in athletes which can be classified in three categories mesomorphy (related to muscle mass), endomorphy (related to fatness) and ectomorphy (related to linearity and slenderness)[7].

In rugby, anthropometry has been used more in recent years to analyze the physical status of players. Firstly, a paper[8] investigated the role of anthropometric qualities in team selection where skinfold thickness was a significant factor to discriminate between selected and non-selected players showing that anthropometrical characteristics could affect team selection for professional players. Another research[9] studied the possible relationship among physiological, anthropometric, skill characteristics and playing performance in rugby. Players with greater body mass and skinfold thickness played fewer minutes. Higher skinfold thickness was related to fewer tackle attempts, completed tackles, dominant tackles and a lower tackling efficiency. Anthropometrics characteristics could represent a crucial point in rugby performance. Another investigation[10] analyzed anthropometric profile in rugby players from Croatia. Comparing the results with data from high level players, backs and forwards players showed a higher body fat percentage, all players were more endomorphic, and forwards were less mesomorphic. The popularity of rugby and the degree of professionalism could affect to anthropometric characteristics. Additionally, another study[11] demonstrated that level of professionalism could have effects in anthropometrical characteristics in rugby. Although, this idea has not been completely demonstrated yet.

Rugby players have been examined in order to identify different anthropometric characteristics among playing position. A study[12] found that props were taller, heavier and presented a higher skinfolds thickness than the rest. Another research[13] analyzed sub-elite rugby players, props were heavier, taller and exhibited a higher sum of skinfolds. Furthermore, it seems that anthropometrical profile could differ in function of position on the field, despite this theory has not been totally validated yet.

The objectives of the current study were to explore the anthropometric characteristics, body composition and somatotype profile of rugby players from an amateur Spanish team.

Material and method

Participants

A total of thirty-one senior's male players from an amateur Spanish rugby team voluntary participated. Players were regularly involved in competitive trainings and matches, and they had not suffered important previous injuries. Players were aged 22.86 ± 3.31 years old. Participants have at least two years of experience in rugby. The distribution in different positions in on the field was prop (n = 3), hooker (n = 2), second row (n = 4), lock or flanker (n = 5), half-back (n = 3), five-eight or fly half (n=3), centre (n = 3), wing (n = 5) and full back (n = 3). The experimental protocols were done following the ethics rules for Helsinki Declaration. All experimental procedures were in accordance with the Pablo de Olavide University Ethical Committee rules. The players delivered informed written consents which had been signed. The inclusion criteria was to belong to the rugby team and the exclusion criteria was injuries that prevented the practice of rugby.

Data were collected in the training pitch facilities during the beginning of the competitive season and positions on the field were determined using a previous validated distribution[12,13].

Descriptive analysis

Anthropometric characteristics examined were height, body mass, three diameters (wrist, biepicondylar humerus and femur), six body circumferences (arm relaxed, arm tensed, thigh, calf, hip and waist perimeters) and six skin folds (triceps, subscapular, supraspinale, abdominal, thigh and calf). Measures were recollected following the recommendations from the International Society for the Advancement of Kinanthropoemtry (ISAK)[14-16]. Fat mass was calculated according to Carter´s equation[17]. Muscle mass was obtained with three different equations[18-20]. Somatotype was determined according to Carter and Health method[21,22]. Somatotype Attitudinal Distance (SAD) and Somatotype Attitudinal Mean (SAM) were also determined[21,23]. Proportionality was assessed with Z-Phantom analysis that uses a theoretical human reference and constituted a bilaterally symmetrical pattern. The values Z-Phantom were obtained from the Ross and Wilson formula[24].

Anthropometric measures were collected by a highly trained technician (ISAK level three). The body mass was collected by electronic weighing machine (Tanita UM-076). Height was determined with a stadiometer (Seca, 213 version). Skinfolds were measured with a slim guide skinfold caliper. Bone breadths and body perimeters were also collected with validated material (an anthropometric tape and a small sliding caliper).

Statistical analysis

SigmaPlot 12.5 version (Systat software) was used for Statistical Analyses. Descriptive statics (mean ± SD) were reported for the different parameters analyzed. Normality was checked to apply a parametric o nor parametric test. T-Student test or Mann-Whitney Rank Sum test analyses were used in order to explore significant differences between backs and forwards players. Z score was also determined according to the formula proposed by Ross and Wilson[24]. The level of significance was set at $p<0.05$.

Results

The mean values and SDs of anthropometric data and body composition obtained from players can be observed in Table 1. Values

Table 1. Mean ± SDs of anthropometric and body components.

Variables	Prop (n=3)	Hooker (n=2)	Second Row (n=4)	Lock (n=5)	Half-back (n=3)	Five-eight (n=3)	Centre (n=3)	Wing (n=5)	Full back (n=3)	Global Average (n=31)
Height (cm)	183.36 ± 3.33	177.30 ± 6.01	183.90 ± 2.47	176.00 ± 0.05	173.80 ± 7.97	176.7 ± 10.7	177.4 ± 0.03	168.10 ± 2.46	177.7 ±7.65	176.70 ± 7.03
Weight (kg)	108.36 ± 4.45	99.20 ± 5.79	100.50 ± 4.95	81.58 ± 6.83	75.26 ± 18.19	77.93 ± 7.55	79.76 ± 8.02	71.50 ± 3.42	85.10 ± 14.54	85.32 ± 14.36
Wrist diameter (cm)	5.66 ± 0.71	5.66 ± 0,02	5.51 ± 0.32	5.49 ± 0.22	5.17 ± 0.26	5.54 ± 0.47	5.72 ± 0.30	5.17 ± 0.31	5.29 ± 0.49	5.44± 0.38
Humerus diameter (cm)	7.17 ± 0.27	7.14 ± 0,04	7.17 ± 0.55	6.83 ± 0.52	6.71 ± 0.16	6.96 ± 0.59	7.05 ± 0.24	6.94 ± 0.30	7.31 ± 0.49	7.01 ± 0.40
Femur diameter (cm	10.32 ± 0.37	9.98 ± 0.27	10.23 ± 0.70	9.53 ± 0.18	9.90 ± 1.44	9.68 ± 0.25	9.73 ± 0.36	9.11 ± 0.34	9.51 ± 0.46	9.73 ± 0.63
Arm relaxed circumference (cm)	38.13 ± 3.11	35.85 ± 0.63	35.15 ± 2.23	33.84 ± 2.75	29.46 ± 4.66	30.56 ± 2.05	31.40 ± 3.60	32.26 ± 3.02	33.50 ± 3.90	33.29 ± 3.61
Arm tensed circumference (cm)	39.06 ± 2.95	37.25 ± 1.06	36.32 ± 2.34	36.64 ± 2.36	31.53 ± 3.86	33.23 ± 1.42	33.96 ± 3.16	34.88 ± 2.46	35.96 ± 4.17	35.44 ± 3.14
Thigh circumference (cm)	61.76 ± 1.45	59.15 ± 0.35	59.47 ± 1.50	54.98 ± 3.86	54.03 ± 5.85	54.36 ± 2.05	53.36 ± 2.37	51.74 ± 1.96	55.10 ± 3.01	55.66 ± 4.06
Calf circumference (cm)	43.20 ± 0.91	41.90 ± 0.70	42.05 ± 1.04	39.18 ± 1.69	38.16 ± 3.86	39.40 ± 2.33	38.26 ± 0.80	37.92 ± 1.47	40.23 ± 4.56	39.84 ± 2.63
Hip circumference (cm)	108.90 ± 1.99	105.50 ± 3.53	107.92 ± 3.36	93.14 ± 6.84	92.23 ± 9.05	92.36 ± 3.62	95.10 ± 7.99	91.02 ± 0.46	97.66 ± 9.20	97.49 ± 8.50
Waist circumference (cm)	101.00 ± 6.10	98.95 ± 2.89	94.25 ± 6.79	83.82 ± 6.54	77.46 ± 7.50	77.63 ± 4.70	81.23 ± 3.66	80.18 ± 4.80	82.90 ± 4.91	85.66 ± 9.51
Triceps skinfold (mm)	23.91 ± 8.00	17.12 ± 8.30	20.25 ± 4.62	10.05 ± 5.23	13.33 ± 7.02	14.50 ± 0.86	11.00 ± 2.29	10.55 ± 3.22	13.25 ± 5.13	14.39 ± 6.17
Subscapular skinfold (mm)	27.00 ± 3.50	19.00 ± 0.00	23.87 ± 4.87	12.80 ± 4.12	14.00 ± 6.55	12.91 ± 3.59	13.83 ± 2.84	12.75 ± 4.99	13.66 ± 0.76	16.30 ± 6.30
Supraspinale skinfold (mm)	28.00 ± 1.80	23.00 ± 11.31	23.81 ± 4.54	10.85 ± 5.23	12.58 ± 5.38	10.50 ± 2.17	13.50 ± 6.38	10.00 ± 2.62	14.16 ± 1.60	15.54 ± 7.57
Abdominal skinfold (mm)	33.50 ± 4.44	28.75 ± 9.54	28.00 ± 0.81	13.20 ± 3.81	16.50 ± 9.26	16.91 ± 3.71	15.00 ± 4.50	14.40 ± 4.76	19.33 ± 4.75	19.71 ± 8.26
Thigh skinfold (mm)	13.75 ± 3.03	16.37 ± 12.19	18.50 ± 3.87	12.75 ± 4.35	19.50 ± 11.05	19.00 ± 3.50	17.50 ± 6.53	12.80 ± 2.98	14.00 ± 1.00	15.66 ± 5.48
Calf skinfold (mm)	14.08 ± 1.87	11.50 ± 4.95	16.12 ± 5.89	6.95 ± 2.28	13.66 ± 7.76	13.33 ± 2.02	9.91 ± 1.90	7.65 ± 2.54	12.25 ± 3.43	11.29 ± 4.68
Σ 6 skinfolds (mm)	140.25 ± 14.35	115.75 ± 46.31	130.56 ± 19.38	66.60 ± 19.57	89.58 ± 46.13	87.16 ± 12.94	80.75 ± 17.76	68.15 ± 17.43	86.66 ± 11.47	92.92 ± 32.95
Endomorphy	6.74 ± 0.59	5.58 ± 1.69	6.06 ± 0.86	3.34 ± 1.17	4.00 ± 1.68	3.74 ± 0.39	3.77 ± 0.88	3.45 ± 1.05	4.02 ± 0.45	4.50 ± 1.50
Mesomorphy	6.42 ± 0.40	6.65 ± 0.36	5.67 ± 0.98	5.93 ± 1.11	5.05 ± 1.11	5.24 ± 0.76	5.20 ± 1.05	6.24 ± 0.59	6.01 ± 0.97	5.80 ± 0.91
Ectomorphy	0.18 ± 0.09	0.10 ± 0.13	0.69 ± 0.32	1.16 ± 1.20	1.56 ± 1.04	1.71 ± 0.92	1.59 ± 0.64	1.12 ± 0.52	1.07 ± 0.28	0.95 ± 0.84
Body fat %	17.32 ± 1.51	14.75 ± 4.86	16.30 ± 2.04	9.58 ± 2.06	12.00 ± 4.84	11.74 ± 1.36	11.07 ± 1.86	10.16 ± 1.93	11.41 ± 1.56	12.35 ± 3.46
Muscle mass Heymsfield y cols (%)	38.65 ± 2.73	42.15 ± 0.10	42.80 ± 2.48	52.16 ± 5.00	56.72 ± 12.49	53.94 ± 2.41	53.58 ± 4.83	56.53 ± 3.25	50.47 ± 6.40	50.29 ± 7.74
Muscle mass Doupe (%)	47.25 ± 2.27	47.38 ± 4.87	45.65 ± 3.25	54.34 ± 2.48	47.07 ± 4.31	48.08 ± 1.70	48.67 ± 0.97	53.06 ± 4.68	50.48 ± 3.03	49.55 ± 4.21
Muscle mass Lee-I (%)	31.13 ± 2.19	32.44 ± 1.02	32.12 ± 2.51	37.82 ± 2.46	38.86 ± 6.86	38.16 ± 1.46	37.26 ± 3.48	39.27 ± 1.52	36.51 ± 2.31	36.2 ± 3.93

Data frequencies for 31 rugby players.

in function of different position (prop, hooker, second row, lock, half-back, five-eight, centres, wing and full back) can be visualized. Statistical differences among these different positions were not analyzed due to there is not enough statistical power to determine differences due to the sample size (2-5 players for each specific position).

Table 2 groups examined players in forward positions (prop, hooker, second row, lock) and backs positions (half-back, five-eight, centre, wing and full back) in order to look for differences between these two groups.

Somatotype classification were props (endomorphy-mesomorphy), hookers (endo-mesomorphy), second-rows (endomorphy-mesomorphy), locks (endo-mesomorphy), half-backs (endo-mesomorphy), five-eights (endo-mesomorphy), centres (endo-mesomorphy), wings (endo-mesomorphy), full backs (endo-mesomorphy), global average (endo-mesomorphy), forwards average (endo-mesomorphy) and backs average (endo-mesomorphy). These results can be observed in Figure 1.

In Table 3 can be seen the individual SAD for each player refers to the mean somatotype value. While, SAD values in function of the position in the field has been analyzed in Table 4. The value obtained in SAM was 1.7 units. In Figure 1 can be observed the Phanton proportionality analyses for body mass, arm-relax circumference, waist circumference,

Table 2. Mean ± SDs of anthropometric data forwards and backs average.

Variables	Forwards Average (n=14)	Backs Average (n=17)	*P* value
Height (cm	180.00 ± 50.00	174.00 ± 70.40	*p* = 0.0140
Weight (kg)	95.24 ± 12.17	77.15 ± 10.48	*p* = <0.001
Wrist diameter (cm)	5.55 ± 0.35	6.99 ± 0.37	*p* = 0.144
Humerus diameter (cm)	7.04 ± 0.44	9.53 ± 0.65	*p* = 0.697
Femur diameter (cm)	9.96 ± 0.52	9.53 ± 0.65	*p* = 0.056
Arm relaxed circumference (cm)	35.42 ± 2.77	31.53 ± 3.30	*p* = 0.002
Arm tensed circumference (cm)	37.15 ± 2.36	34.02 ± 3.04	*p* = 0.004
Thigh circumference (cm)	58.31 ± 3.60	53.48 ± 3.04	*p* = <0.001
Calf circumference (cm)	41.25 ± 2.02	38.69 ± 2.56	*p* = 0.005
Hip circumference (cm)	102.50 ± 8.49	93.36 ± 6.05	*p* = 0.002
Waist circumference (cm)	92.64 ± 9.12	79.91 ± 4.93	*p* = <0.001
Triceps skinfold (mm)	16.94 ± 7.50	12.29 ± 3.91	*p* = 0.034
Subscapular skinfold (mm)	19.89 ± 6.97	13.35 ± 3.82	*p* = 0.002
Supraspinale skinfold (mm)	19.96 ± 8.73	11.89 ± 3.79	*p* = 0.002
Abdominal skinfold (mm)	24.00 ± 9.42	16.19 ± 5.16	*p* = 0.007
Thigh skinfold (mm)	15.12 ± 5.34	16.11 ± 5.73	*p* = 0.625
Calf skinfold (mm)	11.75 ± 5.29	10.92 ± 4.24	*p* = 0.634
Σ 6 skinfolds (mm)	107.67 ± 38.30	80.77 ± 22.30	*p* = 0.021
Endomorphy	5.31 ± 1.73	3.76 ± 0.90	*p* = 0,013
Mesomorphy	6.06 ± 0.88	5.63 ± 0.92	*p* = 0,191
Ectomorphy	0.62± 0.86	1.33 ± 0.68	*p* = 0.002
Body fat %	13.90 ± 4.02	11.07 ± 2.34	*p* = 0.021
Muscle mass Heymsfield y cols (%)	45.16 ± 6.48	54.54 ± 6.03	*p* = <0.001
Muscle mass Doupe (%)	49.34 ± 4.73	49.89 ± 3.87	*p* =0.362
Muscle mass Lee-I (%)	33.99 ± 3.62	38.16 ± 3.17	*p* = 0.002

Table 3. Individual Somatotype Attitudinal Distance (SAD) refers to group somatotype.

Position	SAD
Prop	3.11
Prop	2.23
Hooker	2.60
Hooker	0.91
Second row	2.53
Second row	1.80
Second row	1.33
Second row	1.90
Lock	0.78
Lock	4.00
Lock	2.40
Lock	1.08
Lock	1.03
Half back	1.09
Half back	1.64
Half back	3.44
Five-eight	2.37
Five-eight	0.72
Five-eight	1.29
Centre	0.91
Centre	2.22
Centre	1.85
Wing	0.84
Wing	1.46
Wing	2.69
Wing	1.15
Wing	1.66
Full back	1.33
Full back	0.59
Full back	1.13

Data frequencies for 31 rugby players.

Table 4. Somatotype Attitudinal Distance (SAD) for rugby positions refers to group somatotype.

Position	Mean	SD	Maximum	Minimum
Prop (n=3)	2.43	0.60	3.11	1.95
Hooker (n=2)	1.75	1.19	2.60	0.91
Second row (n=4)	1.89	0.49	2.53	1.33
Lock (n=5)	1.85	1.35	4.00	0.78
Half back (n=3)	2.05	1.22	3.44	1.09
Five-eight (n=3)	1.46	0.83	2.37	0.72
Centre (n=3)	1.66	0.67	2.22	0.91
Wing (n=5)	1.56	0.704	2.69	0.84
Full back (n=3)	1.01	0.38	1.33	0.59
Forwards (n=14)	1.98	0.95	4.00	1.78
Backs (n=17)	1.55	0.76	3.44	0.59
Global average (n=31)	1.73	0.86	4.00	0.59

Data frequencies for 31 rugby players

Figure 1. Somatotype components and Proportionality Phantom analysis.

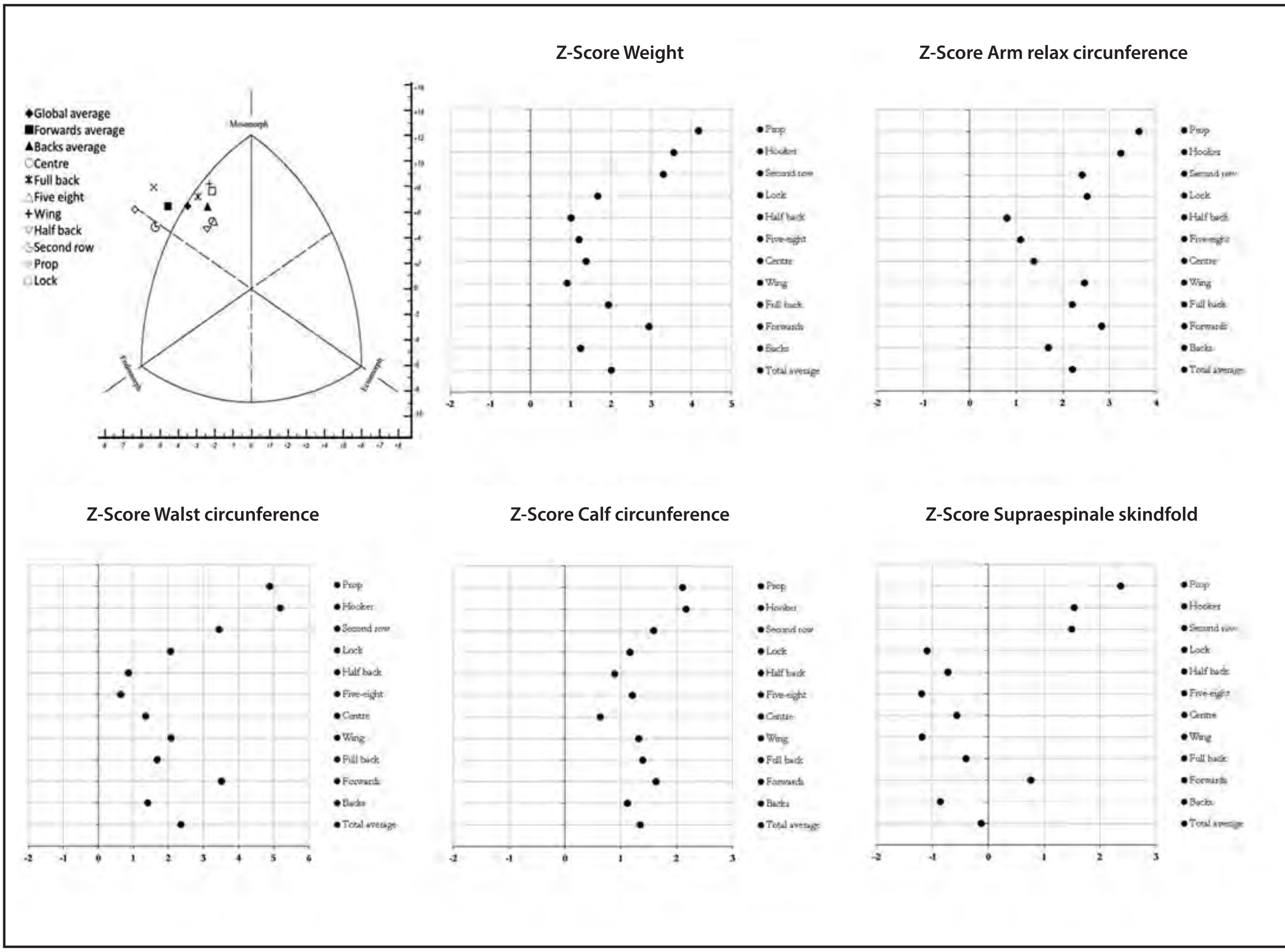

Table 5. Proportionality Phantom analysis.

	Diameters			Circunferences	Skinfolds				
	Humerus	Wrist	Femur	Hip	Triceps	Subscapular	Abdominal	Thigh	Calf
Prop	0.50	0.15	0.13	0.93	1.50	1.34	0.73	-1.71	-0.63
Hooker	1.09	0.83	0.16	1.21	0.27	0.21	0.31	-1.33	-1.04
Second row	0.43	-0.39	-0.10	0.93	0.75	0.97	0.07	-1.19	-0.23
Lock	0.37	0.36	-0.62	-0.80	-1.27	-0,.96	-1.62	-1.76	-1.98
Half back	0.29	-0.51	0.32	-0.81	-0.57	-0.72	-1.22	-0.98	-0.61
Five-eight	0.62	0.45	-0.38	-1.01	-0.32	-0.96	-1.18	-1.04	-0.67
Centre	0.82	0.99	-0.37	-0.62	-1.09	-0.78	-1.42	-1.23	-1.62
Wing	1.56	0.09	-0.61	-0.45	-1.06	-0.85	-1.39	-1.69	-1.77
Full back	1.49	-0.54	-0.84	-0.22	-0.63	-0.81	-0.88	-1.63	-0.93
Forward	0.52	0.17	-0.20	0.35	0.12	0.25	-0.36	-1.52	-1.06
Backs	1.03	0.09	-0.41	-0.60	-0.77	-0.83	-1.24	-1.36	-1.20
Global average	0.80	0.13	-0.31	-0.17	-0.37	-0.34	-0.84	-1.43	-1.13

Table 6. Somatotypes previously described for rugby players.

Reference	Sample analyzed (n)	Endomorphy	Mesomorphy	Ectomorphy
Cheng, *et al*. 2014[31]	Australian junior elite rugby league players (116)	3.6 ± 1.0 (f) 2.6 ± 0.7 (b)	7.5 ± 1.3 (f) 6.5 ± 0.8 (b)	1.0 ± 0.9 (f) 1.7 ± 0.7 (b)
Pienaar & Coetzee 2013[35]	University level rugby players (U19 North-West University, South Africa)[35]	2.63 ± 0.91 2.54 ± 0.97 2.97 ± 1.52 2.88 ± 1.38	6.20 ± 1.18 6.33 ± 1.15 5.82 ± 1.49 5.93 ± 1.56	1.73 ± 1.07 1.77 ± 1.11 1.71 ± 1.15 1.75 ± 1.15
Babic, *et al*. 2001[10]	Rugby players from clubs member of the Croatian-Slovenian rugby league	6.0 ± 1.6 (g) 6.7 ± 1.5 (f) 5.3 ± 1.4 (b)	5.6 ± 1.3 (g) 5.9 ± 1.3 (f) 5.3 ± 1.1 (b)	1.4 ± 0.8 (g) 1.4 ± 0.9 (f) 1.5 ± 0.7 (b)
Babic, *et al*., 2001[10]	Rugby players from New Zealand rugby league	3.7 (f) 2.5 (b)	6.5 (f) 6.2 (b)	1.2 (f) 1.4 (b)
Babic, *et al*., 2001[10]	Rugby players from Italy league	3.5 (f) 2.6 (b)	6.1 (f) 4.9 (b)	1.0 (f) 2.0 (b)
Babic, *et al*., 2001[10]	Rugby players from South Africa league	3.8 (f)	6.1 (f)	1.6 (f)
Babic, *et al*., 2001[10]	Rugby players from France league	3.0 (f) 2.5 (b)	6.0 (f) 5.0 (b)	1.0 (f) 2.5 (b)
Hohenauer, *et al*. 2017[37]	German national rugby union 7s team (17)	2.5 ± 0.74 (g) 2.46 ± 0.77 (f) 2.54 ± 0.71 (b)	6.53 ± 0.84 (g) 6.6 ± 1.08 (f) 6.46 ± 0.61 (b)	1.31 ± 0.64 (g) 1.43 ± 0.85 (f) 1.19 ± 0.44 (b)
Holway & Garavaglia 2009[38]	Rugby players from the seven Group I teams competing in the Buenos Aires Rugby Union (133)	3.3 ± 1.3 (g)	6.8 ± 1.2 (g)	1.1 ± 0.8 (g)
Gabbet 2009[30]	Rugby players from the first-grade rugby in the Goald Coast senior rugby league (Queensland, Australia) (12)	3.1 (best tacklers) 5.4 (worst tacklers)	4.0 (best tacklers) 3.6 (worst tacklers)	0.9 (best tacklers) 1.0 (worst tacklers)
Quarrie, *et al*. 1996[36]	Male senior A rugby club players (New Zealand) (94)	4.5 (props, f) 3.6 (hookers,f) 3.7 (locks,f) 3.7 (loose forwards, f) 2.3 (inside backs, b) 3.1 (midfiled backs,b) 2.4 (outside backs, b)	7.5 (props, f) 7.1 (hookers,f) 5.9 (locks,f) 6.2 (loose forwards, f) 6.2 (inside backs, b) 6.7 (midfiled backs,b) 6.0 (outside backs, b)	0.5 (props, f) 0.9 (hookers,f) 1.6 (locks,f) 1.3 (loose forwards, f) 1.5 (inside backs, b) 1.3 (midfiled backs,b) 1.6 (outside backs, b)

g: global; f: forwards; b: backs.

calf circumference and supraespinale skinfold. The rest of z-values for the other parameters examined are showed in Table 5.

Discussion

The mean body mass and height were 85.32 ± 14.36 kg and 176.70 ± 7.03 cm, the mean sum of 6 skinfolds (triceps, subscapular, supraspinale, abdominal, thigh and calf) was 92.92 ± 32.95 mm. The mean fat percentage was 12.35 ± 3.46% while the mean somatotype values were 4.50 ± 1.50 - 5.80 ± 0.91 – 0.95 ± 0.84. Significant differences between forwards and backs players were obtained in body mass, height, skinfolds, body composition and somatotype components.

Additionally, in the rating scale and somatotype analyses[21], endomorphy values observed in prop, hooker and second row positions are higher than 5 ½ showing a probable high relative adiposity, abundant subcutaneous fat and abdominal fat accumulation. It could be helpful in some specific phases of rugby games. The rest of players exhibited endomorphy values between 3 and 5 indicating a moderate relative adiposity. Moreover, mesomorphy data revealed that subjects analyzed present a high relative skeletal muscle development, large bone diameters, large volume muscles and large joints. Ectomorphy values showed a high body volume per unit of height and their limbs could be relative voluminous. In comparison with somatotypes obtained in rugby players in other studies (Table 6), endomorph component tends to be higher in players analyzed and it could be related with the level of professionalism because amateur players could pay less attention to their adiposity level. While, mesomorph and ectomorph elements seem to be similar.

SAD examination is based on three dimensions and provided precise information about the distance of individuals in relation to the group somatotype. When a subject is closer to "0" value, less is the difference in reference to the group. It has been proposed that a "2" value in SAD is the limit to consider a possible difference. Here in Table 3, ten players presented a value bigger than 2 units and consequently a difference in some of the three somatotype components. Additionally, 1.7 units (higher than 1) was the value obtained in SAM analyses indicating a difference in homogeneity of the group somatotype[25].

Phantom method is used to examine proportionality, a z-value of 0.0 means that the subject has the same proportions to the Phantom. A z-value greater than 0.0 indicates that the subject has higher proportions than the Phantom and a lower z-value shows smaller proportions than the Phantom reference[24,26]. Particularly, our players tend to have greater z-values indicating bigger proportions than the Phantom and backs position tends to have lower z-values for supraespinale skinfold presenting a lower adiposity than the Phantom reference.

Previously, another study[27] examined changes in body composition from the preseason to the end of the season. Players were away from the recommended body composition standard at the beginning of the season. While in the present study, similar fat percent values have been obtained, it is possible that players were also away from the recommended values for body composition in rugby. Another research[10] examined the effects of a microcycle combined with rugby conditioning program on anthropometric measures. All players showed lower skinfold thickness than skinfold values found in the current research. This is related to the previous idea mentioned that players analyzed might be away from the recommended standard of body composition.

A previous study[28] explored the anthropometric profile of elite rugby seven players. They presented lower values than players from the present study for skinfolds; several factors could explain this situation. The measures of sevens rugby player were taken during the international competition season when the players surely presented a high level of physical condition. The data of our players were taken at the beginning of the season when they did not play competitive matches, sevens rugby players were elite level athletes while our players were nonprofessional, suggesting that the level of professionalism could affect to body composition. Supplementary to this last idea, one study[29] analyzed amateur rugby players. Anthropometric characteristics of nonprofessional players were poorly developed compared with professional players. Even, another investigation[30] found that sub-elite rugby players exhibited a higher sum of seven skinfolds than elite players. Consequently, the level of professionalism could affect to anthropometrical characteristics of players.

Another study[10] found that forwards were heavier, taller and presented higher fat percentage than backs, these discoveries were also found in our investigation where forwards showed a higher body mass, height and body fat percentage than backs. Other studies[12,13] found that props were taller, heavier and had higher skinfold thickness than the rest of players. Additionally, props were heavier and presented the highest values in the sum of six skinfolds and in body fat and they were almost the tallest players. Moreover, another research[29] discovered differences in body mass between forwards and backs. Taking all these data in consideration, we think that it could exist differences among playing position in rugby. Furthermore, differences were obtained in some anthropometric characteristics between forwards and backs positions such as in body mass, sum of 6 skinfolds, body fat percent, muscular mass, endomorphy and ectomorphy components. As a paper[31] introduced some years ago, the physical rugby performance and anthropometric characteristics observed in players could be tightly related to the demands imposed by their position.

Previously, it has been proposed that anthropometric and body composition studies are really useful in sport performance management[32-34]. The current study is one of the first studies that examines anthropometrical profile in amateur Spanish rugby players and it shows the potential advantages of anthropometry, somatotype and body composition analyses on rugby. It seems that differences could exist between forwards and backs players in body mass, height, skinfolds, body composition and somatotype components, consequently training plans and diets prescription should take in consideration rugby player´s position in the field. Furthermore, the present paper proposes that the levels of professionalism could affect to body composition in rugby players. Therefore, the level of professionalism should be considered in anthropometric analysis. Thus, further meticulous research is needed to support these ideas.

The present study has limitations, for example only Spanish nonprofessional male rugby players have been studied. Accordingly, the results cannot be extrapolated to the rest of rugby male players, female rugby players or other team sports.

Finally, anthropometrical measures would be an adequate instrument to evaluate body composition in rugby. It has been proposed that anthropometric profile in rugby could be related to the specific position on the field, although further studies would be necessary to confirm this theory. The level of professionalism could affect to the anthropometrics characteristics in rugby players.

Conflict of interest

The authors do not declare a conflict of interest.

Bibliography

1. Pearce LA, Sinclair WH, Leicht AS, Woods CT. Physical, anthropometric, and athletic movement qualities discriminate development level in a rugby league talent pathway. *J Strength Cond Res.* 2018;32:3169-76.
2. García M, Martínez-Moreno JM, Reyes-Ortiz A, Suarez Moreno-Arrones L, García AA, García-Caballero M. Changes in body composition of high competition rugby players during the phases of a regular season; influence of diet and exercise load. *Nutr Hosp.* 2014;29:913-21.
3. Requena B, García I, Suárez-Arrones L, Sáez de Villarreal E, Orellana JN, Santalla A. Off-season effects on functional performance, body composition and blood parameters in top-level professional soccer players. *J Strength Cond Res.* 2017;31:939-46.
4. Sutton L, Scott M, Wallace J, Reilly T. Body composition of English Premier League soccer players: influence of playing position, international status, and ethnicity. *J Sports Sci.* 2009;27:1019-26.
5. Norton K, Olds T. *Anthropometrica: a textbook of body measurement for sports and health courses.* 1a. ed. Sydney, Australia. Editorial UNSW Press; 1996. p. 413.

6. Mathews DK, Fox EL. *Bases fisiologicas da educação fisica e dos desportos.* 2a. ed. Rio de Janeiro, Brasil. Editorial: Interamericana; 1979. p.487.
7. Carter JEL. Heath BH. *Somatotyping. Development and Application*s. Cambridge (NY), 1a. ed. NY, USA. Editorial Cambridge University Press; 1990. p. 352-419.
8. Gabbett TJ, Jenkins DG, Abernethy B. Relative importance of physiological, anthropometric, and skill qualities to team selection in professional rugby league. *J Sports Sci* 2011;29:1453-61.
9. Gabbett TJ, Jenkins DG, Abernethy B. Relationships between physiological, anthropometric, and skill qualities and playing performance in professional rugby league players. *J Sports Sci.* 2011;29:1655-64.
10. Babic Z, Misigoj-Durakovic M, Matasic H, Jancic J. Croatian rugby project-part I: Anthropometric characteristics, body composition and constitution. *J Sports Med Phys Fitness*. 2001;41:250-5.
11. Ross A, Gill ND, Cronin JB. Comparison of the anthropometric and physical characteristics of international and provincial rugby sevens players. *Int J Sports Physiol Perform*. 2015;10:780-5.
12. Gabbett TJ. A comparison of physiological and anthropometric characteristics among playing positions in junior rugby league players. *Br J Sports Med.* 2005;39:675-80.
13. Gabbett TJ. A comparison of physiological and anthropometric characteristics among playing positions in sub-elite rugby league players. *J Sports Sci.* 2006;24:1273-80
14. Ross WD, Marfell-Jones MJ. Kinanthropometry. In: MacDougall JD, Wenger HA, Green HJ, editors. *Physiological testing of the elite athlete.* Ottawa. Editorial CASS; 1983. p. 75-115.
15. Ross WD, De Rose EH, Ward R. Anthropometry applied to sport medicine. In: Dirix A, Knuttgen HG, Tittel K, editors. *The Olympic Book of Sports Medicine*. Oxford. Editorial Blackwell Scientific Publication; 1988. p. 233-65.
16. Ross WD, Marfell-Jones MJ. Kinanthropometry. In: MacDougall JD, Wenger HA, Green HJ, editors. *Physiological testing of the elite athlete*. London. Editorial Human Kinetics; 1991. p. 223-308.
17. Carter JEL. Body composition of Montreal Olympic athletes. In: Carter JEL, editor. *Physical Structure of Olympic Athletes.* Part I. Karger, Basel. Editorial Medicine Sport Science; 1982. p. 107-16.
18. Heymsfield SB, Mcmanus C, Smith J, Stevens V, Nixon DW. "Revised equation for calculating bone free arm muscle area". *Am J Clin Nutr*. 1982;36:680.
19. Doupe MB, Martin AD, Searle MS, Kriellaars DJ, Giesbrecht GG. "A new formula for population -based estimation of whole-body muscle mass in males". *Can J Appl Physiol.* 1977;22:598.
20. Lee RC, Wang Z, Heo M, Ross R, Janssen I, Heymsfield SB. "Total-body skeletal muscle mass: development and cross-validation of anthropometric prediction models". *Am J Clin Nutr.* 2000;72:796.
21. Carter JEL, Heath BH. *Somatotyping: development and applications* (Vol.5). Cambridge, England. Editorial Cambridge University Press;1990. p. 398-420.
22. Carter JEL, Aubry P, Sleet DA. Somatotype of Montreal Olympic athletes. In: Carter JEL, editor. *Physical Structure of Olympic Athletes.* Part I. Karger, Basel. Editorial Medicine Sport Science; 1982. p. 25-52.
23. Carter JEL. *The Heath-Carter Anthropometric Somatotype.* Instruction Manual. San Diego, Department of Exercise and Nutritional Sciences, San Diego State University; 2002. p. 10-15.
24. Ross WD, Wilson NC. A stratagem for proportional growth assessment. *Acta Pediatr.* 1974;169:182-228.
25. Irurtia-Amigó A, Busquets-Faciabén A, Marina Evrard M, Galilea Ballarini PA, Carrasco-Marginet M. Height, weight, somatotype and body composition in elite Spanish gymnasts from childhood to adulthood. *Apunts Med Esport.* 2009;161:18-28.
26. Almagià A, Araneda A, Sánchez J, Sánchez P, Zúñiga M, Plaza P. Elección del modelo de proporcionalidad antropométrica en una población deportista; comparación de tres métodos. *Nutr Hosp*. 2015;32:1228-33.
27. García M, Martínez-Moreno JM, Reyes-Ortiz A, Suarez L, García AA, García-Caballero M. Changes in body composition of high competition rugby players during the phases of a regular season; influence of diet and exercise load. *Nutr Hosp*. 2014;29:913-21.
28. Higham DG, Pyne DB, Anson JM, Eddy A. Physiological, anthropometric, and performance characteristics of rugby sevens players. *Int J Sports Physiol Perform*. 2013;8:19-27.
29. Gabbett TJ. Physiological and anthropometric characteristics of amateur rugby league players. *Br J Sports Med*. 2000;34:303.
30. Gabbett T, Kelly J, Ralph S, Driscoll D. Physiological and anthropometric characteristics of junior elite and sub-elite rugby league players, with special reference to starters and non-starters. *J Sci Med Sport*. 2009;12:215-22.
31. Cheng HL, O'Connor H, Kay S, Cook R, Parker H, Orr R. Anthropometric characteristics of Australian junior representative rugby league players. *J Sci Med Sport*. 2014;17:546-51.
32. Deiseroth A, Nussbaumer M, Drexel V, Hertel G, Schmidt-Trucksäss A, Vlachopoulos C, *et al*. Influence of body composition and physical fitness on arterial stiffness after marathon running. *Scand J Med Sci Sports.* 2018;28:2651-8.
33. Vorup J, Pedersen MT, Melcher PS, Dreier R, Bangsbo J. Effect of floorball training on blood lipids, body composition, muscle strength, and functional capacity of elderly men. *Scand J Med Sci Sports*. 2017;27:1489-99.
34. Kanehisa H, Ikegawa S, Fukunaga T. Body composition and cross-sectional areas of limb lean tissues in Olympic weight lifters. *Scand J Med Sci Sports.* 1998;8:271-8.
35. Pienaar C, Coetzee B. Changes in selected physical, motor performance and anthropometric components of university-level rugby players after one microcycle of a combined rugby conditioning and plyometric training program. *J Strength Con Res* 2013;27:398-415.
36. Quarrie KL, Handcock P, Toomey MJ, Waller AE. The New Zealand rugby injury and performance project. IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *Br J Sports Med.* 1996;30:53-6.
37. Hohenauer E, Rucker AM, Clarys P, Küng UM, Stoop R, Clijsen R. Anthropometric and performance characteristics of the German rugby union 7s team. *J Sports Med Phys Fitness.* 2017;57:1633-41.
38. Holway FE, Garavaglia R. Kinanthropometry of Group I rugby players in Buenos Aires, Argentina. *J Sports Sci.* 2009;27:1211-20.

Original article

Effects of blood flow restriction training on bone and muscle tissue: a pilot study

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Summary

The studies completed so far support the hypothesis that low intensity training (LIT) associated with blood flow restriction (BFR) increases muscle hypertrophy (MH) and maximum dynamic force (MDF). However, there is a lack of firm evidence linking this methodology with adaptations in the bone.
The objective of this study was to establish the effect of four LIT protocols associated with BFR, in the MH, MDF, bone mass (BM), bone mineral density (BMD) and bone mineral concentration (BMC) of the lower limb over a period of 11 weeks of training.
Sixteen moderately trained individuals were recruited. A random distribution of the participants was carried out, being distributed. G1: Electro-Neuromuscular Stimulation (ENMS) + BFR; G2: Treadmill walk + BFR; G3: Squat 90º + BFR; G4: Only BFR. Direct measurement of the MDF, Anthropometry and Dual Radiological Densitometry was used to measure the variables. The measurements were made at the beginning and the end of the 11 weeks.
In the MH variable, the walking treatments + BFR and ENMS + BFR registered main improvements compared to the rest of the interventions. The MDF is affected and improved by the ENMS, walking and squats are associated with BFR, in a similar way to the BFR application only. Modifications were observed in BM, BMD and BMC. The ENMS + BFR led the results, improving the BMD and BMC. The walk + BFR showed to improve the BM and the BMD at the same time.
The BFR added to the stimuli, ENMS, walk and squat generates positive effects on the MH, MDF and bone tissue of the lower limb. The BFR also generates changes without the association to another stimulus, but to a lesser extent. It was not possible to achieve a statistically significant difference (p> 0.05) between the groups.

Key words:
Muscle strength. Hypertrophy. Bone. Occlusion. Blood flow.

Efectos del entrenamiento con restricción del flujo sanguíneo sobre el tejido muscular y óseo: un estudio piloto

Resumen

Los estudios completados hasta el momento respaldan la hipótesis de que el entrenamiento de baja intensidad (EBI) asociado con restricción del flujo sanguíneo (RFS) aumenta la hipertrofia muscular (HM) y fuerza dinámica máxima (FDM). Sin embargo, se carece de evidencias firmes que relacionen esta metodología con adaptaciones en el hueso.
El objetivo de este estudio fue establecer el efecto de cuatro protocolos de EBI asociados a RFS, en la HM, FDM, masa ósea (MO), densidad mineral ósea (DMO) y concentración mineral ósea (CMO) del miembro inferior en un periodo de 11 semanas de entrenamiento.
Dieciséis individuos medianamente entrenados fueron reclutados. Se realizó una distribución aleatoria de los participantes quedando distribuidos. G1: Electro Estimulación Neuromuscular (EENM) + RFS; G2: Caminata en treadmill + RFS; G3: Sentadilla 90º + RFS; G4: Solo RFS. Se utilizó medición directa de la FDM, Antropometría y Densitometría Radiológica Dual para medir las variables. Las mediciones fueron realizadas al inicio y al final de las 11 semanas.
En la variable HM los tratamientos de caminata + RFS y EENM + RFS registraron las principales mejoras frente al resto de las intervenciones. La FDM se ve afectada y mejorada por la EENM, la caminata y las sentadillas asociados a RFS, de similar manera a solo la aplicación de RFS. Se observaron modificaciones en la MO, DMO y CMO. La EENM + RFS lidero los resultados, mejorando la DMO y CMO. La caminata + RFS mostro mejorar la MO y la DMO al mismo tiempo.
La RFS sumado a los estímulos, EENM, caminata y sentadilla genera efectos positivos sobre la HM, la FDM y tejido óseo del miembro inferior. La RFS también genera cambios sin la asociación a otro estimulo, pero en menor medida. No se logró establecer una diferencia estadísticamente significativa (p>0,05) entre los grupos.

Palabras clave:
Fuerza muscular. Hipertrofia. Hueso. Oclusión. Flujo sanguíneo.

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Introduction

Low-intensity training (LIT) combined with blood flow restriction (BFR) has been shown to increase muscle strength (MS) and hypertrophy in a similar way to conventional high-intensity resistance exercise. The studies completed to date support the hypothesis that BFR training may provide not only a novel approach to induce adaptation in muscle but also in bone, which was previously thought to occur only with high-intensity and impact exercises. In general, it is necessary to lift loads of approximately 70% of an individual's one repetition maximum (1RM) to obtain significant increases in size and MS, and it is also necessary to perform high-impact activities to stimulate the quality and production of bone tissue (BT)[1-6].

Among the various training instruments and methods to promote MS and muscle hypertrophy (MH), this novel approach has emerged, known as occlusion training (OT), *Kaatsu* Training, Blood flow-restricted exercise (BFRE) or blood flow restriction training (BFRT). It consists in placing an inflatable occlusion cuff or other type of rigid or elastic band around a limb in order to partially reduce the amount of blood delivered to the tissues for a given amount of time, producing hypoxia. This is similar to exercising in anaerobic conditions, with the subsequent physiological and metabolic responses. BFRE is put forward as a unique option for rehabilitation and training, given that it has the potential to produce positive adaptations by training with an intensity that is very similar to that of activities of daily living (10-30% of the maximum workload), improving MS, MH3 and possibly BT[4,7-9].

Low-intensity BFRE offers a unique training option for the development of MH, given that it permits training with an intensity of 20% 1RM and achieves improvements equivalent to those obtained at 65% 1RM, as well as having positive implications for a wide variety of population, specifically senior citizens, the rehabilitation of athletes, bed-bound patients, fractures, cardiac rehabilitation and even astronauts, who are not physically capable of withstanding high mechanical loads[10-15]. Furthermore, there are many beneficial proposals and mechanisms with regard to MS, and a relatively unexplored area relating to BT response.

This study aims to determine whether four low-intensity training protocols combined with BFR are able to produce effects and differences between each protocol, with regard to maximum dynamic strength (MDS), bone mass (BM), bone mineral density (BMD) and bone mineral content (BMC) of the lower limb (LL).

Material and method

A quasi-experimental pilot study was conducted with the convenience selection of 16 participants, forming 4 training groups with 4 participants per group (2 females and 2 males). The participants are moderately trained volunteer students from the first and second years of the Physical Education degree course at the Universidad Católica del Maule (UCM) University, Chile. The subjects completed 11 weeks of training ($\bar{x}$22 ± 4 sessions). With the exception of their classes, they did no extra training during the experimental phase and, therefore, all the physical exercises performed were identical, as detailed in Table 1[16].

Table 1. Characteristics of the sample and distribution of groups.

Groups (G)	$\bar{X}$ - SD	Age (Years)	Weight (Kg)	Height (Cm)	BMI
G1	$\bar{X}$	18.0	62.3	160.25	24.15
NMES + BFR	SD	0.50	8.40	3.75	2.15
G2	$\bar{X}$	19	63.8	164.9	23.3
TW + BFR	SD	1.00	9.90	6.10	1.90
G3	$\bar{X}$	19.33	63.93	164.53	23.53
SQ90º + BFR	SD	0.47	8.03	10.15	0.48
G4 + BFR	$\bar{X}$	19.50	72.00	171.85	24.35
	SD	0.50	5.00	2.15	1.05
Total	$\bar{X}$	19.11	65.33	165.29	23.80
	SD	0.74	8.81	7.88	1.52

BFR: Blood flow restriction; NMES: Neuromuscular electrical stimulation; TW: Treadmill walking; 90ºSQ: 90º squat; BMI: Body mass index; $\bar{X}$: Mean; SD: Standard deviation.

All participants were informed of the aims and duration of the study, giving their written consent to voluntary participate in the same. The research project was approved by the Scientific Ethics Committee of the UCM, under the ethical guidelines laid down in the World Medical Association's Helsinki Declaration on ethical principles for medical research involving human subjects. The dietary variable was controlled by applying the food intake questionnaire (OQ)[17], observing no body-image or eating disorders.

The inclusion criteria were as follows: Be students in academic years 2014 - 2015 of the UCM Physical Education degree course, aged between 17-20 years, male or female gender. The exclusion criteria were as follows: Be a member of a sports team or take part in some type of scheduled and systematic training, be under treatment for a lower limb injury or disability, exhibit a painful lower limb injury or disability. Inclusion in the final analysis required 70% attendance of the sessions.

Techniques and instruments

The measurements were taken in week 1 prior to the intervention and subsequently in week 12, immediately after the training period had concluded. In order to measure the MDS based on 1RM, the direct protocol was used on an incline press set at 90º and adapted to perform it on each limb separately. 90º knee flexion was controlled by an acrylic universal goniometer (Carci brand) with a scale of 0º-360º. The validity, reliability and objectivity levels for the evaluation of maximum strength are based on the recommendations of Brown, (2003) and the ASEP (American Society of Exercise Physiologists)[18].

The "International Working Group of Kinanthropometry" standardised protocol was used for the evaluation of the anthropometric variables[19]. All measurements were taken by a single observer with extensive experience and certified to ISAK level III. Body mass was measured barefoot and wearing as little clothing as possible, using a digital scale with an accuracy of 200 g and a range of 0 to 150 kg (Tanita brand).

Height was measured by positioning the subject, without shoes, in the Frankfurt plane, using an aluminium stadiometer graduated in millimetres and with a scale of 0-2.50 m (Seca brand). Skinfold was measured using a skinfold calliper (Harpenden) which exercises a constant pressure of 10 g/mm. For the circumferences, a nylon tape measure graduated in millimetres was used (Seca brand) with an accuracy of 0.1 cm. The anthropometric body measurements were taken and adapted from the studies made by Vieitez, (2001); Medina, *et al.* (2013) and Norton, *et al.* (1996)[19-21], showing the internationally used validity, reliability and objectivity levels.

For the measurement of the BM, BMD, BMC, bone densitometry (BD) also known as DXA (Dual-energy X-ray Absorptiometry) was used with the protocol proposed by the manufacturer (Lunar Prodigy; General Electric: Fairfield, CT, USA)[22-24]. The accuracy of the DXA is high, with an error margin of 2-6% for body composition[25]. The objectivity of the BM is very high (95-99%),the validity is 85-97%[23].

Procedures

All the training activities and the measurement of variables were conducted at the UCM, specifically at the human performance laboratory located in the technology building, from 15:00 - 17:00 hours. For 3 months, the subjects performed three training sessions a week, on Tuesdays, Thursdays and Fridays, corresponding to the duration of the training, including 10 minutes preparation time, the placement of devices, pre- and post-stretching of the muscle region trained.

The blood pressure cuffs used had a width of 5 cm and a length of 70 cm, with an initial pressure of 110 mmHg. The cuff was adjusted at a pressure of 0 mmHg at the time of placement, measurement and seal. The BFR was applied to the proximal thigh (fifth proximal thigh, measured from the base of the patella to the inguinal crease) applied to the right thigh, remaining in the same position during all the sets as well as the rests.

The preparation and use of the cuffs were based on the review made by Reina, *et al.* (2014), while the initial pressure and the variation parameters were established according to the recommendations made by Loenneke, *et al*. (2014)[14,26].

Task distribution and assignment

Participants were randomly divided into uniform groups, based on gender and group size.

Group 1 (G1): Neuromuscular electrical stimulation (NMES) + BFR 15 minutes of NMES was applied using a consecutive asymmetric two-phase square wave with a pulse width of 300 µs and a frequency of 50 Hz, a current of 40-50 mA, a medium-high perception (it was the maximum tolerated level by subjects) generating a visible muscle contraction. The EMS system (CDM TENS/EMS® Everyway Medical Instruments CO., Ltd. Edition: V1.0) was programmed with a contraction/rest time of 16/0 s. respectively, an 8 s. ramp, 16 s. at ON and 0 s.at OFF[27]. The initial pressure of the cuff was 110 mmHg. Variation during exercise was 110 - 130 mmHg during performance.

4 one-size 4x4 cm adhesive electrode pads were used. These were placed on the motor points of the Quadriceps femoris muscle, respectively under the rectus femoris insertion, 10 cm under each anterosuperior iliac spine, the most prominent area of the vastus medialis and the vastus lateralis. The NMES + BFR was performed with the subject in a seated position, maintaining the feet on the floor with the knee at a 90º angle in each session[27].

Group 2 (G2): Exercise with treadmill walking (TW) + BFR. The subjects performed 5 sets of 2 minutes walking with a 2 minute rest, at a speed calculated according to the Cooper test average speed and controlled with a pulsometer, staying between 50-60% of the maximum heart rate. The HP Cosmos, Mercury model treadmill was used. The initial pressure of the cuff was 110 mmHg. The variation during the performance of the exercise was 110 – 220 mmHg.

Group 3 (G3): Dynamic squat exercise at 90º + BFR. 90º dynamic squats were performed, 5 sets, 2 minute execution, 1 minute rest, pulsometer-controlled execution speed, staying between 50-60% of the maximum heart rate. A 40 cm bench was used to control the knee flexion angle, maintaining it between 0º and 90º during the exercise, with the feet resting at hip height. The initial pressure of the cuff was 110 mmHg. The variation during the performance of the exercise was 110 – 220 mmHg.

Group 4 (G4): BFR alone. BFR alone, in a sitting position for 15 minutes, with the feet resting on the floor and the torso against the backrest. The initial pressure of the cuff was 110 mmHg. There was no pressure variation during the application.

Statistical analysis

The SPSS® (Statistical Package for the Social Sciences) software program for Windows, version 20.0, was used. The measure of central tendency (Mean) was calculated and the measure of spread (Standard deviation), in addition to the simple mathematical calculation of the percentage of progress between the initial and final evaluations for all variables. The Shapiro-Wilk test was performed in order to determine the distribution normality of the data, and the Levene test for the homogeneity of variances, both with a confidence level of 95% and significance of 5% ($p>0.05$). Once the normality of the data and the homogeneity of the variances had been established, the paired t-test was applied in order to compare the pre- and post-evaluations of each group and of the subjects as a whole. The one-way analysis of variance or of one factor (ANOVA) was used to analyse whether there the four treatments differed significantly with regard to their means and variances, in addition to including the Tukey *Post Hoc* test for multiple comparisons. The assumed confidence level was 95% and significance of 5% ($p<0.05$) for these latter tests.

Results

Maximum dynamic strength

The study revealed an increase in the strength indices in all groups. Statistical significance was observed for the t-test in the pre- and post-

Table 2. Effects on the maximum dynamic strength of the lower limb.

	Groups							
	NMES + BFR		TW + BFR		90º SQ + BFR		BFR	
MDS RLL (Kg)	↑*	(1)	↑	(2)	↑	(4)	↑*	(3)
MDS LLL (Kg)	↑*	(1)	↑	(3)	↑	(2)	↑	(4)

Increase (↑); Decrease(↓); No effect (↓); (*) Statistical significance P<0.05; Order of response to treatment (1)>(4); MDS: Maximum dynamic strength. RLL: Right lower limb; LLl: Left lower limb; BFR: Blood flow restriction; NMES: Neuromuscular electrical stimulation; TW: Treadmill walking; 90ºSQ: 90º squat.

evaluation for the subjects as a whole (p=0.002), also for group G1 in the right lower limb (RLL) (p=0.037), left lower limb (LLL) (p=0.028) and for group G4 in the RLL (p=0.049). On the other hand, the groups exhibited differences in their percentages of progress and initial data, making it possible to order and compare their response to treatment (Table 2). However, no significant difference was observed between all the groups for ANOVA in RLL difference (p=0.84), LLL (p=0.66) and between groups for *Post Hoc* in RLL (p=0.845), LLL (p=0.664).

Muscle hypertrophy

With regard to MT (kg), Group 4, solely subjected to the application of BFR, improved by 4.15%, while group G2 which performed TW + BFR improved by 3.78%, as shown in Table 3. This variable decreased in the other two groups. No statistical significance was found for the t-test in the pre- and post evaluations for the subjects as a whole and for each group, nor for the the ANOVA and Post Hoc tests (p>0.05) between the groups. A significant difference was solely observed for the TW group in the muscle tissue to bone tissue ratio (p=0.042).

Bone tissue

The effects observed are varied, as shown in Table 4. Statistical significance was found in the t-test for G2 in the lower limb difference (LLD), in the BM (p=0.049) and for the pre-and post-evaluation of the subjects as a whole in the BMC of the right femoral neck (RFN) (p=0.046) and total right femur (TRF) (p=0.049). There is no significant difference between the groups (ANOVA) and Post Hoc (p>0.05) for BM, BMD and BMC.

Table 3. Effects on anthropometric indicators related to muscle hypertrophy

	Groups							
	NMES + BFR		TW + BFR		90ºSQ + BFR		BFR	
MT(Kg)	↓	(4)	↑	(2)	↓	(3)	↑	(1)
RMAT	↑	(1)	↓	(1)	↓	(3)	↓	(2)
RMBT	↓	(3)	↑*	(1)	↓	(4)	↑	(2)
MRTC (Cm)	↑	(2)	↑	(1)	↓	(3)	↓	(4)
MeRTC (Cm)	↑	(1)	↑	(3)	↑	(2)	↓	(4)
MRC (Cm)	↓	(3)	↓	(4)	↓	(2)	↓	(1)

Increase (↑); Decrease (↓); No effect (↔); (*) Statistical significance P<0.05; Treatment response order (1)>(4). MT. Muscle tissue; Kg. Kilograms; RMAT. Ratio of muscle to adipose tissue; RMBT. Ratio of muscle to bone tissue; MRTC Maximum right thigh circumference; Cm. Centimetres; MeRTC. Medial right thigh circumference; MRC. Maximum right calf.

Table 4. Effects on the bone tissue.

	Groups							
	NMES + BFR		TW + BFR		90ºSQ + BFR		BFR	
BM RLL	↓	(4)	↑	(1)	↑	(2)	↑	(3)
BM LLL	↓	(4)	↑	(1)	↑	(3)	↑	(2)
BM LLDI	↓	(1)	↑*	(3)	↑	(4)	↓	(2)
BMD RFN	↑	(1)	↓	(3)	↑	(2)	↓	(4)
BMD RFD	↑	(1)	↑	(2)	↑	(3)	↓	(4)
BMD TRF	↑	(1)	↑	(2)	↑	(3)	↓	(4)
BMC RFN	↑	(1)	↓	(3)	↓	(2)	↓	(4)
BMC RFD	↑	(1)	↓	(3)	↑	(2)	↓	(4)
BMC TRF	↓	(1)	↓	(3)	↓	(2)	↓	(4)

Increase (↑); Decrease (↓); No effect (↔);(*) Statistical significance P<0.05; Treatment response order (1)>(4). BM: Bone mass. BMD: Bone mass density. RLL: Right lower limb; LLL: Left lower limb; LLD: Lower limb difference; RFN Right femoral neck; RFD; Right femoral diaphysis; TRF: Total right femur; BMC; bone mineral concentration.

Discussion

This discussion is based on the three parameters that represent the variables analysed herein, with emphasis on the interventions that show limited information in the literature.

Maximum dynamic strength

González-Badillo, *et al.* (2005) conducted a study to determine the influence of the training volume on the strength levels of a group of junior weightlifters. Their conclusions point in the same direction as this study, given that a moderate training volume was shown to be more effective in increasing MS than low or high volumes[28].

Takarada, *et al.* (2000) obtained very similar results, with the BFR group showing strength gains of ~18%, while the conventional training group improved by ~22%. As was the case for our investigation, this study also reported that the differences between groups did not reach statistical significance levels[29].

The study made by Karabulut, *et al.* (2010) is extremely relevant, given that it shows an exercise performed in our investigation, namely the leg extension. The study compares the effects of two types of resistance training protocols on MS in older men. The findings suggest that the leg MS improves with the low-load BFRE and the LIT protocol (20% 1-rm) with vascular restriction, which was almost as effective as the high intensity resistance training protocol (80% 1-RM) for increasing MS in older men. Unfortunately, it does not explain what happened in our study, given that the LL to which BFR was not applied had similar strength gains to the limb with BFR[30].

Muscle hypertrophy

Neuromuscular electrical stimulation and blood flow restriction

Natsume, *et al.* (2015) studied the results of low-intensity NMES combined with BFR on muscle size and MS of 8 healthy, untrained volunteers, of a mean age of 26 years, 174 cm and 71 kg. The training dose used was twice per day, 5 days a week, for two weeks (20 sessions), in the morning and afternoon with a 5-hour interval, seated with a fixed knee angle of 75º, for 23 min. They used two-phase rectangular discharges with cycles of 30 Hz and 8 sec. stimulation with a 3 sec. rest interval, recorded at 5-10% of the maximal voluntary contraction. The BFR device was 10.5 cm. (MT-870 Digital Tourniquet; Mizuho, Tokyo, Japan), using a pressure calculated from the thigh circumference, ranging from 140-200 mmHg., not reporting the variation produced by muscle contraction (which the authors establish as a study limitation), they performed 5 min. sets with 1 min. rests. Their findings show that, after 2 weeks of training, the application of BFR+NMES generated hypertrophy by 3.9% and this decreased by 3% after 2 weeks of detraining. Furthermore, there was an increase in the maximal isometric knee extension strength + 14.2% and isokinetic maximal strength of 7.0% to 8.3%, finding no significant changes with the sole application of NMES, comparing the initial and final evaluation. In addition to the two treatments, no significant differences were obtained using ANOVA and t-test. This work showed an important training density, yet it was only conducted over 2 weeks. Our work made the evaluation with a dynamic leg press test, the dose and time frames differ significantly from our study, although they do confirm a difference in the results with G1 of our study, in the improvements in strength, which were 47.34% in the NMES+BFR group and 20% in the BFR alone group[31].

Another limited report on the combination of NMES and BFR was made by Slysz, *et al*. (2017). The intervention was made for 32 minutes, 4 days a week for six weeks. Leg strength increased 32 ± 19 kg in the NMES+BFR group, which differed from the 3 ± 11 kg change in the control group ($p=0.03$). The isolated NMES and BFR groups showed increases of 16 ± 28 kg and 18 ± 17 kg, respectively, but these did not statistically differ from the control, or from one to another. There were no statistically significant alterations for the muscle mass. Comparing the results with G1 of our study, the strength improvements were 26 Kg in the NMES group and 16.25 kg for the group that only performed BFR. These results are partly similar to the findings herein, with regard to the fact that the difference in thigh circumference was not significant, which was related to the poor response in terms of muscle mass increase, maximal right muscle circumference ($t=0.960$) and right medial thigh circumference ($t=0.122$)[32].

Treadmill and blood flow restriction

Abe, *et al.* (2006) examined the acute and chronic effects of walk training with and without BFR on MRI-measured muscle size and MDS and isometric strength, together with blood hormonal parameters. This study reported a far greater increase of strength in the treadmill walking group, 31.7% in the LL with the BFR device and 20.8% in the one without, which could be due to the fact that they completed 6 weeks of training, three times a week, which confirms the conclusions of Loenneke, *et al.* (2012) in their meta-analysis, whereby a greater frequency of sessions and days per week does not produce better results, and the correlation between a greater number of weeks and strength gains. The characteristics of the subjects with regard to age, body composition, training level and training dose were similar to those of our study[33,3].

Squats and blood flow restriction

Abe, *et al*. (2005) investigated the effects on young subjects of 2 weeks of training performed twice daily, 6 days per week with 3 sets of two exercises, squat and leg curl. The experimental group for BFR + Exercise showed strength increases of 17% for squat and 23% for leg curl, also significantly increasing the IGF-1 growth factor ($p <0.01$). No significant changes in relative strength were observed in the pre- and post-test for both groups. They conclude that hypertrophy and strength gains in the thigh occur after 2 weeks. In our study, the group performing the squats improved its strength by 19.45%. As in the study described, no significant difference was observed in the test ($t=0.337$), ($p>0.05$). Our group completed 11 weeks of training but with fewer sessions, a lower frequency per week and only with squats. We observe that these two protocols, although they differ considerably and have the squat exercise in common, improve the strength of the lower limb in a similar manner. In our study, significant changes were observed in MS with and without BFR, while MH did not show this response, this is due to the use of anthropometry and not measurements to determine the CSA as reported by other studies that specifically evaluated this variable[34].

Bone tissue

Sato, *et al.* (2005) investigated the hypothesis that moderate exercise intensities associated with BFR would generate adaptations in the BT similar to the responses of high intensities. They measured the bone alkaline phosphatase (BALP) found on the osteoblasts responsible for bone formation. Their study was conducted on healthy males subjected to a twice daily walk with BFR on the thighs with a 4-hour interval between sessions, for 3 weeks. The findings were of interest, given that they determined significant increases in the MRI-measured muscle CSA ($p <0.01$), strength ($p <0.01$) and BALP ($p <0.05$), the BALP increase for the experimental group was 10.8% and 0.3% for the control group. There was no significant change in IGF-1 for either group. The authors concluded that 3 weeks BFR walk training increases the BALP, a serum marker of bone turnover. These blood markers were not recorded in our investigation, however the data proposed by these authors could explain the BM and BMD increases that give our treadmill group the leading position for the average response in these variables[35].

In their study, Bemben, *et al.* (2007) proposed to determine the acute effect on the blood markers responsible for BT formation, using low intensity training (LIT) combined with BFR, a single LIT group and a control group. They evaluated 30 minutes after 1 set of 30 reps followed by 3 sets of 15 reps with 30 seconds rest between sets at 20% 1-RM. They evaluated the BALP and cross-linked N-telopeptide (NTx) of type I collagen (bone remodelling biomarker) concluding that a single bout of BFR at 20% 1-RM resulted in decreases in the NTx bone resorption marker but had no effect on the BALP bone formation marker[8].

The study made by Karabulut, *et al*. (2011) compared the effects of different resistance training protocols on bone marker concentrations in older men with a mean age of 56.8 years, for a 6 week duration. The serum concentrations of BALP and NTx improved in both resistance training protocols, suggesting increased bone turnover with a balance favouring bone formation. Therefore, despite using a low mechanical load combined with BFR, this is a potentially effective training alternative to traditional high intensity training for enhancing bone health in older men. They also used BD, not finding any changes in the BM, BMD and BMC, associating this with the training duration of just 6 weeks. As the authors did not provide the breakdown made in our study, we are unable to make an appropriate comparison. However, in a similar way to our findings, the difference values were not significant on comparing the groups[9].

Another of the few works available on the effect of BFR on BT is provided by Loenneke, *et al.* (2013), in a study of the case and rehabilitation of an osteochondral fracture of the right knee of a 22-year-old body-builder, with a height of 175 cm and weight of 70 kg. His progress was favourable, due to the application of BFR, however the conclusions obtained are clinical and individual in terms of pain, radiograph review and magnetic resonance imaging, not providing conclusive data on BM, BMD and BMC, and with no control group to compare the results[36].

Although these prior results show an effect on the bone system, there is an evident lack of studies in this respect. The comparison of our results on BT is an inconclusive task, given the limited number of studies published with regard to the adaptations that this training generates on this tissue in particular, and even less so with the combination of NMES and BFR[2-6,13,37,38]. The study limitations include the small sample size, the convenience selection of participants and no comparison between males and females, which must be addressed and controlled in future investigations.

Conclusions

It can be concluded that BFR combined with low-intensity stimuli such as NMES, treadmill and squat, produces positive effects on the MDS, MT and the BT of the LL. BFR also generates changes when used alone without another stimulus, although to a lesser extent. There is a difference in the response of the MT and BT and also in the MDS to different forms of exercise, being unable to establish a statistically significant difference for moderately trained healthy subjects in an 11 week period.

Future studies should be undertaken in order to further examine the underlying mechanisms of the process of MH induced by a hypoxic stimulus, specifically to clarify the reasons why studies show phenomena such as hypertrophy or MDS gains in non-occluded muscles. Particular importance should be given to the development of an investigation line using a control group to establish a dose-response, adaptations in the short and long term, and to the generation of greater evidence in the area of bone tissue adaptation and rehabilitation.

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Conflict of interest

The authors have no conflict of interest at all.

Bibliography

1. Pearson SJ, Hussain SR. A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. *Sports Med.* 2015;45:187-200.
2. Slysz J, Stultz J, Burr JF. The efficacy of blood flow restricted exercise: A systematic review-meta-analysis. *J Sci Med Sport.* 2016;19:669-75.
3. Loenneke JP, Wilson JM, Marín PJ, Zourdos MC, Bemben MG. Low intensity blood flow restriction training: a meta-analysis. *Eur J Appl Physiol.* 2012;112:1849-59.
4. Loenneke J, Young K, Fahs C, Rossow L, Bemben D, Bemben M. Blood flow restriction: Rationale for improving bone. *Med Hypotheses.* 2012;78:523-7.
5. Loenneke JP, Pujol TJ. The Use of occlusion training to produce muscle hypertrophy. *Strength Cond J.* 2009;31:77-84.
6. Chulvi-Medrano I. Entrenamiento de fuerza combinado con oclusión parcial superimpuesta. Una revisión. *Rev Andal Med Deport.* 2011;4:121-8.
7. Sato Y, Abe T. KAATSU-walk training increases serum bone-specific alkaline phosphatase in young men. *Int J Kaatsu Training Res*. 2005;1:77-81.
8. Bemben D, IJ P, Abe T, Sato Y. Effects of a single bout of low intensity KAATSU resistance training on markers of bone turnover in young men. *Int J Kaatsu Training Res.* 2007;3:21-6.
9. Karabulut M, Bemben DA, Sherk VD, Anderson MA, Abe T, Bemben MG. Effects of high-intensity resistance training and low-intensity resistance training with vascular restriction on bone markers in older men. *Eur J Appl Physiol.* 2011;111:1659-67.
10. Sumide T, Sakuraba K, Sawaki K, Ohmura H, Tamura Y. Effect of resistance exercise training combined with relatively low vascular occlusion. *J Sci Med Sport*. 2009;12:107-12.
11. Takarada Y, Sato Y, Ishii N. Effects of resistance exercise combined with vascular occlusion on muscle function in athletes. *Eur J Appl Physiol.* 2002;86:308-14.
12. Takano H, Morita T, Iida H, Asada K, Kato M, Uno K, *et al.* Hemodynamic and hormonal responses to a short-term low-intensity resistance exercise with the reduction of muscle blood flow. *Eur J Appl Physiol.* 2005;95:65–73.
13. Scott BR, Loenneke JP, Slattery KM, Dascombe BJ. Exercise with blood flow restriction: an updated evidence-based approach for enhanced muscular development. *Sports Med.* 2015;45:313-25.
14. Reina C, Domínguez R. Entrenamiento con restricción del flujo sanguíneo e hipertrofia muscular. *Rev Int Cienc Deporte.* 2014;10:366-82.
15. Hackney KJ, Everett M, Scott JM, Ploutz-Snyder L. Blood flow-restricted exercise in space. *Extrem Physiol Med.* 2012;1:1-14.
16. Hernández R, Fernández C, Baptista P. *Metodología de la investigación.* México. Editorial McGraw-Hill; 2010.p.170-94.
17. O'Donell W, Warren W. *Cuestionario de sobreingesta alimentaria.* México. Editorial El Manual Moderno; 2007.p.1-26.
18. Brown LE, Weir JP. Recomendação de procedimentos da Sociedade Americana de Fisiologia do Exercício (ASEP) I: avaliação precisa da força e potência muscular. *R Bras Ci e Mov.* 2003;11:95-110.
19. Norton K, Whittingham N, Carter L, Kerr D, Gore C, Marfell-Jones M. Measurement techniques in anthropometry. *Anthropometrica*. 1996;1:25-75.

20. Vieitez JA. Validación por disección de cadáveres de 7 métodos antropométricos para estimar la masa muscular humana. *Rev Cub Salud Publica.* 2001;15:115-20.

21. Medina FS, Ramírez WA, Leal DM, López VF, Canteras J. Metodología y fiabilidad de la medición del perímetro de muslo. A*ct Fís Des Hum*. 2013;4:150-4.

22. Ramos RL, Armán JA, Galeano NA, Hernández AM, Gómez JG, Molinero JG. Absorciometría con rayos X de doble energía. Fundamentos, metodología y aplicaciones clínicas. *Radiologia.* 2012;54:410-23.

23. Espallargues M, Sampietro-Colom L, Estrada MD, Sola M, del Rio L, Setoain J, *et al.* Identifying bone-mass-related risk factors for fracture to guide bone densitometry measurements: a systematic review of the literature. *Osteoporos Int.* 2001;12:811-22.

24. Gómez JC. Densidad mineral ósea en niños y adolescentes. Revisión de literatura. VIREF *Revista de Educación Física*. 2015;4:58-73.

25. Albanese CV, Diessel E, Genant HK. Clinical applications of body composition measurements using DXA. *J Clin Densitom*. 2003;6:75-85.

26. Loenneke JP, Thiebaud RS, Abe T, Bemben MG. Blood flow restriction pressure recommendations: the hormesis hypothesis. *Med Hypotheses*. 2014;82:623-26.

27. Linares M, Escalante K, La Touche R. Revisión bibliográfica de las corrientes y parámetros más efectivos en la electro estimulación del cuádriceps. *Fisioterapia*, 2004;26:235-44.

28. González-Badillo JJ, Gorostiaga EM, Arellano R, Izquierdo M. Moderate resistance training volume produces more favorable strength gains than high or low volumes during a short-term training cycle. *J Strength Cond Res.* 2005;19:689-97.

29. Takarada Y, Takazawa H, Ishii N. Applications of vascular occlusion diminish disuse atrophy of knee extensor muscles. *Med Sci Sports Exerc.* 2000;32:2035-9.

30. Karabulut M, Abe T, Sato Y, Bemben, MG. The effects of low-intensity resistance training with vascular restriction on leg muscle strength in older men. *Eur J Appl Physiol.* 2010;108:147-55.

31. Natsume T, Ozaki H, Saito AI, Abe T, Naito H. Effects of Electrostimulation with Blood Flow Restriction on Muscle Size and Strength. *Med Sci Sports Exerc.* 2015;47:2621-7.

32. Slysz J, Burr JF. The Effects of Blood Flow Restricted Electrostimulation on Strength and Hypertrophy. *J Sport Rehabil.* 2018;27.3:257-62.

33. Abe T, Kearns CF, Sato Y. Muscle size and strength are increased following walk training with restricted venous blood flow from the leg muscle, Kaatsu-walk training. *J Appl Physiol.* 2006;100:1460-6.

34. Abe T, Yasuda T, Midorikawa T, Sato Y, Inoue K, Koizumi K, *et al.* Skeletal muscle size and circulating IGF-1 are increased after two weeks of twice daily "KAATSU" resistance training. *Int J Kaatsu Training Res.* 2005;1:6-12.

35. Sato Y, Abe T. KAATSU-walk training increases serum bone-specific alkaline phosphatase in young men. *Int J Kaatsu Training Res*. 2005;1:77-81.

36. Loenneke JP, Young KC, Wilson JM, Andersen JC. Rehabilitation of an osteochondral fracture using blood flow restricted exercise: a case review. *J Bodyw Mov Ther.* 2013;17:42-5.

37. Wernbom M, Augustsson J, Raastad, T. Ischemic strength training: a low-oad alternative to heavy resistance exercise?. *Scand J Med Sci Sports.* 2008;18:401-16.

38. Manini TM, Clark BC. Blood flow restricted exercise and skeletal muscle health. *Exerc Sport Sci Rev*. 2009;37:78-85.

Original article

High-performance athletes' attitude towards doping: Validation of the Spanish version of the Performance Enhancement Attitude Scale for Colombia

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Summary

Background: Doping is the use of substances to achieve a better performance in sports. This practice is considered to be growing worldwide. Despite regulations by the World Anti-Doping Agency, 14–39% of high-performance athletes have consumed prohibited substances at least once in their sports career. The attitudes towards this type of consumption are used as predictors of the intent of usage of prohibited substances to improve physical performance.
Objective: This study aimed to validate the Spanish Version of the Performance Enhancement Attitude Scale of high-performance athletes in the Colombian context.
Methodology: A cross-sectional study was performed with a convenience sampling of 112 athletes aged 15 and older, registered in a State Sports Institute in Medellín, Colombia in 2016. The participants self-completed Petróczi and Aidman instrument, Performance Enhancement Attitude Scale, adapted into Spanish by Morente-Sánchez, et al. in 2014. The reliability of the scale was assessed using Cronbach's Internal Consistency Coefficient and an exploratory and confirmatory factor analysis (CFA) was conducted to evaluate the scale's structure.
Results: The scale had a reliability of 0.87 and the factor analysis confirmed the unidimensionality. Of all the athletes participating in the research, the Performance Enhancement Attitude Scale average was 35.8 of 102 points, indicating a low tendency of attitudes towards doping.
Conclusion: The psychometric properties of the 17 items of the Performance Enhancement Attitude Scale are adequate and could be used when assessing attitudes towards doping of high-performance athletes in similar contexts. This information could be used for the purposes of developing educational strategies for doping prevention in our athletes.

Key words:
Sports. Doping in sports. Athletic performance.

Actitud frente al dopaje de deportistas de alto rendimiento: Validación de la versión española de la *Performance Enhancement Attitude Scale* para Colombia

Resumen

Introducción: El dopaje es el uso de sustancias para lograr un mejor desempeño en los deportes. Esta práctica parece estar creciendo en todo el mundo. A pesar de las regulaciones de la *World Anti-Doping Agency,* 14–39% de los deportistas de alto rendimiento han consumido sustancias prohibidas al menos una vez durante su carrera deportiva. las actitudes hacia este tipo de consumo se emplean como predictores de la intención de uso de sustancias prohibidas para mejorar el rendimiento físico.
Objetivo: El objetivo del estudio fue validar en deportistas de alto rendimiento en el contexto colombiano la versión española de la escala de Actitudes frente al mejoramiento del rendimiento. Diseño: Se realizó un estudio de corte transversal en 2016 con una muestra por conveniencia de 112 deportistas de 15 y más años inscritos en un instituto deportivo estatal en Medellín (Colombia).
Metodología: Los participantes autodiligenciaron el instrumento de Petróczi y Aidman *Performance Enhancement Attitude Scale* (PEAS), adaptado al español por Morente-Sánchez et al. Se evaluó la confiabilidad de la escala con el coeficiente de consistencia internal de Cronbach y se hicieron análisis factorial exploratorio y confirmatorio para evaluar la estructura de la escala.
Resultados: Los resultados indicaron que la escala tenía una confiabilidad de 0,87 y el análisis factorial confirmó la unidimensionalidad. En los deportistas participantes en la investigación el promedio de la PEAS fue de 35,8 de 102 puntos posibles, indicando baja tendencia de actitudes hacia el dopaje.
Conclusión: Las propiedades psicométricas de los 17 ítems de la PEAS son adecuadas, y podría ser utilizada en la evaluación de actitudes hacia el dopaje en deportistas de alto rendimiento en contextos similares. Esta información podría ser utilizada para el desarrollo de estrategias educativas para la prevención del dopaje en nuestros deportistas.

Palabras clave:
Deportes. *Doping* en los deportes. Rendimiento atlético.

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Introduction

Doping is the use of substances to achieve a set goal and has been recognised as a specific form of drug consumption[1]. In sports, this practice is defined as the occurrence of one or more of the 10 anti-doping rule violations. This practice, which seems to be growing worldwide, is considered a major global public health problem, which led to the establishment of the World Anti-Doping Agency (WADA) in 1999[2]. This agency stated that the number of abnormal findings in anti-doping tests has increased by more than 20% since 2012[3]. Even though the implementation of control measures has allowed to maintain a prevalence of positive tests of almost 2%, 14–39% of high-performance athletes have consumed prohibited substances at least once in their sports career, estimating that a higher percentage may have resorted to this type of practice[4-6].

In the absence of available information regarding the use of substances associated with doping, the attitudes towards this type of consumption are used as predictors of the intent of usage of prohibited substances to improve physical performance[7-13].

There are several scales implemented to assess aspects related to attitudes towards doping in high-performance athletes, such as: the *Performance Enhancement Attitude Scale* (PEAS) by Petróczi and Aidman, a unidimensional instrument composed of 17 items with six Likert-type response options that range from 1 = totally in disagreement to 6 = totally in agreement, with a reliability of 0.77[12]. This scale was translated and adapted into Spanish by Morente-Sánchez *et al*. using various samples of high-performance athletes, with an overall reliability of 0.82[14]; the *Sport Orientation Questionnaire* (SOQ), a 25 items-scale distributed in three dimensions (competitiveness, winning-orientation and goal-orientation), with Likert-type response options of five points, ranging from 'in agreement' to 'totally in disagreement'[15]. It has high internal consistency coefficients in the three dimensions (competitiveness = 0.94, winning-orientation = 0.83 and goal-orientation = 0.80); the *Doping Use Belief* (DUB) measures are four statements in relation to the use and anti-doping behaviour with three response options ('yes, without restrictions'; 'yes, with restrictions' and 'absolutely not')[15]. The internal consistency of this scale is 0.94[16]. The *Vulnerability of Elite Athletes to Doping Scale* (VEADS) is another instrument, created in Spain, for which the PEAS items were combined with the determining factors of vulnerability to turn to doping[17]. It includes 52 items distributed across four factors (personality traits, behaviour traits, competition circumstances and attitudes towards doping) with a reliability of 0.84 in the domain of attitudes[17].

Given that no information was found regarding studies that implement instruments for the assessment of attitudes towards doping in Colombian athletes, we considered conducting a research for the purposes of determining the reliability and factor validity of the Spanish version of the PEAS in a group of high-performance athletes of a state sports institution from the city of Medellín, Colombia. This scale was implemented as it could be quickly processed, and results could be easily compared with the studies performed in high-performance athlete populations across the world.

Material and method

A cross-sectional descriptive study was conducted in 2016, where high-performance athletes of a state sports institution from the city of Medellín, Colombia over the age of 15 participated. The athletes who failed to complete the survey were excluded from this study.

For data collection purposes, a form including age, sex, sports variables and the PEAS instrument by Petróczi and Aidman, adapted into Spanish by Morente-Sánchez, Femia-Marzo and Zabala was used[14,16]. This self-report scale contains 17 items with Likert-type response options scored from one to six (one = strongly in disagreement, two = in disagreement, three = slightly in disagreement, four = slightly in agreement, five = in agreement and six = strongly in agreement).

The scale's total score ranges from 17 to 102; the higher the score, the stronger the tendency towards doping behaviours. The items that make up the scale are as follows: *P01_Legalising products to improve performance would be beneficial for sports, P02_Taking drugs is necessary to be competitive, P03_The risks related to doping are exaggerated, P04_Recreational drugs encourage athletes to train and compete at the highest level, P05_Athletes should not feel guilty for violating the rules and taking drugs to improve their performance, P06_Athletes are pressured to take drugs that improve performance, P07_Health problems and injuries derived from rigorous training are as harmful as the doping effects, P08_The media exaggerate the issue of doping, P09_The media should talk less about doping, P10_Sports are the only professional alternative for athletes, P11_Athletes who take recreational drugs do so because they are helpful to overcome sports situations, P12_Recreational drugs help athletes overcome boredom during trainings, P13_Doping is an inevitable part of competitive sports, P14_Athletes usually waste time as a result of injuries and drugs can help them make up for lost time, P15_Doping does not imply cheating as everyone does it, P16_Only the quality of performance should be valued, rather than the way athletes achieve their results and P17_There is no difference between taking drugs, aerodynamic shapes or special bathing suits, as all of them serve to improve performance.*

The information was gathered when athletes attended out-patient consultations, physiotherapy or pre-participatory evaluations in the sports institution by three of the main researchers for two months in 2016. After agreeing to take part in the research, the athlete signed the informed consent and completed the self-administered questionnaire. This was a convenience sampling.

Selection bias were controlled by inviting all athletes attending a consult at the out-patient service were data was collected. No athlete denied participating on the study, therefore there were no evident not-response bias. On the other hand, information bias were controlled by: 1) an anonymously-completed form; 2) PEAS scale being short (17 items) and easy to complete; 3) the data base being designed and completed by two people: one dictating and verifying the correct submission of the data and another one being in charge of submitting the data into the SPSS software; 4) all answer option from each variable were codified; and 5) the three main researchers that collected the data being trained on standardized data collection techniques.

The statistical analysis was conducted in the SPSS vr.23 and SPSS AMOS vr.25 programme (Chicago, U.S.A.). The following statistical analysis of data was performed: (i) *Descriptive analysis:* the average, standard deviation, skewness, kurtosis, item-total correlation coefficient and Cronbach's Alpha Coefficient (if the item is deleted) were estimated. (ii) *Exploratory Factor Analysis* (EFA): through the analysis of the main components and Varimax orthogonal rotation. The suitability of the matrix to carry out the analysis was assessed using the Kaiser-Meyer-Olkin (KMO) statistic, considering that the model is suitable with a value ≥ 0.5 and the Bartlett's test of Sphericity that rejects the hypothesis is null if $p < 0.05$, which indicates an interrelationship between variables[18]; (iii) CFA: a structural equation model was performed for latent variables. The following indexes were assessed, with acceptance values as stated below[19]: Goodness of Fit Index (GFI) ≥ 0.85, *Adjusted Goodness of Fit Index* (AGFI) ≥ 0.80, *Square Root Mean Residual* (SRMR) ≤ 0.10, *Root Mean Square Error of Approximation* (RMSEA) ≤ 0.08, chi-square goodness of fit (CFMIN) ≤ 3, *Comparative Fit Index* (CFI) ≤ 0.95, and: (iv) *Reliability:* it was estimated using Cronbach's Alpha Coefficient, considering that a cut point of 0.7 or over was an acceptable value[20].

The research was approved by the ethics committee of the School of Health Sciences of the University the authors are affiliated to and was classified as 'minimum risk' as per resolution No. 008430 of 1993 of the Colombian Ministry of Health; the signed informed consent was obtained from every participant before providing the survey.

Results

A total of 119 athletes participated in the study, seven of which were excluded as they failed to complete the questionnaire; therefore, the results described derive from 112 people. The average age of the participants was 21.58 ± 3.46 years (15 as minimum, 33 as maximum), 60.7% were men and, among the type of sports, a higher percentage did karate, judo and practised athletics (Table 1).

Table 1. Sports practised by the 112 participants.

Sport	Frequency	Percentage
Karate	19	17.0
Judo	14	12.5
Athletics	12	10.7
Fencing	8	7.1
Rugby	8	7.1
Indoor volleyball	7	6.3
Cycling	6	5.4
Weightlifting	5	4.5
Badminton	4	3.6
Diving	4	3.6
Football	4	3.6
Archery	3	2.7
Basketball	2	1.8
Handball	2	1.8
HapKido	2	1.8
Wrestling	2	1.8
Swimming	2	1.8
Softball	2	1.8
Taekwondo	2	1.8
Other*	4	3.6

* Each sport with a participant: baseball, indoor football, triathlon and beach volleyball.

The descriptive statistics of the PEAS items can be observed in Table 2. The grade point average per item was 2.1 ± 0.4 (1.4 as minimum and 2.8 as maximum). The abovementioned table shows that all the grade point averages per item were lower than 3, showing the athletes' disagreement with each and every statement in the scale. Tolerance on doping was lower in the items *P02_Taking drugs is necessary to be competitive and P15_Doping does not imply cheating as everyone does it* (1.4 and 1.5, respectively). On the other hand, three items were more widely accepted: *P07_Health problems and injuries derived from rigorous training are as harmful as the doping effects,* with a score of 2.7 and 2.6 in items *P11_Athletes who take recreational drugs do so because they are helpful to overcome sports situations, P08_The media exaggerate the issue of doping* and *P14_Athletes usually waste time as a result of injuries and drugs can help them make up for lost time after an injury each.*

In the analysis of the item-total correlations, all items showed adequate values exceeding 0.25. It could also be noted that most of the skewness and kurtosis indexes are lower than 2, indicating similarities with the standard curve. The PEAS' total internal consistency, evaluated with Cronbach's alpha statistics, was 0.87 (0.88 in women and 0.86 in men). All items were relevant because if they were individually removed, the alpha of the total scale would not have changed at all.

In the EFA of the internal structure of the 17 items of PEAS, it could be seen that the model was adequate (KMO 0.827; χ^2 of the Bartlett's test of Sphericity = 672; $p < 0.001$). The EFA showed four factors with eigenvalues above 1 and the first factor itself explained the 34.10% of the variance of the test items (2º = 9.77%, 3º = 7.59% and 4º = 6.88%). Also, a significant drop was observed in the eigenvalue from the first to the second factor (5.79 to 1.66) and an inspection of the matrix of non-rotating components demonstrated that all items had high factor loads in the first factor before rotation. All of this led us to think that the test items were inclined to co-variate in a single unidimensional scale.

Moving to the CFA, the single-factor model was considered suitable as it had CFMIN= 2.21, GFI = 0.94; SRMR = 0.13 and RMSEA = 0.104; and it was very close to the acceptance values in CFI = 0,72.

The EFA and CFA results are summarised in Table 3. The factor loads of PEAS show a range from 0.34 to 0.71, while standardised errors are around 0.2. Except from items 6, 7 and 10, the *t* student values of the 14 remaining items were ≥ 1.96, indicating that they have a significance value lower than 0.05; it is worth noting that items 2, 5, 15, 16 and 17 had a t higher than 2.56 ($p < 0.01$). In the multiple correlation analysis (R^2), it could be observed that the reliability of the PEAS items for the latent factor was between 0.14 and 0.44.

The total average of the scale was 35.8 ± 11.7 of 102 possible points, indicating low tendency to doping behaviours. No statistically significant differences were found in the score by sex for the total scale (men = 36.15 ± 11.43; women = 35.16 ± 12.20. $p = 0.731$) or for individual items.

Age showed a low, although significant correlation ($p < 0.05$), with the total PEAS score ($r = 0.25$) and with items *P17_There is no difference between taking drugs and other ways to improve performance* ($r = -0.19$) and *P06_ Athletes are pressured to take drugs that improve performance.*

The items that were strongly correlated and statistically significant, ($p < 0.001$) with the total PEAS score were: *P14_ Doping helps athletes not to waste time after an injury* ($r = 0.67$; $p < 0.001$), *P09_ The media should talk less about doping* ($r = 0.66$), *P17_There is no difference between doping*

Table 2. Descriptive statistics of the 17 items of the PEAS scale in 112 high-performance athletes.

Summary of the question	Average deviation	Standard	Skewness	Kurtosis	Item-total correlation*	α if the item is deleted
P01_The products' legalisation is beneficial	2.03	1.20	1.30	1.27	0.49	0.86
P02_Doping is necessary	1.38	0.69	2.42	7.81	0.58	0.86
P03_The doping risks are exaggerated	2.46	1.43	0.80	–0.21	0.52	0.86
P04_Recreational drugs are motivational	1.88	1.08	1.58	2.57	0.47	0.86
P05_Not feeling guilty for using them	1.83	0.95	1.31	1.86	0.51	0.86
P06_Athletes feel pressured to improve	2.13	1.21	1.22	1.13	0.33	0.86
P07_Health problems due to training are as harmful as them	2.73	1.48	0.44	–1.04	0.41	0.86
P08_ The media exaggerate the doping issue	2.62	1.45	0.72	–0.46	0.52	0.86
P09_ The media should talk less about doping	2.28	1.31	1.04	0.78	0.58	0.85
P10_ Sports are the only professional alternative	2.30	1.49	0.93	–0.05	0.35	0.86
P11_ Drugs help in sports situations	2.60	1.26	0.41	–0.89	0.52	0.86
P12_ Drugs help overcome boredom	1.99	1.12	1.59	3.05	0.43	0.86
P13_ Doping is inevitable	1.88	1.11	1.33	1.14	0.48	0.86
P14_ Doping helps athletes not to waste time after being injured	2.58	1.29	0.59	–0.45	0.60	0.85
P15_ Doping is not cheating, everyone does it	1.52	1.08	2.45	5.56	0.58	0.85
P16_ Valuing performance, not how athletes achieve results	1.70	1.06	1.62	2.37	0.54	0.86
P17_There is no difference between doping and other ways of improving performance	1.94	1.13	1.18	0.62	0.58	0.85

* All odds were < 0.001.

Table 3. Structure of the EFA coefficients, factor loads, squared multiple correlations (R^2) and *t* student values of the 17 items of the PEAS in the study sample (n = 112).

Item	EFA		CFA			
	PCA*	MLE**	Standardised factor loads	Standardised errors	*t*-value	R^2
P01_Legalising products	0.57	0.51	0.53	0.21	2.52	0.28
P02_Doping_required	0.67	0.62	0.63	0.14	4.50	0.40
P03_risks_exaggerated	0.59	0.56	0.55	0.28	1.96	0.30
P04_recreational_drugs	0.57	0.53	0.53	0.21	2.52	0.28
P05_ Not_feeling_guilty	0.61	0.56	0.58	0.19	3.05	0.34
P06_pressured_to improve_performance	0.41	0.34	0.37	0.21	1.76	0.14
P07_health_problems	0.46	0.41	0.42	0.27	1.56	0.18
P08_media_exaggerates	0.60	0.61	0.57	0.25	2.28	0.32
P09_media_talk_less	0.64	0.64	0.61	0.26	2.35	0.37
P10_sports_single_alternative	0.41	0.36	0.36	0.26	1.38	0.13
P11_drugs_help_sports_situations	0.58	0.52	0.52	0.24	2.17	0.27
P12_drugs_help_overcome_boredom	0.52	0.47	0.48	0.21	2.29	0.23
P13_doping_inevitable	0.56	0.48	0.52	0.21	2.48	0.27
P14_waste_time	0.67	0.61	0.63	0.26	2.42	0.40
P15_doping_is_not_cheating	0.68	0.68	0.66	0.22	3.00	0.44
P16_value_quality_performance	0.63	0.71	0.61	0.21	2.90	0.37
P17_no_difference	0.66	0.66	0.64	0.25	2.56	0.41

*Main components analysis, **maximum likelihood estimator.

and other ways of improving performance (r = 0.65) and *P02_Doping is necessary* (r = 0.62).

Discussion

This study included 112 athletes registered in a state sports institution of the city of Medellín; the average age was 21.6 years, similar to the data reported by Morente-Sánchez *et al.* who collected information from 14 Spanish studies that used PEAS to assess attitudes towards doping[14]. This age is compatible with the conclusion of the sports training process, during which our athletes reach their level of development from the biological point of view and when the highest level required to start achieving sporting performances is reached.

Regarding sex, just like in the present study, Muwonge *et al*. reported 60.7% of male population[21]. This can be understood as the practice of the most frequent sports in our studies is more common in the male population.

The KMO measure of the sampling adequacy to conduct the factor analysis was 0.82, indicating a strong partial correlation in the data of this study. Besides, the probability value of the Bartlett's test of Sphericity was statistically significant for an interrelationship between the variables that make up the scale, therefore, arising four factors from the 17 items, although the first one explained the 34% of the scale variance and, since no item-total correlation coefficient was lower than 0.20, no item was removed and the scale was handled as a single-dimension one with its total number of items. The PEAS' unidimensionality has already been reported by the authors of the scale, and, in the Spanish version, Morente-Sánchez *et al*. mention that a potential second latent dimension, although a very weak one, was found[14].

The CFIN indicator of the CFA was 2.2 and it was considered adequate, being a bit higher than the value of 1.8 reported by Petróczi and Aidman and by Morente-Sánchez *et al*.[12,14]. The PEAS in our study had a high internal consistency, with a Cronbach's alpha of 0.87, being slightly lower in men than in women (0.86 *vs*. 0.88). These values exceed the range from 0.71 to 0.85 reported by Morente-Sánchez *et al.* and the value of 0.77 of the scale's authors, in studies in which the same instrument had been implemented[12,14].

The average of the PEAS scale for our participants was 35.8, which is within the range from 28.8 to 39.9 found by Morente-Sánchez and Zabala in Spanish athletes and is lower than the value of 39.8 estimated by Muwonge *et al*. in Ugandan athletes[21,22]. All these studies indicate that high-performance athletes show low tendency to doping behaviours. For its part, Allen et al. reported that high-performance athletes are against this practice to improve their performance[23]. Another study, showed that the athletes that had resorted to doping at some point in their careers tend to be more tolerant towards this behaviour and that athletes that take forbidden drugs mainly do this to improve their performance, although they recognise this is an unethical practice that may result in health problems and put them at risk of being sanctioned for their use[1,22].

This research showed no statistically significant differences in the PEAS score as regards sex, a finding that coincides with those reported by Ugandan, Spanish and Danish athletes, whereas Poland and Greek male athletes had more permissive on doping attitudes than women[13,14,21,24,25].

In the case of our participants, age was significantly related to the total PEAS score, a result similar to that obtained in the study conducted by Morente-Sánchez *et al.* in which younger athletes showed greater scores concerning their attitudes towards doping[14]. This could be associated with the need to be more competitive with regard to older athletes.

This study concludes that the psychometric properties of the 17 items of PEAS were adequate and that they could be used when assessing the attitudes of high-performance athletes towards doping in similar contexts. This information could be used for the purposes of developing educational strategies for doping prevention in our athletes. These educational approaches could be specially aimed to younger and more competitive athletes with greater PEAS scores in order to warn them about the risks of doping and to encourage fair play among all groups of athletes.

The major limitation of this study has to do with the fact that the answers provided by the participants to the questions of this questionnaire were self-reported and not subsequently verified, which could imply a margin of error that is present in all subjective answers and can be conditioned by factors that are not within the scope of the researchers. Nevertheless, the anonymity of questionnaires encouraged honesty at the moment of answering questions.

This study's strength is being the first research on Latin-American athletes' attitudes towards doping, whereby it also aims to expand scientific knowledge on said subject that affects athletes' image around the globe.

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Conflict of interests

The authors declare to have no conflicts of interest whatsoever.

Bibliography

1. Petroczi A, Aidman E. Psychological drivers in doping: The life-cycle model of performance enhancement. *Subst Abuse Treat Prev Policy*. 2008;3:7.
2. Pitsch W, Emrich E. The frequency of doping in elite sport: results of a replication study. *Int Rev Sociol Sport*. 2012;2:559-80.
3. 2015 anti-doping testing figures report. (November 2016). World Anti-doping Agency. Retrieved January 18, 2019, from: https://www.wada-ama.org/sites/default/files/resources/files/2015_wada_anti-doping_testing_figures_report_0.pdf
4. Kim T, Kim YH. Korean national athletes' knowledge, practices, and attitudes of doping: a cross-sectional study. *Subst Abuse Treat Prev Policy*. 2017;12:7.
5. de Hon O, Kuipers H, van Bottenburg M. Prevalence of doping use in elite sports: a review of numbers and methods. *Sports Med*. 2015;45:57-69.
6. Zucchetti G, Candela F, Villosio C. Psychological and social correlates of doping attitudes among Italian athletes. *Int J Drug Policy.* 2015;26:162-8.
7. Collins R W. Lowering restrictions on performance enhancing drugs in elite Sports. *Inquiries J.* 2017 [cited 17 June 2019]; 9. Available from: http://www.inquiriesjournal.com/a?id=1590
8. Creado S, Reardon C. The sports psychiatrist and performance-enhancing drugs. *Int Rev Psychiatry.* 2016;28:564-71.
9. Halliburton AE, Fritz MS. Health beliefs as a key determinant of intent to use anabolic-androgenic steroids (AAS) among high-school football players: implications for prevention. *Int J Adolesc Youth*. 2018;23:269-80.

10. Moston S, Engelberg T. Part I. Anti-Doping Investigations. In: *Detecting Doping in Sport.* 1st Ed. London: Routledge; 2017. p 1-45.
11. Ntoumanis N, Ng JY, Barkoukis V, Backhouse S. Personal and psychosocial predictors of doping use in physical activity settings: a meta-analysis. *Sports Med*. 2014;44:1603-24.
12. Petroczi A, Aidman E. Measuring explicit attitude towards doping: review of the psychometric properties of the performance enhancement attitude scale. *Psychol Sport Exerc.* 2009;10:390-6.
13. Psouni S, Zourbanos N, Theodorakis Y. Attitudes and intentions of Greek athletes and coaches regarding doping. *Health.* 2015;7:1224-33.
14. Morente-Sánchez J, Femia-Marzo P, Zabala M. Cross-cultural adaptation and validation of the Spanish version of the performance enhancement attitude scale (Petróczi 2002). *J Sports Sci Med.* 2014;13:430-8.
15. Gill DL, Deeter TE. Development of the Sport Orientation Questionnaire. *Res Q Exerc Sport.* 1988;59:191-202.
16. Petroczi A. Attitudes and doping: a structural equation analysis of the relationship between athletes' attitudes, sport orientation and doping behaviour. *Subst Abuse Treat Prev Policy.* 2007;2:34.
17. Gutiérrez J, Viuda-Serrano A. Creación y validación de la 'Escala de Vulnerabilidad de Atletas de Élite ante el Dopaje' (EVAED). In: Pardo R, González T, Irureta-Goyena P. *El fenómeno del Dopaje desde la perspectiva de las Ciencias Sociales*. Madrid: Universidad Politécnica de Madrid; 2015. p. 102-20.
18. Che MS, Tasmin R, Takala J, Norazlin H. Factor retention decisions in exploratory factor analysis results: a study type of knowledge management process at Malaysian university libraries. *Asian Soc Sci.* 2013;9(15):227-40.
19. Gallagher MW, Brown TA. Introduction to confirmatory factor analysis and structural equation modelling. In: Teo T. *Handbook of quantitative methods for educational research.* Rotterdam: Springer; 2013. p. 289-314.
20. Vaske JJ, Beaman J, Sponarski CC. Rethinking internal consistency in Cronbach's Alpha. *Leisure Sci.* 2017;39:163-73.
21. Muwonge H, Zavuga R, Kabenge PA. Doping knowledge, attitudes, and practices of Ugandan athletes': a cross-sectional study. *Subst Abuse Treat Prev Policy*. 2015;22:37.
22. Morente-Sánchez J, Zabala M. Doping in sport: a review of elite athletes' attitudes, beliefs, and knowledge. *Sports Med.* 2013;43:395-411.
23. Allen J, Taylor J, Dimeo P, Dixon SR, L. Predicting elite Scottish athletes' attitudes towards doping: examining the contribution of achievement goals and motivational climate. *J Sports Sci.* 2015;33:1-8.
24. Kim T, Kim YH. Korean national athletes' knowledge, practices, and attitudes of doping: a cross-sectional study. *Subst Abuse Treat Prev Policy*. 2017;12:7.
25. Sas-nowosielski K, Budzisz A. Attitudes Toward Doping Among Polish Athletes Measured with the Polish Version of Petroczi's Performance Enhancement Attitude Scale. *Pol J Sport Tourism*. 2018;25:10-3.

Effect of soy supplementation on inflammation and lactic acid induced by exhaustive exercise in rats

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Summary

Introduction: Exhautive physical exercise generates inflammatory and lactic acid markers. The supplementation with natural substances is reason for analysis due to its limited side effects.
Objective: To determine the inflammatory response and the level of lactic acid induced by exhaustive physical exercise after the ingestion of soybean in animal model.
Materials and method: Thirty male Sprawley dawley rats from 180 to 200 g were used, healthy divided into three groups: sedentary (C), with soybean intake tested (E+TP) and without soybean intake tested (E). The E + TP and E groups performed the Morris Water Maze Test. Inflammatory markers were determined as tumor necrosis factor alpha (TNF-a), interleukin 1 beta (IL-1β), interleukin 6 (IL-6) in plasma by ELISA technique, enzyme cyclooxygenase 2 (COX-2), nitric oxide synthase (iNOS) and as anti-inflammatory marker Peroxisome proliferator-activated receptor gamma (PPAR-γ), which was measured in quadriceps muscles by Western-blot technique and measured lactic acid in blood.
Results: A significant decrease in plasma was obtained in the inflammatory levels of TNF-α (600 vs 350 pg/ml), IL-1β (450 vs 150 pg/ml), and IL-6 (480 vs 100 pg/ml), COX-2 (52 vs. 25 RDU) and iNOS (58 vs. 8 RDU) in the E+TP group compared to the E group. In addition an increase in the expression of the PPAR-γ protein was observed (18 vs 65 RDU) in the group E+TP compared to group E. Regarding the measurements of lactic acid, the groups obtained maximum values of: E: 35, C: 22 and E+TP: 28 Mmol/Lactate, which indicates that Group E and E+TP although they underwent the same test, lactic acid levels are heterogeneous.
Conclusion: The intake of soy mitigates the levels of lactic acid and inflammatory markers induced by exhautive physical exercise in animal models.

Key words:
Inflammation. Lactic acid. Soy. Exercise. Exhaustive.

Efecto de la suplementación con soja sobre la inflamación y ácido láctico inducido por ejercicio físico exhaustivo en ratas

Resumen

Introducción: El ejercicio físico exhaustivo genera marcadores inflamatorios y de ácido láctico. La suplementación con sustancias naturales es motivo de análisis debido a sus escasos efectos secundarios.
Objetivo: Determinar la respuesta inflamatoria y el nivel de ácido láctico inducidos por ejercicio físico exhaustivo después de la ingesta de soja en modelo animal.
Materiales y método: Se emplearon treinta ratas macho de raza Sprawley dawley de 180 a 200 g, sanos divididos en tres grupos: sedentario (C), con ingesta de soja a prueba (E+TP) y sin ingesta de soja a prueba (E). Los grupos E+TP y E, realizaron la prueba Morris Water Maze Test. Se determinaron marcadores inflamatorios como factor de necrosis tumoral alfa (TNF-a), interleuquina 1 beta (IL-1β), interleuquina 6 (IL-6) en plasma mediante técnica ELISA, enzima ciclooxigenasa 2 (COX-2), óxido nítrico sintaza (iNOS) y como marcador antiinflamatorio Receptor gamma activado por proliferador de peroxisoma (PPAR-γ), el cual, se midió en músculos cuádriceps mediante técnica de Western-blot y se midió el ácido láctico en sangre.
Resultados: Se obtuvo una disminución significativa en plasma de los niveles inflamatorios de TNF-α (600 vs 350 pg/ml), IL-1β (450 vs 150 pg/ml), e IL-6 (480 vs 100 pg/ml), COX-2 (52 vs 25 RDU) e iNOS (58 vs 8 RDU) en el grupo E+TP en comparación con el grupo E. Además se observó un aumento de la expresión de la proteína PPAR-γ (18 vs 65 RDU) en el grupo E+TP en comparación con el grupo E. Respecto a las mediciones de ácido láctico los grupos obtuvieron valores máximos de: E:35, C:22 y E+TP:28 Mmol/Lactato, lo cual, indica que el grupo E y E+TP a pesar que se sometieron a la misma prueba, los niveles de ácido láctico son heterogéneos.
Conclusión: La ingesta de soja mitiga los niveles de ácido láctico y de marcadores inflamatorios inducidos por el ejercicio fisico exhautivo en modelo animal.

Palabras clave:
Inflamación. Ácido láctico. Soja. Ejercicio. Exhaustivo.

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Introduction

Scientific evidence links the beneficial effects of soy consumption with decreased oxidative stress after exercise. Similarly, soy supplementation combined with moderate exercise could have a beneficial effect on the lipid profile in ovariectomised rats. In this context, it is worth considering that exhaustive endurance exercise may be associated with physiological responses through markers which determine peripheral inflammatory activation as an immune response to protect and stabilise homeostasis[1,2]. In response to inflammation, circulating cytokines like TNF-α, IL-6, IL-10 and IL-1β increase following exercise, evidenced in high-intensity exercise chiefly in the form of muscle and organ damage, and suppression of the immune barrier[3-5].

To reduce the inflammatory damage caused, nonsteroidal anti-inflammatory drugs (NSAIDs), among the drugs the World Health Organization (WHO) promotes for their analgesic, anti-inflammatory and antiplatelet effects, have been used6. Given that exercise is the gradual summation of physical stimuli, the use of substances such as NSAIDs in endurance sports is evident[7], as seen from their use at the 2007 Pan American Games[8] and the Sydney 2000 Summer Olympics[9,10]. However, it should be noted that taking NSAIDs is related to a deterioration of the renal and digestive systems, and cardiovascular problems such as hypertension[11-13].

Meanwhile, natural substances are available which possess antioxidant and anti-inflammatory properties, such as the flavonoids found in fruits, vegetables and seeds, natural compounds known as nutraceuticals, phytonutrients or phytochemicals[14,15]. These include phenolic compounds, isothiocyanates, terpenoids, alkaloids, polyunsaturated fatty acids and flavonoids, metabolite subgroups with anti-inflammatory functions[16-20].

One of these substances is found in soy, which is rich in flavonoids and shows beneficial effects for the health through isoflavones and proteins that are potentially effective for human health and the prevention of various chronic diseases due to their anti-inflammatory effect[21,22].

Materials and methods

Sample

Experimental study conducted on thirty 12-month-old Sprawley Dawley rats belonging to the laboratory of the University of Valencia (Spain) with an average weight of 190 g, bred and kept in hygienic conditions with controlled temperature, humidity and light/dark cycle (12/12 hours), in compliance with regulations (Directive 86/609/EEC, OJ L358.1, 12 December 1987 and the National Institutes of Health's Guide for the Care and Use of Laboratory Animals, NIH. Publ. No. 85-23, 1985) and with the approval of the institution's ethical committee (AP-073/09).

Procedure

The necessary measures were taken to minimise the pain and discomfort of the laboratory animals. 3 groups were used, each consisting of n: 10, with the following intervention: control group (C), soy intake group and performance of the Morris Water Maze task[23] (E+TP) and group without soy intake with intervention (E). The three groups performed the Morris Water Maze task without prior training and with a proportional increase of 35% gravitational body weight, showing average lactate levels of 28 mmol/lactate, an indicator of exhaustive effort through quasi submersion in water[24]. The group with soy intake was given 0.5 g per kilogram of body weight. All the rats used in the experiment were euthanised immediately after the Morris Water Maze procedure.

Measurements

Inflammatory markers were measured: tumour necrosis factor alpha (TNF-a), interleukin 1β (IL-1β) and interleukin 6 (IL-6) in plasma using ELISA, and cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS) in soleus using the western blot technique. The anti-inflammatory marker peroxisome proliferator-activated receptor gamma (PPAR-γ) and lactic acid in plasma were also measured.

Statistical analysis

The values were expressed as mean±SD. Parametric normality tests were applied. Differences between groups were evaluated by one-way ANOVA for independent samples. Statistical significance was accepted at $p \leq 0.05$. The data sets in which F was significant were examined by a modified t- test.

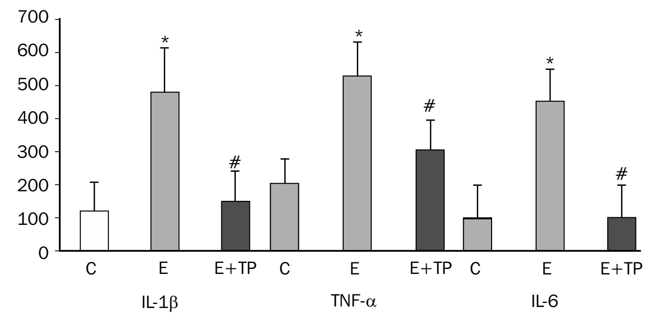
Results

The results showed a significant decrease in the E+TP group compared to the E group in inflammatory levels of TNF-α, IL-1β and IL-6 in plasma (Figure 1), and the expression of COX-2 and iNOS proteins (Figure 2), along with an increase in the expression of the PPAR-γ protein (Figure 3). The inflammation values of the E+TP group were similar to those of group C. Lactic acid levels decreased with soy intake (Figure 4).

Discussion

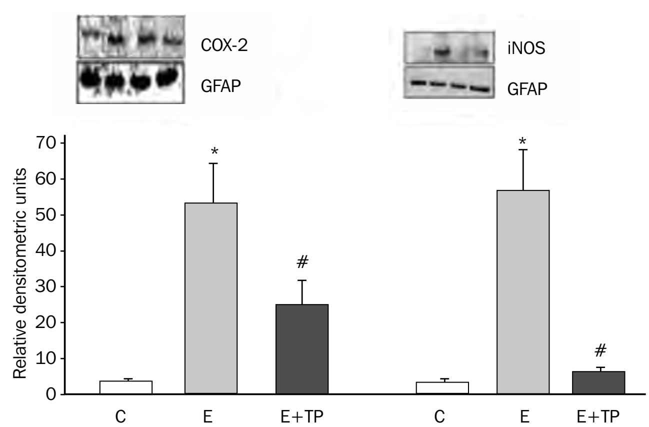
Muscle damage is evident due to the incidence of physical exercise. Different studies have identified an increase in creatine kinase (CK) in both older and younger individuals[25,26]. In our study, we observed higher levels of lactic acid when the Morris Water Maze procedure adapted with an increase in gravitational weight was performed. In this context, the oxidative balance of the human body is essential for metabolic regulation, the production of metabolic energy, the activation and inactivation of biomolecules, signal transduction, cell turnover and control of vascular tone, among other things. If this equilibrium between the oxidising systems (reactive species generators) and antioxidants is thrown off balance in favour of the former, by excessive production of

Figure 1. Levels of interleukin 1β (IL-1β), tumour necrosis factor alpha (TNF-α) and interleukin 6 (IL-6) (pg/ml) in plasma.



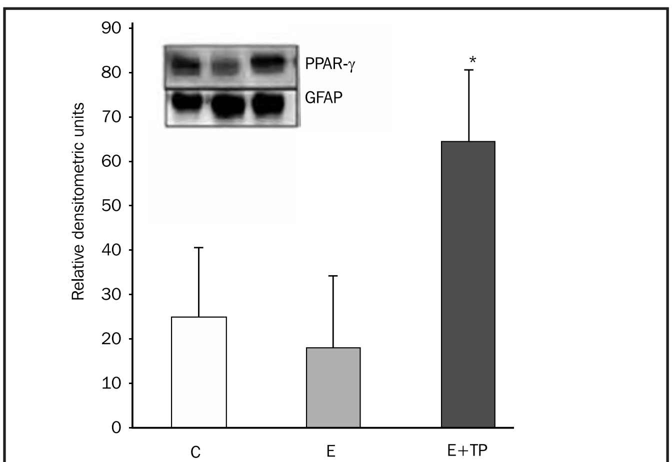
*p<0.05 vs control. #p<0.05 vs E+TP.

Figure 2. Protein expression of cyclooxygenase-2, COX-2 and inducible nitric oxide synthase (iNOS) (RDU) in quadriceps muscles.



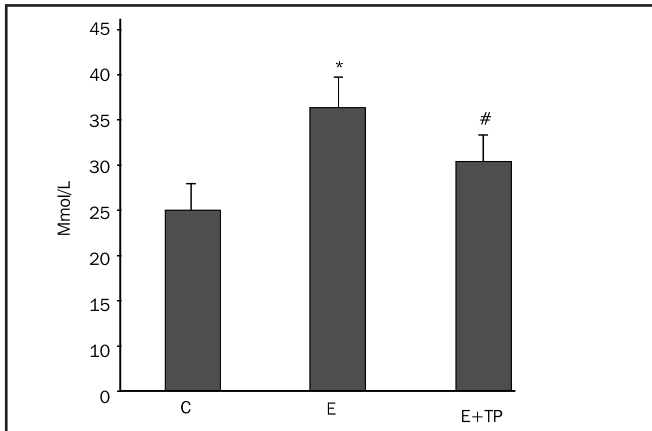
*p<0.05 vs control. #p<0.05 vs E+TP.

Figure 3. Levels of peroxisome proliferator-activated receptor gamma (PPAR-γ) (pg / ml) in plasma.



*p<0.05 vs control. #p<0.05 vs E+TP.

Figure 4. Lactic acid levels in plasma.



*p<0.05 vs control. #p<0.05 vs E+TP.

ROS and RNS, the weakening of the antioxidant systems is related to inflammation[27].

It is evident that free radicals play an important role as mediators of muscle damage and inflammation caused as a result of strenuous exercise. It is suggested that the generation of oxygen free radicals increases during exercise as a result of the increase in mitochondrial VO_2 and the greater flow of electrons in the transport chain due to a greater production of lactic acid and even the redistribution of blood flow that occurs in exertions of this kind[28].

Scientific evidence suggests that trained subjects show a greater overall antioxidant capacity than untrained subjects as a result of muscular endurance adapting to training, given that increased oxygen consumption would cause a greater increase in cell damage, which is offset by the higher antioxidant status of these subjects[29]. To help reduce this metabolic stress, some have proposed supplements to enhance the antioxidant defences of the system, but "those who consume more vegetables may naturally have an improved antioxidant defence system" without pills to counteract the oxidative stress induced by exercise, due to this increased amount[30]. This represents evidence consistent with the results of our study, which aimed to show the implication of soy for inflammatory levels through experimentation. It can be considered that plant foods are on average 64 times more antioxidant than meat and indeed contemplate a greater intake of foods which provide phytonutrients[31].

It is necessary to take into account fundamental mitigators such as the muscle damage caused by exercise, which has been widely documented. The sensation of pain and discomfort after moderate or exhaustive exercise is a product of muscle action and is compounded with greater eccentric actions, maximum intensity appearing between 24 and 48 hours after carrying out the physical activity[32]. From this perspective, our study establishes this biochemical condition, which is part of the preliminary hypothesis, in consideration of soy as an inhibitor of inflammatory processes shown in the sustained sample[33].

Vitamins C and E have been used to alleviate delayed onset muscular soreness (DOMS). Thompson *et al.* (2001) gave 16 men vitamins supplements (C and E) 14 days before causing muscle damage with intermittent running, showing that supplementation has beneficial effects, unlike Beaton *et al*. (2002), who gave 18 athletes the same vitamin supplements 30 days before the exercise. With their protocol, similar to the one used by Thompson *et al.,* Silva *et al*. (2010) concluded that supplementation with these vitamins plays an important role in the defence against DOMS and oxidative stress[34].

Connolly et al. (2006) concluded that drinking cherry juice before and after eccentric exercise reduced the symptoms of damage and aided recovery, which is relevant for comparison with the data thrown up by our study, a comparison which leads to consideration of a relationship between the two and ultimately identification of soy as an inhibitor of inflammatory processes[35,36].

It is concluded that exposure to the consumption of polyphenols promotes recovery from the muscle damage, inflammation and oxidative stress induced by exercise due to their immune response to inflammatory processes. The results of this study are consistent with those previously named, so justification by means of comparative studies is effective when it comes to accepting the prior hypothesis and a decrease in the expression of COX-2 and iNOS proteins ($p < 0.05$) is observed in group E+TP compared to group E. Group E+TP gives values similar to those of group C and shows an increase in the expression of the PPAR-γ protein ($p < 0.05$) compared to group E. E+TP gives values similar to those of group C.

Regarding the limitations of the study, we suggest that experiments be conducted with different tests to determine exhaustive exercise and that the supplementation be altered to include other substances in such a way as to question the effects on the inflammatory response.

Conflict of Interests

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

Bibliography

1. Suzuki K. Exhaustive exercise-induced neutrophil-associated tissue damage and possibility of its prevention. *J. Nanomed. Biother. Discov.* 2017;7:156.
2. Stawski R, Walczak K, Kosielski P, Meissner P, Budlewski T, Padula G, *et al.* Repeated bouts of exhaustive exercise increase circulating cell free nuclear and mitochondrial DNA without development of tolerance in healthy men. *PLoS ONE*. 2017;12:e0178216.
3. Suzuki K. Cytokine Response to exercise and its modulation. *Antioxidants*. 2018;7:7.
4. Suzuki K, Nakaji S, Yamada M, Totsuka M, Sato K, Sugawara K. Systemic inflammatory response to exhaustive exercise: cytokine kinetics. *Exerc. Immunol. Rev.* 2002;8:6-48.
5. Peake J, Wilson G, Hordern M, Suzuki K, Yamaya K, Nosaka K, *et al.* Changes in neutrophil surface receptor expression, degranulation, and respiratory burst activity after moderate- and high-intensity exercise. *J Appl Physiol.* 2004;97(2):612-8.
6. Pablo-López de Abechuco I, Gálvez-Múgica M, Rodríguez D, Rey J M Del, Prieto E, Cuchi M, *et al.* Uso de antiinflamatorios no esteroideos y monitorización de la función renal: Estudio piloto en un centro de salud de Atención Primaria. *Nefrología Madr.* 2012;32:777-81.
7. Alaranta A, Alaranta H, Helenius I. Use of prescription drugs in athletes. *Sports Med.* 2008;38:449-63.
8. Da Silva ER, De Rose EH, Ribeiro JP, Sampedro LB, Devos, DV, Ferreira AO, *et al.* Nonsteroidal anti-inflammatory use in the XV Pan-American Games (2007). *Br J Sports Med.* 2011;45:91-4.
9. Corrigan B, Kazlauskas R. Medication use in athletes selected for doping control at the Sydney Olympics (2000). *Clin J Sport Med*. 2003;13:33-40.
10. Huang SH, Johnson K, Pipe AL. The use of dietary supplements and medications by Canadian athletes at the Atlanta and Sydney Olympic Games. *Clin J Sport Med.* 2006;16:27-33.
11. Maroon J C, Bost J W, Maroon A. Natural anti-inflammatory agents for pain relief. S*urg Neurol Int*. 2010;1:80.
12. Chavez Gallardo A, Mallaopoma Soriano F. Consumo de antiinflamatorios no esteroideos y su relación con alteraciones gastrointestinales en población adulta del distrito de Huancayo. [tesis doctoral] Huancayo: Servicio de Publicaciones, Universidad Roosevelt. 2018. Disponibel en: http://repositorio.uroosevelt.edu.pe/xmlui/bitstream/handle/ROOSEVELT/90/Consumo%20de%20antiinflamatorios%20no%20esteroideos%20y%20su%20relaci%C3%B3n%20con%20alteraciones%20gastrointestinales%20en%20poblaci%C3%B3n%20adulta%20del%20distrito%20de%20Huancayo.pdf?sequence=1&isAllowed=y
13. Candia-Luján R, de-Paz-Fernández J A. ¿Son efectivos los antiinflamatorios no esteroides en el tratamiento del dolor muscular tardío? *Ciencia UAT*. 2014;9:76-83.
14. Jayarathne S, Koboziev I, Park O, Oldewage-Theron A, Shen C, Moustaid-Moussa N. Anti-inflammatory and anti-obesity properties of food bioactive components: Effects on adipose tissue. *Prev Nutr Food Sci.* 2017;22:251-62.
15. Min-Hsiung P., Ching-Shu L., Chi-Tang H. Anti-inflammatory activity of natural dietary flavonoids. *Food Funct*. 2010;1:15-31.
16. Caballero-Gutiérrez L, Gonzáles GF. Alimentos con efecto antiinflamatorio. *Acta Med Peru.* 2016;33:50-64.
17. Bellik Y, Hammoudi SM, Abdellah F, Iguer-Ouada M, Boukraâ L. Phytochemicals to prevent inflammation and allergy. *Recent Pat Inflamm Allergy Drug Discov.* 2012;6:147-58.
18. Young-Joon S. NF-κB and Nrf2 as potential chemopreventive targets of some anti-inflammatory and antioxidative phytonutrients with anti-inflammatory and antioxidative activities. *Asia Pac J Clin Nutr.* 2008;17(S1):269-72.
19. Pinazo MD, Boscá L. Propiedades antiinflamatorias de los ácidos grasos poliinsaturados omega-3. Indicaciones en oftalmología. *Arch Soc Esp Oftalmol.* 2012;87:203-5.
20. Salminen A, Kauppinenc A, Kaarniranta K. Phytochemicals suppress nuclear factor-kB signaling: impact on health span and the aging process. *Curr Opin Clin Nutr Metab Care.* 2012;15:23-8.
21. Ganesan K., Xu B. A critical review on polyphenols and health benefits of black soybeans. *Nutrients*. 2017;9:455.
22. Wang Q, Ge X, Tian X, Zhang Y, Zhang J, Zhang P. Soy isoflavone: The multipurpose phytochemical. *Biomed Rep*. 2013;1:697-701.
23. Morris RGM. Spatial localization does not require the presence of local cues. *Learn Motiv.* 1981;12:239-60.
24. Zoremba N, Homola A, Rossaint R, Syková E. Interstitial lactate, lactate/pyruvate and glucose in rat muscle before, during and in the recovery from global hypoxia. *Acta veterinaria Scandinavica.* 2014;56:72.
25. Bouzid M A, Hammouda O, Matran R, Robin S, Fabre C. Changes inoxidative stress markers and biological markers of muscle injury with aging at rest and in response to an exhaustive exercise. *PLoS One.* 2014; 9, e90420.
26. Marnett L. Lipid peroxidation—DNA damage by malondialdehyde. *Mutat Res.* 1999;424:83-95.
27. Sánchez I, Torres V, Moreno O, Rodríguez A. Determinación del estrés oxidativo mediante peroxidación lipídica en cristalinos humanos con cataratas. *MedULA*. 2011;20:42-5.
28. Gerecke KM, Kolobova A, Allen S, Fawer JL. Exercise protects against chronic restraint stress-induced oxidative stress in the cortex and hippocampus. *Brain Res.* 2013;1509:66-78.
29. Matheus NJ, Mendoza CA, Meléndez C, Flores CA, Corro AC, Medina IC, *et al.* Entrenamiento aeróbico: efecto sobre el estado oxidativo hepático. *Rev Int Cienc Deporte.* 2016;12:309-23.
30. Fogarty M C, Hughes C M, Burke G, Brown J C, Davison G W. Acute and chronic watercress supplementation attenuates exercise-induced peripheral mononuclear cell DNA damage and lipid peroxidation. *Br J Nutr.* 2013;109:293-301.

31. Neubauer O, Yfanti C. Antioxidants in athlete´s basic nutrition: considerations towards a guideline for the intake of vitamin C and vitamin E. En: Lamprecht M, Editor. *Antioxidants in sport nutrition.* 1a ed. Florida: CRC Press; 2015. p. 52-79.

32. Bubbico A, Kravitz L. Eccentric exercise. *IDEA Fitness Journal* [Internet] 2010 [cited 2019 March 26]; 7, 50-9. Available: http://www.unm.edu/~lkravitz/Article%20folder/eccentricUNM.html

33. Armstrong RB, Ogilvie RW, Schwane JA. Eccentric exercise-induced injury to rat skeletal muscle. *J Appl Physiol Respir Environ Exerc Physiol.* 1983;54:80-93.

34. Beaton D, Bombardier C, Guillemin F, Ferraz M. Recommendations for the cross-cultural adaptation of health status measures. *Am Acad Orthop Surg*. 2002;12:1-9.

35. Moreira O, Oliveira C, Luján R, Romero-Pérez E, de Paz JA. Métodos de evaluación de la masa muscular: una revisión sistemática de ensayos controlados aleatorios. *Nutr Hosp*. 2015;32:977-85.

36. Connolly DAJ, McHugh MP, Padilla-Zakour OI. Efficacy of a tart cherry juice blend in preventing the symptoms of muscle damage. *Br J Sports Med.* 2006;40:679-83.

Original article

Association between the intermittent recovery Yo-Yo test and a high-intensity intermittent exercise on Argentinian rugby players

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Summary

Introduction: Yo-Yo level 1 intermittent recovery test (YYrec-1) is widely used in team sports, as a measure of high intensity efforts ability. The objective of this study was to relate the performance in YYrec-1 and in an intermittent high intensity run to the fatigue, in amateur rugby players.
Material and method: 26 rugby players with an average 19,3±1,8 years old from the Unión Rugby de Cuyo league were measured 2 times. In the first session, anthropometric measures and YYrec-1 were taken. In the second, players performed a running change of direction protocol (10" work/10" pause) at 100% speed reached individually in YYrec-1 (Int-10x10). The subjects rested four day between both sessions.
Results: in the YYrec-1 final speed was 15,1±0,5 km•h-1 and the accumulated distance 1102,3±342,0 meters. The Int-10x10 results were: 39,6±18,6 repetitions, 1653,1±746,0 meters y 791,5±371,4 seconds. Correlations between YYrec-1 final speed and Int-10x10 variables were: r=0,32 with the accumulated repetitions, r=0,25 with the accumulated meters and r=0,32 with the accumulated time (sec). Correlations between accumulated meters in YYrec-1 and Int-10x10 were: r=0,20 for the accumulated repetitions, r=0,13 for the accumulated meters and r=0,20 for accumulated time.
Conclusion: In this group of amateur players, indicators of performance in YYrec-1 weren´t related with indicators used for explain performance in Int-10x10 exercise.

Key words:
Yo-yo intermittent recovery test level 1. 20 m shuttle run test. Intermittent exercise. Intermittent training. Change of directions. Team sports.

Asociación entre el test Yo-Yo de recuperación intermitente y un ejercicio intermitente de alta intensidad en jugadores argentinos de rugby

Resumen

Introducción: El test Yo-Yo de recuperación intermitente nivel 1 (YYrec-1) es ampliamente utilizado en los deportes de conjunto, para medir la capacidad de repetir esfuerzos de alta intensidad. El objetivo de este estudio fue relacionar el rendimiento entre el YYrec-1 y una carrera intermitente de alta intensidad en jugadores amateur de rugby.
Material y método: 26 jugadores de rugby con una edad promedio 19,3±1,8 pertenecientes a la liga Unión Rugby de Cuyo fueron medidos en 2 sesiones. En la primera sesión se realizaron mediciones antropométricas y se aplicó el YYrec-1. En la segunda sesión realizaron carreras de 10 segundos con un cambio de dirección separadas por 10 segundos de pausa, al 100% de la velocidad individual hasta la fatiga (Int-10x10). Entre las sesiones hubo un descanso de cuatro días.
Resultados: en el YYrec-1 la velocidad obtenida fue 15,1±0,5 km•h^{-1} y la distancia acumulada 1102,3±342,0 metros. En el Int-10x10 se obtuvo 39,6±18,6 repeticiones, 1653,1±746,0 metros y 791,5±371,4 segundos. Las correlaciones entre la velocidad alcanzada del YYrec-1 y las variables del Int-10x10 fueron; r=0,32 para las repeticiones acumuladas, r=0,25 para los metros acumulados y r=0,32 para el tiempo acumulado. Entre los metros acumulados del YYrec-1 y el Int-10x10 se obtuvo; r=0,20 para las repeticiones acumuladas, r=0,13 para los metros acumulados y r=0,20 para el tiempo acumulado.
Conclusión: En este grupo de jugadores *amateurs*, no se encontró relación entre las variables que explican el rendimiento en el YYrec-1, con las utilizadas para explicar el rendimiento en el Int-10x10.

Palabras clave:
Test yoyo de recuperación intermitente nivel 1. Test de ir y volver en 20 metros. Ejercicio intermitente. Cambio de dirección. Deportes de conjunto.

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Introducción

Traditionally, physical coaches have used maximum oxygen consumption (VO_2max) to monitor the aerobic performance of their athletes[1]. This concept was later replaced by maximum aerobic speed (MAS) measured directly[2] or estimated from the final speed achieved (FSA) with an indirect field test[3,4].

However, in team sports there is a strong trend towards assessing aerobic performance using an incremental and intermittent test with a rest, based on the 20m-SRT[5]. For example: interval shuttle run test[6], level 1 and 2 intermittent resistance Yo-Yo test, level 1 and 2 intermittent recovery Yo-Yo test[7,8], the 30-15 intermittent fitness test[9], the Carminatti test[10], FOOTEVAL test[11], 45-15 test[12], intermittent Andersen test[13], among others.

From the tests mentioned, in greater measures, literature recommends the level 1 intermittent recovery Yo-Yo test (YYrec-1)[14-22]. This test aims to measure the ability to repeat high-intensity intermittent efforts and/or the capacity to recover from this kind of exercise[14]. For this reason, its validity and applicability has been studied in various team sports; basketbal[l15,16], football[7,17], rugby union[18], rugby league[19], handball[20], Australian football[21], seven-aside rugby[22] among other team sports.

The validity of YYrec-1 is based on the association obtained between the metres accumulated in the YYrec-1 and the total match performance (total metres covered) and/or the metres covered at high intensity (races over 15.0 km•h^{-1})[14]. The relationships obtained are between r=0.70 and r=0.77 for football[14], r=0.88 for handball[20], and r=0.77 for basketball[15]. These studies assume that the gold method used to assess intermittent effort, is the performance obtained in one or various matches. This way of validating YYrec-1 means we can dispose of the traditional tests that estimated VO_2max and MAS.

On the other hand, other studies have obtained similar correlations using different, non-intermittent tests; Rampini *et al,* observed a correlation of r=0.65 in professional football players between the FSA and the UMTT and the metres covered at high intensity during the match (+14.4 km•h^{-1}), and r=0.64 with the metres covered at very high intensity (+19.8 km•h^{-1})[23]. Castagna *et al* (2010), applied the 20m-SRT and the YYrec-1 on elite football players, obtaining similar correlations to performance in a match; with r= 0.76 for the 20m-SRT and r= 0.74 for the YYrec-1[24]. Buchheit *et al,* applied the MAS-EVAL test on academy footballers and they found r=0.70 between the metres covered at extremely high intensity (+19.0 km•h^{-1}) and field MAS[25]. Swaby *et al*, applied a continuous test of 1,200 metres to professional rugby players and they obtained r=0.75 with the total distance of a rugby match[26].

As shown in mentioned studies, the performance obtained in any of the aerobic tests used, whether intermittent or not, is linked to performance in a match[14,20,22-26]. Therefore, if the strength of the YYrec-1 is associated to this paradigm, other tests, that are not intermittent in nature, should be considered and not assigned exclusively to the YYrec-1.

The study by Swaby[26] is the only study - for now - to associate match performance with an aerobic test. However, the study did not consider high intensity runs. To date, we have not found any studies that associate performance in a rugby match with the performance achieved in the YYrec-1. For this reason if the aim of the YYrec-1 is to find the subjects that tolerate high-intensity effort[14] the best, a simple way of checking this would be to link the YYrec-1 performance with an exercise in which the real capacity of tolerance to this type of effort can be counted, such as, for example; intermittent running protocol with intra-exertion rests, a commonly used method by team sport coaches[2-3]. Based on the above, this study aims to observe the relationship between the performance indicators achieved in the YYrec-1 and the capacity to perform during intermittent exertion till exhaustion (10 seconds of work with 10 seconds of rest) at 100% of the YYrec-1 speed, among 1st division amateur rugby players.

Material and method

Design and study sample

The study had a cross-cutting and non-probabilistic correlational design. The players were chosen for their availability. The assessments were performed at the club during normal training hours between 20:00 and 21:00 (evening), during the post-season phase (2 weeks after finishing the annual championship). Measurements were taken over 2 sessions. In the first session, anthropometric measurements were taken, and the YYrec-1 test was applied. In the second session, high-intensity intermittent exercise was applied (100% of the speed achieved in the YYrec-1) to exhaustion, with direction change (50% of the distance out and 50% of the distance back). There was a 4-day rest period between the 1st and 2nd sessions. In all the assessments, the subjects wore the same clothing (t-shirt and shorts) and footwear (boots). On-field assessments were carried out on a grass pitch. The subjects did not perform any exercise in the 48 hours prior to the tests.

Subjects

26 rugby players belonging to the Cuyo Rugby Union were recruited for this study. All the players were aged between 18 and 25 years. The following were excluded from the study: a) minors aged under 18 years, b) subjects with any kind of neuromuscular injury and/or cardiorespiratory disease, and c) less than 3 years of experience as a club player. Before signing the informed consent, the subjects were notified verbally and in writing about the procedures, the benefits and the risks of participating in this study.

Procedures

Anthropometrics: Body mass and standing height were measured. The measurements were carried out in accordance with the International Society for the Advancement of Kinanthropometry[27]. Body Mass Index (BMI) was calculated by dividing the subject's body weight by the height expressed in square metres.

Level 1 intermittent recovery Yo-Yo test (YYrec-1): This consists in running for as long as possible between two lines separated by 20 metres, out and back, with a 10-second pause every 40 metres. The running pace is marked by a beeping sound. The subject must step behind the 20 m line with one foot at the same time as the beep sounds. The test ends when the subject stops due to exhaustion or when he/she fails twice consecutively to step over the line before the beep sounds. The total distance covered is used to assess the subject's performance, despite the stage not being completed[14]. The final speed achieved (FSA) was also registered, even though the final stage had not been completed. Before starting the test, the subjects performed a 5-minute warm up, which consisted in joint mobility, and low-intensity running. All the players were familiarised with this test.

High-intensity intermittent exercise with 180º direction change (Int-10x10): the exercise consisted in running for 10 seconds with 1 direction change (5 seconds out, 5 seconds back) at 100% of the FSA of the YYrec-1, with a 10-second passive rest. The work-rest ratio was 1:1. The exercise was performed till exhaustion, determined in the following ways: a) when subjects stopped because they could no longer keep running, or b) because on two consecutive occasions they did not make the distance in time. The intensity used was the FSA of the final stage of the YYrec-1 (complete or incomplete)[14]. This work mode based on the YYrec-1 can be observed in various studies and trainers[28-30]. A beep was used to mark the work pace and rest. Each player had an individual track marked out with the corresponding distance. Example: for the subject that reached the speed of 15.0 km•h^{-1} in the YYrec-1, there is a corresponding 10-second run of 41.7 metres, in two stretches of 20.8 metres.

Statistical analysis

The data was analysed using the statistics package (SPSS) 22.0. Beforehand, the Kolmogorov-Smirnov test and the Levene test were performed to corroborate the presence of normality and homoscedasticity in the study sample. Next, descriptive statistics were applied to calculate the frequencies, average, standard deviation and confidence interval. To establish the statistically significant differences between the positions (forwards and backs), the ANOVA one-way parametric test was used for the YYrec-1. To establish the differences between the positions in the Int-10x10, the non-parametric Mann-Whitney U test was applied, as normality was not observed. The relationship between the YYrec-1 and the intermittent exercise was calculated using the Pearson correlation coefficient, with the following criteria: 0.1 very low; 0.1-0.3, low; 0.3-0.5, moderate; 0.5-0.7, good; 0.7-0.9, very good; and 0.9-1.0, perfect[31]. The Spearman Rho rank correlation coefficient was applied between the positions occupied by each player in each of the variables (YYrec-1 and Int-10x10). In all cases, an alpha level of $p<0.05$ was accepted.

Results

Table 1 describes the physical characteristics of the rugby players and the field test performances.

In the YYrec-1 the confidence interval was 14.9-15.3 km•h^{-1} for the speeds reached and 972-1,239 metres for the accumulated distances.

In the Int-10x10 the confidence interval was 33-46 for the repetitions achieved, 1,391-1,929 metres for the accumulated distance and 661-932 seconds for the accumulated time.

Table 1. Anthropometric and field values.

Variables	Average ± SD All (n= 26)	Average ± SD Backs (n= 13)	Average ± SD Forwards (n= 13)	p>
Descriptive data				
Age (years)	19.3 ± 1.8	19.6 ± 2.4	18.9 ± 0.9	Ns
Height (m)	1.74 ± 0.07	1.71 ± 0.07	1.77 ± 0.05	0.05
Body Mass (Kg)	72.5 ± 11.6	65.10 ± 8.04	80.1 ± 9.7	0.05
BMI (kg•m^2)	24.0 ± 3.4	22.3 ± 2.2	25.6 ± 3.6	0.05
YYrec-1				
Speed (km•h-1)	15.1 ± 0.5	15.5 ± 0.5	14.8 ± 0.4	0.001
Accumulated Distance (m)	1102.3 ± 342.0	1301.5 ± 290.1	903.1 ± 271.3	0.001
Intermittent exercise 10x10				
Repetitions (no.)	39 ± 18	32.1 ± 8	47 ± 23	Ns
Distance (m)	1653.1 ± 746.0	1383.8 ± 357.6	1922.5 ± 935.1	Ns
Time (s)	791 ± 371	643 ± 160	940 ± 462	Ns

p: significant differences between Backs and Forwards.
BMI: Body Mass Index.

Significant differences were observed between forwards and backs in height, body weight, BMI, speed achieved and accumulated distance in the YYrec-1 (p<0.05)

Table 2. Correlations obtained.

	Exercise Intermittent 10x10 (rep)	Exercise Intermittent 10x10 (m)	Exercise Intermittent 10x10 (s)
All (n= 26)			
YoYo rec-1 (km•h-1)	-0.32	-0.25	-0.32
YoYo rec-1 (m)	-0.20	-0.13	-0.20
Backs (n= 13)			
YoYo rec-1 (km•h^{-1})	0.28	0.38	0.28
YoYo rec-1 (m)	0.39	0.48*	0.39
Forwards (n= 13)			
YoYo rec-1 (km•h^{-1})	-0.30	-0.25	-0.30
YoYo rec-1 (m)	0.05	0.07	0.05

* p< 0.05 significant correlation.
rep: repetitions. m: metres. s: seconds

Differences were not observed in the amount of repetitions, the work time and the metres accumulated in the Int-10x10.

Table 2 displays the correlations obtained between the performance of the YYrec-1 and the Int-10x10. The correlations were not significant except when the analysis was performed separately by positions, in which the backs obtained a low but significant correlation between the metres covered in the YYrec-1 and in the Int-10x10.

The correlations obtained between the BMI and the YYrec-1 were as follows: r=0.43 for the speed of the YYrec-1, and r=0.40 for the metres accumulated. Between the BMI and the Int-10x10 they were: r=0.23 in the repetitions accumulated, r=0.19 for the metres accumulated, and r=0.23 for the time accumulated.

Figure 1 displays a dispersion graph with 3 axes. Axis "y" shows the metres accumulated in the Int-10x10. The double "x" axis shows the metres accumulated in the YYrec-1 and the speed of the stage to which it belongs. The dotted vertical lines describe the start of one stage and the end of the other. This double x axis was graphed with the aim of reflecting how in a single stage, the participants accumulate different metres, given that the YYrec-1 takes into account incomplete stages.

Figure 1. Relationship between the Int-10x10 and the YYrec-1. White circles: Forwards (n= 13). Black circles: Backs (n= 13).

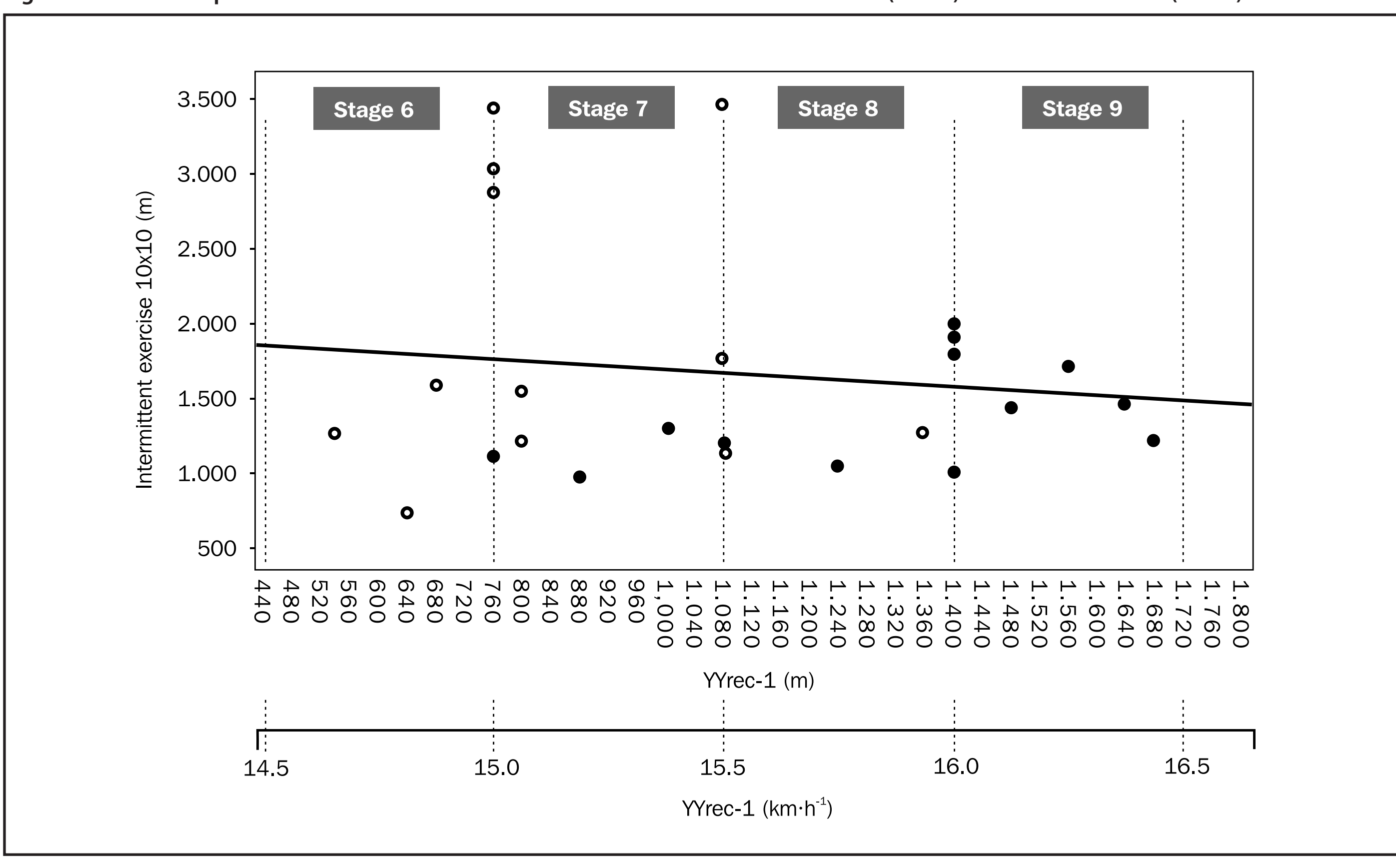

Table 3. Position of each player, depending on performance in the YYrec-1 and the Int-10x10.

Player	Position based on YYrec-1 (m)	Int-10x10 (m)
1	15th	1st
2	23rd	2nd
3	21st	3rd
4	22nd	4th
5	5th	5th
6	6th	6th
7	8th	7th
8	9th	8th
9	13th	9th
10	3rd	10th
11	24th	11th
12	18th	12th
13	2nd	13th
14	4rd	14th
15	16th	15th
16	10th	16th
17	26th	17th
18	19th	18th
19	1st	19th
20	12th	10th
21	14th	21st
22	20th	22nd
23	11th	23rd
24	7th	24th
25	17th	25th
26	25th	26th

YYrec-1: Level 1 intermittent recovery Yo-Yo test. Int-10x10: non-linear intermittent exercise of 10 s of work and 10 s of rest. m: metres accumulated.
(Spearman's Rho = 0.03).

Discussion

The main study finding was the observation of a weak relationship between the YYrec-1 performance and performance of the Int-10x10 in this group of amateur rugby players. The subjects that accumulated greater distances in the YYrec-1 were not those that performed better in the Int-10x10 (Figure 1). Taking into account the objective proposed by Bangsbo[14], these results generate certain confusion; in theory the subjects who obtained the highest performance in the YYrec-1, should present a greater capacity in this kind of effort. To gauge a deeper understanding of this point of discussion, Table 3 displays all the cases ordered from highest to lowest performance achieved in the Int-10x10 (metres accumulated).

It can be observed that the player who accumulated the most metres in the Int-10x10 came in 15th place in the YYrec-1 (m). Likewise, the subject who performed the best in the YYrec-1 (m) came in 19th position in the Int-10x10. There may be various reasons behind this disparity between performance, mentioned below.

Greater dispersion was observed in the Int-10x10 values compared to those of the YYrec-1. This can be seen in Figure 1, in the confidence interval described. The physical conditions of the players can also influence the test performance. Various players could not complete the sixth stage of the YYrec-1 (Figure 2).

The first 5 stages are considered specific to the warm up, and from the sixth stage the test is started; accumulating 320 metres per stage (8 x 40 metres)[14]. Even so, these players could cover similar or greater distances in the Int-10x10, compared to other players that achieved higher stages in the YYrec-1. This can be seen in Figure 1. This disparity between performances in the two tests is due to the fact we are measuring and comparing two different concepts. YYrec-1 has the following characteristics: it is a progressive, maximum test, performed to exhaustion, with an out and back route of 20 metres (similar to 20 m-SRT), discontinuous (rest every 40 metres), and the speed increases every 320 metres (8x40 metres). In any case, it still remains a test that, given its protocol, is similar to aerobic power tests. For this reason, various studies have discovered similar correlations between performance in a match with other field tests like the YYrec-1[23-25]. Confusion occurs when Bangsbo expresses that YYrec-1 measures capacity[14]. By capacity we understand the total capacity of available energy in a metabolism given to a specific speed[32]. An example of this is the time limit, which measures the work capacity (aerobic resistance) to a percentage of the MAS continuously. First the MAS (incremental test) is located, then the time limit is measured (resistance test). Between these two variables (MAS and time limit), the correlations are moderate to weak[32]. The same occurs in our study; the YYrec-1 represents the incremental test, and the Int-10x10 represents the aerobic capacity to tolerate intermittent work, at a stable speed.

We were unable to find an identical study to ours in literature, applied to rugby players. In any case, there are two studies that we feel are worth discussing, as they share the same objective. Dupont et al, directly measured the aerobic performance of amateur footballers using a portable gas analyser, with two field tests; the UMTT and the YYrec-1[33]. Next, an intermittent running exercise was applied until exhaustion, which consisted in running in a straight line for 15 seconds with a 15 second rest (Int-15x15), at the same speed for all the footballers: 21.0 km•h^{-1}. The authors discovered an r=0.76 between the MAS of the UMTT and the time accumulated in the Int-15x15 and r=0.74 between the speed of the YYrec-1 and the time accumulated in the Int-15x15. It was concluded that the speed of both tests was related to the performance of the Int-15x15. An incremental test (UMTT) or out and back with rests (YYrec-1) obtains the same degree of relationship as an Int-15x15. This observed relationship is due to the design used. In contrary to our study, the speed established in the Int-15x15 was the same for all the footballers (21.0 km•h^{-1}), regardless of the speeds obtained in the tests. Among the players, this represented a percentage range of between 114 and 144% of the MAS of the UMTT, and a percentage range of 123 and 138% of the YYrec-1 speed. The faster the speed achieved by the players in the UMTT and/or YYrec-1 tests, the lower the intensity represented in the Int-15x15. For this reason, the players with the highest MAS benefitted during the Int-15x15, as speeds above 120% of the MAS significantly compromised other energy substrates in producing energy[34]. The second study was applied to amateur and professional footballers[35]. The athletes were measured with the YYrec-1 and in an intermittent exercise of 10 seconds of work and 20 seconds of rest (Int-10x20) at the same intensity: 18.0 km•h^{-1}. The authors found that the footballers that produced the most lactate during the Int-10x20, covered less distance in the YYrec-1 (r=0.81). Both in the Dupont[33] and Rampinini[35] studies, they associated performance in the YYrec-1 with high-intensity intermittent exercise, just as in our study, but on football players. We believe that this should also be considered when analysing the results. Unlike football, hockey or basketball, in rugby performance is closely linked to the number of contacts per match (tackles, rucks, mauls, scrums); they increase in amount and intensity depending on the position and level of play[36]. Therefore, not necessarily, the results found in this study should be similar to those found in other studies that used athletes that perform differently in the field. This is important to mention, as it is the first study to associate both tests using rugby players as the study subject.

With regards to positions, the differences found in the YYrec-1 performance between the positions coincide with other studies. Santana[18] and Nakamura[37] observed differences in the performance of the YYrec-1 between forwards and backs (Table 4). Furthermore, the performance in the YYrec-1 obtained in this study is only similar in one study[18] and is lower than a further 2 studies[36-37]. On a national level we were unable to find a published bibliography. For this reason, Table 4 only displays YYrec-1 performances of a single club from the province of Buenos Aires (Alumni Association), the current champions of the 2018 tournament of the URBA top 12 (personal communication). As it can be appreciated, performance is higher in the players in this study, in both positions. Even if the reality of the sample reflects the characteristics of the amateur league, the performances in the YYrec-1 are low compared to the studies mentioned.

Figure 2. Description of the YYrec-1 protocol and the performance achieved by the players.

Stage		Speed (km•h^{-1})	Metres accumulated 1	2	3	4	5	6	7	8
W	1	10	40							
	2	12	80							
	3	13	120	160						
	4	13.5	200	240	280					
	5	14	320	360	400	440				
S	6	14.5	480	520	560	600	640	680	720	760
	7	15	800	840	880	920	960	1000	1040	1080
	8	15.5	1120	1160	1200	1240	1280	1320	1360	1400
	9	16	1440	1480	1520	1560	1600	1640	1680	1720
	10	16.5	1760	1800	1840	1880	1920	1960	2000	2040
	11	17	2080	2120	2160	2200	2240	2280	2320	2360
	12	17.5	2400	2440	2480	2520	2560	2600	2640	2680
	13	18	2720	2760	2800	2840	2880	2920	2960	3000
	14	18.5	3040	3080	3120	3160	3200	3240	3280	3320
	15	19	3360	3400	3440	3480	3529	3560	3600	3640

W: stages with the aim of warming up; S: stages where the test starts.

Table 4. Performance obtained in the YYrec-1 in different studies and superior studies.

Studies	n=	Level	Position	YY rec-1 (km•h^{-1})	YY rec-1 (m)
Pook P. [37]	3	Professional	McCaw R. *	19,0	3400
			Williams SN. *	19,0	3360
			Smitch C. *	19,0	3480
Arcuri CR. **	13	Amateur	1st lines	14,9±0,9	-
	7		2nd lines	15,5±1,4	-
	17		3rd lines	16,3±1,3	-
	4		½ Scrum	16,4±0,6	-
	6		Opening	16,3±1,3	-
	15		Centre	16,5±1,0	-
	8		Wing	16,6±1,6	-
	6		Full Back	16,0±1,2	-
Santana[18]	29	Amateur	All	15,4±1,2	972±394
			Forwards	14,9±0,9	792±277
			Backs	16,4±0,8	1283±312
Nakamura[38]	25	Professional	Forwards	-	1802±231
	17		Backs	-	2305±361
This study	26	Amateur	All	15,1±0,5	1102±342
	13		Forwards	14,8 ± 0,4	903 ± 271
	13		Backs	15,5 ± 0,5	1301 ± 290

*Rugby Elite Selection New Zealand (All Blacks).
** Superior Rugby Institution, Alumni Association Club Alumni, Top 12 URBA Tournament, Buenos Aires, Argentina (personal communication).

To conclude, certain limitations should have been considered, which we have observed throughout the study. Expanding the sample, taking into account the position of play. Measuring other physical condition components, which would enable us to explain the correlations found, such as, for example; strength levels (1RM) levels of muscle power (jumps with and without loads), speed (long sprints), acceleration (short sprints), body composition (muscle mass and adipose), agility (505 test, t-test), MAS (aerobic power), anaerobic reserve (difference between MAS and sprint speed), among others.

We conclude that in this group of players (amateur rugby), the performance achieved in the YYrec-1 is not related to performance in a high-intensity intermittent exercise with 10 seconds of work and 10 seconds of rest.

Practical applications

The YYrec-1 can be used to describe and categorise the rugby players. Furthermore, the speed of the YYrec-1 can be used to plan aerobic training sessions. On the other hand, if the sports coach is interested in measuring the work capacity during high-intensity effort (intermittent resistance), the protocol applied in this study could be used (Int-10x10) or another variation of it.

Conflict of interest

The authors claim to have no conflict of interest whatsoever.

Bibliography

1. Aziz AR, Chia MY, The KC. Measured maximal oxygen uptake in a multi-stage shuttle test and treadmill-run test in trained athletes. *J.Sports Med Phys Fitness.* 2005;45:306-14.
2. Dupont G, Akakpo K, Berthoin S. The effect of in-season, high-intensity interval training in soccer players. *J Strength Cond Res.* 2005;18;584-9.
3. Dellal A, Keller D, Carling C, Chaouachi A, Wong del P, Chamari K. Physiologic effects of directional changes in intermittent exercise in soccer players. *J Strength Cond Res*. 2010;24;3219-26.
4. Garcia GC, Secchi JD. Relación de las velocidades finales alcanzadas, entre el course navette de 20 metros y el test de VAM-EVAL. Una propuesta para predecir la velocidad aeróbica máxima. *Apunts Med Esport*. 2013;48:27-34.
5. García GC, Secchi JD. 20 meters shuttle run test with stages of one minute. An original idea that has lasted for 30 years. *Apunts Med Esport*. 2014;49:93-103.
6. Lemmink KA, Visscher C, Lambert MI, Lamberts RP. The interval shuttle run test for intermittent sport players: evaluation of reliability. *J Strength Cond Res*. 2004; 18:821-7.
7. Krustrup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, Pedersen PK, Bangsbo J. The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Med Sci Sports Exerc.* 2003;35:697-705.
8. Krustrup P, Mohr M, Nybo L, Jensen JM, Nielsen JJ and Bangsbo J. The Yo-Yo IR2 test: physiological response, reliability, and application to elite soccer. *Med Sci Sports Exerc.* 2006;38:1666-73.
9. Buchheit M. The 30-15 intermittent fitness test: accuracy for individualizing interval training of young intermittent sport players. *J Strength Cond Res.* 2008;22:365-74.
10. Carminatti LJ, Possamai CA, de Moraes M, da Silva JF, de Lucas RD, Dittrich N, Guglielmo LG. Intermittent versus continuous incremental field tests: Are maximal variables interchangeable? *J Sports Sci Med*. 2013;12:165-70.
11. Manouvrier C, Cassirame J, Ahmaidi S. Proposal for a specific aerobic test for football players: The "Footeval". *J Sports Sci Med.* 2016;15:670-7.
12. Castagna C, Iellamo F, Impellizzeri FM, Manzi V. Validity and Reliability of the 45-15 Test for aerobic fitness in young soccer players. *Int J Sports Physiol Perform*. 2014;9:525-31.
13. Andersen LB, Andersen TE, Andersen E, Andersen BEM. Bem intermittent running test to estimate maximal oxygen uptake_ the Andersen test. *J Sports Med Phys Fitness.* 2008;48:434-7.
14. Bangsbo J, Iaia I, Krustrup P. The Yo-Yo Intermittent Recovery Test. A Useful tool for evaluation of physical performance in intermittent sports. *Sports Med.* 2008;38;37-51.
15. Castagna C, Impellizzeri FM, Rampinini E, D'Ottavio S, Manzi V. The Yo-Yo intermittent recovery test in basketball players. *J Sci Med Sport*. 2008;11:202-8.
16. Bem Abdelkrim N, Chaouachi A, Chamari K, Chtara M, Castagna C. Positional role and competitive-level differences in elite-level men's basketball players. *J Strength Cond Res.* 2010;24(5):1346-55.
17. Redkva PE, Paes MR, Fernandez R, da-Silva SG. Correlation between match performance and field tests in professional soccer player. *J Hum Kinet*. 2018; 13;213-9.
18. Sant'anna RT, de Souza Castro FA. Aerobic power and field test results of amateur 15-a-side rugby union players. *J Sports Med Phys Fitness*. 2017;57:1605-12.
19. Atkins SJ. Performance of the Yo-Yo Intermittent Recovery Test by elite professional and semiprofessional rugby league players. *J Strength Cond Res*. 2006; 20:222-5.
20. Souhail H, Castagna C, Mohamed HY, Younes H, Chamari K. Direct validity of the yo-yo intermittent recovery test in young team handball players. *J Strength Cond Res.* 2010;24:465-70.
21. Veale JP, Pearce AJ, Carlson JS. The Yo-Yo Intermittent Recovery Test (Level 1) to discriminate elite junior Australian football players. *J Sci Med Sport.* 2010; 13:329-31.
22. Higham DG, Pyne DB, Anson JM, Eddy A. Physiological, anthropométrie, and performance characteristics of rugby sevens players. *Int J Sports Physiol Perform*. 2013;8:19-27.
23. Rampinini E, Bishop D, Marcora SM, Ferrari Bravo D, Sassi R, Impellizzeri FM. Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. *Int J Sports Med.* 2007;28;228-35.
24. Castagna C, Manzi V, Impellizzeri F, Weston M, Barbero Alvarez JC. Relationship between endurance field tests and match performance in young soccer players. *J Strength* Cond *Res*. 2010;24;3227-33.
25. Buchheit M, Mendez-Villanueva A, Bourdon PC. Match running performance and fitness in youth soccer. *Int J Sports Med*. 2010;31;818-25.
26. Swaby R, Jones PA, Comfort P. Relationship between maximum aerobic speed performance and distance covered in rugby union games. *J Strength Cond Res.* 2016;30:2788-93
27. Stewart A, Marfell-Jones M, Olds T, Ridder H. *Protocolo Internacional para la valoración antropométrica.* Australia. Editorial; Standards for Anthropometric Assessment. En (ISAK). 2011. 51-88.
28. Arcuri CR, García GC, Secchi JD. Capitulo 6. Entrenamiento aeróbico. En: *Estrategia para la evaluación de la condición física en niños y adolescentes.* Villa GE, Secchi JD, García GC, Arcuri CR. Entre Rios; Editorial UAP; 2017. 143-61.
29. Heaney N. The effect of a four week aerobic interval training block using maximal aerobic speed as the intensity measure with elite female hockey players. *J Aust Strength Cond.* 2012;20:97-102.
30. Attene G, Pizzolato F, Calcagno G, Ibba G, Pinna M, Salernitano G, *et al.* Sprint vs. Intermittent training in young female basketball players. *J Sports Med Phys Fitness.* 2014;54:154-61.
31. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc.* 2001:41;3-13.
32. García GC, Secchi JD, Arcuri CR, Santander MD. Evaluación de la resistencia aeróbica a través del tiempo límite en ambos sexos. *Arch Med Dep.* 2018;35:35-40.
33. Dupont G, Defontaine M, Bosquet L, Blondel N, Moalla W, Berthoin S. Yo-Yo intermittent recovery test versus the Université de Montréal Track Test: relation with a high-intensity intermittent exercise. *J Sci Med Sport.* 2010:13;146-50.
34. Dupont G, Blondel N, Lensel G, Berthoin S. Critical velocity and time spent at a high level of VO2 for short intermittent runs at supramaximal velocities. *Can J Appl Physiol.* 2002;27:103-15.
35. Rampinini E, Sassi A, Azzalin A, Castagna C, Menaspà P, Carlomagno D, Impellizzeri FM. Physiological determinants of Yo-Yo intermittent recovery tests in male soccer players. *Eur J Appl Physiol.* 2010;108:401-9.
36. Roberts SP, Trewartha G, Higgitt RJ, El-Abd J, Stokes KA. The physical demands of elite English rugby union. *J Sports Sci.* 2008;26:825-33.
37. Pook P. *Complete conditionong rugby.* Ed. Human Kinetcis. 2012. United States.
38. Nakamura FY, Pereira LA, Moraes JE, Kobal R, Kitamura K, Cal Abad CC, Teixeira Vaz LM, Loturco I. Physical and physiological diferences of backs and forwards from the Brazilian National rugby union team. *J Sports Med Phys Fitness.* 2017;57:1549-1556.

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Vascular injuries associated with paddle tennis. Paget-Schroetter Syndrome

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Summary

Introduction: Padel is a young sport that attracts millions of people, of both sex, all ages and social status. Practicing padel brings numerous health benefits, but it can also induce injuries.
Objectives: To analyze the relationship between vascular and padel pathology, and present the most significant aspects of Paget-Schroetter syndrome, and relate them to padel.
Methodology: Literature review, until August 1, 2019, in PubMed, Google and specialized Spanish journals; and presentation of a clinical case.
Results: The search did not find any reference between padel and vascular pathology, but I identify 20 articles that relate racket sports and vascular pathology, to infer some of its aspects to padel. Clinical case: A 34-year-old male, a regular padel practitioner, diagnosed (echo-Doppler) with a right axillary subclavian venous thrombosis (Paget-Schroetter syndrome); satisfactorily treated by local fibrinolysis (through catheter) and resection of the first rib (thoracoscopy). Currently asymptomatic and under oral anticoagulation.
Conclusions: 1) Little bibliography in this regard; 2) Low frequency of vascular complications during racquet sports; and 3) First case of the literature, of a Paget-Schoetter syndrome associated with padel player.
Practical consequences: 1) The mechanism of production is explained by the combination of triggers (repetition of shoulder movements, associated with forced positions - abduction of the arm), and predisposing factors (venous compression by anomalous anatomical structures); and 2) Think of this entity, mainly before young people, athletes, and without a pathological history; only early management prevents complications (pulmonary embolism), relapses and sequelae (post-thrombotic syndrome).

Key words:
Padel player. Tennis player. Racket sport. Vascular disorders. Venous disease. Venous thrombosis. Paget-Schroetter syndrome.

Lesiones vasculares asociadas a la práctica del pádel. El síndrome de Paget-Schroetter

Resumen

Introducción: El pádel es un joven deporte que atrae a millones de personas, de ambos sexos, de todas las edades y condición social. Practicarlo aporta numerosos beneficios para la salud, pero también puede inducir lesiones.
Objetivos: Analizar la relación patología vascular y pádel, y presentar los aspectos más significativos del síndrome de Paget-Schroetter, y relacionarlos con dicho deporte.
Metodología: Se realiza una revisión de la literatura, hasta el 1 de agosto del 2019, en PubMed, Google y revistas españolas especializadas; conjuntamente presentamos un caso clínico.
Resultados: La búsqueda realizada no encontró ninguna referencia entre pádel y patología vascular, pero identificó 20 artículos que relacionan deportes de raqueta y patología vascular, que nos permite inferir algunos de sus aspectos al pádel. Caso clínico: Varón de 34 años, practicante habitual de pádel, diagnosticado mediante eco-Doppler de una trombosis venosa axilo-subclavia derecha (síndrome de Paget-Schroetter); fue tratado satisfactoriamente mediante fibrinolisis local, a través de catéter, y posterior resección de la primera costilla (toracoscopia). Actualmente está asintomático y bajo anticoagulación oral.
Conclusiones: 1) Escasa bibliografía al respecto; 2) Baja frecuencia de complicaciones vasculares durante la práctica de los deportes con raqueta; y 3) Primer caso de la literatura, de un síndrome de Paget-Schroetter asociado al pádel.
Consecuencias prácticas: 1) El mecanismo de producción se explica por la combinación de factores desencadenantes (repetición de movimientos del hombro, asociados a posiciones forzadas - abducción del brazo), y predisponentes (compresión venosa por estructuras anatómicas anómalas); y 2) Pensar en esta entidad, fundamentalmente ante jóvenes, deportistas, y sin antecedentes patológicos; únicamente un manejo precoz evita complicaciones (embolia pulmonar), recidivas y secuelas (síndrome postrombótico).

Palabras clave:
Pádel. Tenis. Deportes de raqueta. Patología vascular. Enfermedades venosas. Trombosis venosas. Síndrome de Paget-Schroetter.

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Introduction

Paddle tennis is one of the most recently added sports in the racket and stick sports category (badminton, frontenis, tennis, table tennis, squash, etc.)[1]. Conceived as a sporting (amateur and professional) or leisure activity, each day more people - men and women of all ages - take up the sport. In this respect, a report about the sporting habits of Spanish people by the Spanish Sports Council and the Sociological Research Centre, in collaboration with the National Statistics Institute, revealed that in 2015, 4.2 million Spaniards played paddle tennis; some 3 million more than in 2010[2].

However, this growing participation in paddle tennis in Spain and other places around the world does not correlate with the number of scientific publications produced about paddle tennis and sports medicine. This fact contrasts with other sports, where the major North American leagues have particular prominence (American football, baseball, basketball and hockey)[3-4] or tennis[5-6].

We know that playing paddle tennis gives physical and psychological benefits (personal and social), and that it should also encourage healthy living habits[7]. There is also some data available about the negative side[8,9]. García-Fernández, *et al.*[9] have quantified 2.75 injuries per every 1,000 hours of exposure to the risk (similar percentage to the injury rate in other racket sports). Paddle tennis is considered a low static and high dynamic sport, entailing intense yet short bursts of effort; despite its similarity to tennis, it is less aerobic in nature. During the game of paddle tennis, hits and impacts are made and received repeatedly yet intermittently, on a hard surface (hybrid court, somewhere between racket/stick sports and wall and net sports), where numerous turns, jumps, bends and stretches, starts and stops, etc. are performed. In this context, injuries are more frequent among amateur players than among professionals, especially due to the false concept that claims you do not have to be in shape to play paddle tennis. In fact, the number of injuries increases significantly with age and body mass index[8-9].

Two joints are particularly affected in paddle tennis: the knees and elbows. This is why the locomotor system is where the highest concentration of frequent injuries is found (epicondylitis or tennis elbow, ankle sprains, etc.) Chard *et al.*[10] regarding 631 injuries - excluding paddle tennis players - observed that traumatic injuries were most frequent in squash (59%), compared to tennis (21%) or badminton (20%).

With regards to vascular disease, and following the example of other racket sports, its frequency should be sporadic. However, this can change given the high and growing number of paddle tennis players. Precisely, the recent diagnosis and treatment of axillary subclavian thrombosis (Paget-Schroetter Syndrome) in an amateur paddle tennis player, motivated this study.

Material and method

SA search was performed on PubMed/Medline up to 1st August 2019 using the following terms: "Padel", "Padel players" or "Padel sport"; 5 references were found, despite none of them being related to vascular disease.

We widened the search using the following terms: "Paddle", "Paddle Tennis", "Tennis", "Tennis player", "Racket", "Racket player", "Racket sport", "Racquet player", "Racquet sport", "Athlete", and "Sport", both individually as well as combined with the following terms: "Vascular diseases", "Vascular disorders", "Vascular injuries", "Arterial diseases", "Arterial disorders", "Arterial injuries", Venous disease", "Venous disorders", "Venous injuries", "Venous thrombosis", and "Venous thromboembolism".

Another search was performed collectively, using similar key words, in four Spanish journals: Angiología (channel of communication of the Spanish Angiology and Vascular Surgery Society), Medicina del Deporte Archives (official publication of the Spanish Federation and Society of Sports Medicine), Apunts. Medicina de l'Esport (Consell Català de l'Esport), and Revista Andaluza de Medicina del Deporte (Official publication of the Andalusian Sports Medicine Centre.

Vascular injuries and paddle tennis

We did not find any specific references of paddle tennis (or paddle) and vascular injuries. To focus on the issue of vascular injuries we used the bibliography available about racket/stick sports in general and tennis in particular.

Table 1 displays the different pathologies and vascular injuries linked to playing a racket sport. In this respect, at least five arterial and four venous diseases have been linked to the practice of tennis[11-14] and these may logically appear in paddle tennis.

Table 2 displays the different pathologies and vascular injuries linked to some racket sports that have been reported in medical literature[4,15-33]. Evidently, only 15 clinical cases and 5 reviews have been described.

Table 1. Vascular diseases described in racket sports[11-14].

Arterial disease
Ischaemia in the upper extremities:
- Upper thoracic outlet syndrome
- Entrapment of the humeral artery
- Raynaud Syndrome *
- Hypothenar hammer syndrome *
Ischaemia in the lower extremities:
- Entrapment of the popliteal artery
Compartment exertion syndromes (chronic)
Dissections:
- Axillary artery
Venous pathology
Deep vein thrombosis (DVT):
- Upper extremity (Paget-Schroetter Syndrome)
- Lower extremity
Varicose veins
Venous traumatises:
- Venous tears (Tennis leg syndrome) **

* Pathology with similar components.
** Tennis leg: Differential diagnosis with the DVT.

Table 2. Vascular pathology in the practice of racket/stick sports. Literary review.

Author/s (country) [reference]	Review, year	Sport	Pathology	Type publication
Coon & Willis (USA)[15]	Arch Surg, 1967	Tennis	Axillary subclavian DVT. Paget-Schroetter Syndrome	C
Brunner (Germany)[16]	Z Unfallmed Berufskr, 1968	Badminton	Axillary subclavian DVT "exertion-induced". Paget-Schroetter Syndrome	C
Languasco, *et al* (Italia)[17]	Angiologia, 1988	Tennis	Copo di fusta or Tennis leg	R
Priest (USA)[18]	Clin Sports Med, 1988	Tennis	Thoracic outlet syndrome (TOS)	R
Gilbert & Ansari (USA)[19]	Hosp Pract (Off Ed), 1991	Tennis	Calf swelling	C
Capek & Holcroft (USA)[20]	J Vasc Interv Radiol, 1993	Tennis	Traumatic ischaemia in the hand	C
Koga, *et al* (Japan)[21]	Am J Sport Med, 1993	Badminton	Hypothenar hammer syndrome	C
Stubington & Rigg (GB)[22]	Br J Sport Med, 1995	Squash	Arterial-venous fistula Traumatic superficial temporal artery	C
Nakamura, *et al* (Japan)[23]	Eur J Vasc Endovasc Surg, 1996	Tennis	Hypothenar hammer syndrome	C
Weber & Churchill (Australia)[24]	Aust NZ J Surg, 1996	Squash	Chronic compartment syndrome (leg)	C
Caiati, *et al* (USA)[25]	Am J Sport Med, 2000	Tennis	Dissecting of the axillary artery	C
Noel & Hayoz (Switzerland)[26]	Vasa, 2000	Tennis	Claudication of the hand (hypothenar hammer syndrome)	C
Zell, *et al* (Germany)[27]	Angiology, 2001	Racket	Paget-Schroetter Syndrome	R
Pluim, *et al* (Netherlands)[5]	Br J Sport Med, 2006	Tennis	Diverse	R
Vasdekis, *et al* (Greece)[28]	J Vasc Surg, 2006	Tennis	Closed trauma of the common femoral artery	C
Kohen, *et al* (USA)[29]	Del Med J, 2013	Lacrosse	Axillary subclavian DVT: Paget-Schroetter Syndrome	C
Ise, *et al* (Japan)[30]	J Cardiol Cases, 2014	Tennis	PTS popliteal (traumatic)	C
Tracy, *et al* (USA)[31]	Curr Sport Med Res, 2016	Lacrosse	Arterial-venous fistula Traumatic superficial temporal artery	C
Abe & Fujii (Japan)[32]	J Hand Surg Asia Pac Vol, 2017	Tennis	Chronic compartment syndrome (forearm)	C
Bhatia, *et al* (India)[33]	Med J Armed Forces India, 2019	Tennis	Tennis leg	R
Lozano (Spain)	Arch Med Deporte, 2019	Paddle tennis	Axillary subclavian DVT: Paget-Schroetter Syndrome	C

USA, United States of America; GB, Great Britain.
* C: Clinical case: R: Review

The exceptionalness of vascular injuries caused by playing a racket sport, is not an excuse for its infra-diagnosis, particularly in sports such as paddle tennis, which is practised by a large part of the general public, who even without playing this sport would suffer its epidemiological impact (by age groups, sex and the presence of other risk factors) on vascular diseases, fundamentally those with a high incidence rate and prevalence (e.g. intermittent claudication, venous thrombosis or varicose veins).

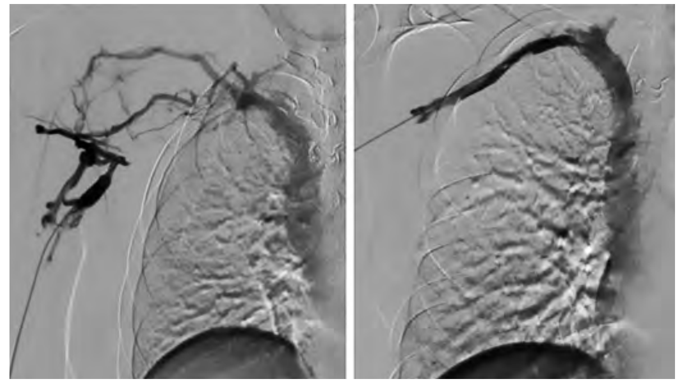
Paget-Schroetter Syndrome

A clinical case is presented, which according to our review is the first described in medical literature in connection with paddle tennis. A collective update is performed (literary review).

Clinical case

34-year old male, with no personal or family antecedents of interest, no toxic habits, no known allergies; claims to have played paddle tennis regularly (2-3 sessions/week, for the past 5 years). He came to A&E with pain and swelling in his right arm that appeared suddenly 5 days before, following one of his regular paddle tennis matches. A D-dimer test (elevated) was requested, as well as an Echo-Doppler, confirming an axillary subclavian venous thrombosis in the upper right extremity (his dominant arm). A diagnostic probability test was not performed. Given that he did not have any antecedents of interest, except for the exertion mentioned, the patient was diagnosed with Paget-Schroetter Syndrome. The patient was admitted into hospital and administered sodium heparin IV in therapeutic measures. The following morning, the patient was sent to a clinical session; given his age, recent clinical history and low risk of bleeding, the collective opinion was to propose fibrinolytics treatment. After informing the patient (risks and benefits), he accepted to undergo fibrinolytics. Local urokinase was administered intra-thrombus via catheter. The patient was admitted into the intensive

Figure 1. Phlebography and local fibrinolytics via catheter: Pre-fibrinolytics (axillary subclavian venous thrombosis) and post-fibrinolytics (resolution of the thrombus).



monitoring unit for analytical monitoring (coagulation, fibrinogen, etc.); in the second angiographic control at 24 hours, re-permeability was observed (Figure 1). The patient was moved to the ward, continuing with anticoagulation (sodium heparin IV). On the 6th day of admission, he was released with oral anticoagulation. During his hospital stay, a thoracic Angio-RM was performed, revealing no osteo-articular alteration of the thoracic outlet. The thrombophilic study was normal. The patient was sent to the thoracic surgery department, where his first rib was successfully resected via video-thoracoscopy. Currently, two months after release from hospital, the patient has no symptoms, and is continuing with the oral anticoagulant treatment (rivaroxaban 20mg/day). He has been advised to refrain from playing paddle tennis until further medical examinations.

Discussion

Deep vein thrombosis (DVT) is a frequent illness, linked to serious complications (e.g. pulmonary embolism - PE) and aftereffects (e.g. post-thrombotic syndrome - PTS) that entail important clinical, social and economic repercussions. Its basic etiopathogeny was described over a century ago (Virchow, 1860). Along this line of ideas, there are numerous illnesses and syndromes associated to DVT. Among them we highlight Paget-Schroetter Syndrome, which in our opinion presents three important characteristics: 1) Infrequent; 2) Fundamentally affects young people (< 40 years), often athletes; and 3) Is relatively unknown by non-specialists in venous pathology; this can lead to errors (diagnostic and therapeutic) with possible consequences, which can occasionally be serious (fatal PE).

Based on our experience[34] and a literary review[35-46], we present the most relevant aspects of this syndrome (concept, frequency, etiopathogeny, clinical history, diagnosis and treatment), with the aim of facilitating early diagnosis, optimising treatment and thus improving the prognostic (mortality rate) of this entity.

Concept and classifications: Initially it is necessary to define thoracic outlet syndrome (TOS). The outlet/inlet of the most important neurovascular structures of the thorax to the arm or vice versa, should cross three anatomical areas that can be conflictive: 1) Interscalene triangle (intercostal-scalene space); 2) Costo-clavicular channel; and 3) Coracopectoral tunnel (sub-pectoral/subcoracoidal area). There are a whole host of causes (cervical rib, subclavian muscle hypertrophy, etc.) and syndromes (scalene syndrome, pectoralis major syndrome, etc.) that may compress some or all the existing neurovascular structures (brachial plexus, artery and subclavian vein) (Figure 2). However, the impact is spread differently: neurological (95%), arterial (4%) and venous (1%).

In turn, venous TOS can be classified as: 1) Compression without DVT (denominated McCleery syndrome and characterised with venous swelling), and 2) Compression with DVT: this latter group, depending on aetiology, is subdivided into: a) Primary (25%) or Paget-Schroetter Syndrome (spontaneous or strain-induced axillary subclavian thrombosis) and b) Secondary (75%). Secondary aetiology is linked fundamentally to central venous channelling techniques (diagnostic or therapeutic - reservoirs), but they can also be due to polyglobulia, congestive cardiac insufficiency or extrinsic compressions for different pathologies (e.g. primary or metastatic cancer)[35].

Figure 2. Anatomy of the thoracic outlet. Conflictive zones of possible venous compression.

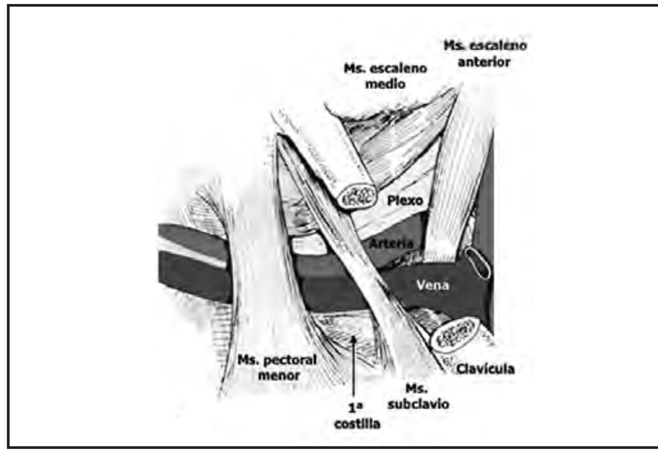
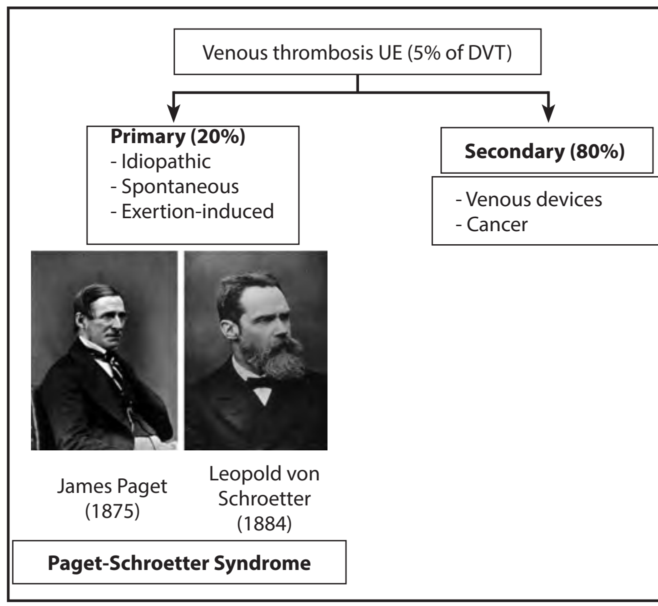


Figure 3. Classification of the venous thromboses in the upper extremity.



Historical overview: the English pathologist, James Paget (1875)[36] and the Austrian internist, Leopold Schrötter Ritter von Kristelli (known in medical literature as Leopold von Schrötter) (1884)[37], independently studied and characterised the syndrome. In 1949, Hughes performed a literature review and discovered 320 cases, proposing the term "Paget-Schroetter Syndrome"[38] (Figure 3).

Frequency: if the DVT of the upper extremities represent around 5% of al DVT cases, Paget-Schroetter Syndrome represents 1% of all venous thromboses. Over the past 5 years, in our department, 3 or 4 cases/year have been diagnosed/treated; two of them related to playing basketball.

Etiopathogeny: although the aetiology of the syndrome is unknown, it is usually related to two factors: a) repeated venous trauma, of diverse intensity and b) anatomical alterations that produce compressions. Strain is present in around 70% of cases. In fact, a third of the cases are people that play physically exerting sports, i.e. those in which the athletes repeatedly use their upper extremities (Table 1)[11-14], and interestingly, it has even been seen in a cheerleader36. Another third appears in professionals that also use their arms repeatedly. The remaining third appears in sedentary patients.

Along with the triggering situation (exertion-induced), there are other predisposing factors: anatomical defects (thoracic outlet syndrome), anovulatory defects, or unknown thrombophilic states. Anatomic defects are present in 90% of the cases, and are bilateral in 65%. This anatomical defect (muscular, bone, etc.) induces the compression of some (or all) vascular-nervous structures (in our case, the axillary and/or subclavian vein) that leave/enter the thorax, fundamentally during forced positions upon performing the exertion, which if repeated, causes the thrombosis of said vein. However, there may be anatomic defects without venous thrombosis and vice versa[35,40-42].

Production mechanism: accordingly, an axillary-subclavian DVT, generally in the dominant arm of a paddle tennis player, would be explained through a combination of factors: a) Triggers (repeated shoulder movements, linked to exertion positions - arm abduction) (Figure 4). Predisposition (vein compression by abnormal anatomic structures), not forgetting a hidden thrombophilic alteration or the ingestion of anovulatories (women of fertile age comprise a quarter of all paddle tennis players), which should also be researched.

Clinical: more frequent among males (2:1) and young people (average age of appearance: 31 years of age, range between 23-53). The dominant extremity is affected in 70% of the cases, with bilateral cases representing 7%[35,40-42].

The most symptomatic patients presented suddenly-appearing swelling (80%) and pain (30-50%) in the arm. Upon physical examination, there was frequently bruising, alteration of the colour of the skin and collateral circulation (Urschel sign) in the most developed cases[35,40-42].

Diagnosis: just as with the lower extremities (LE) (Wells test) for the upper extremities (UE), there is also a diagnostic probability test for DVT (Constans *et al,* 2008)[43]. This comprises four items: the presence of a catheter inserted in the vein (1 point), localised pain (1 point), unilateral swelling (1 points), and alternative diagnosis (- 1 point). A score below 1 point indicates the unlikelihood of DVT (which is ruled out when associated with a negative D-Dimer); more than 1 point implies that DVT is likely and requires the use of image techniques to confirm/reject the DVT diagnosis.

The D-dimer is less useful in terms of DVT and LE. The Echo-Doppler (97% sensitivity and 96% specificity), is the test of choice. MRA or angio-CTA (resting and hyper-abduction manoeuvres - Wright) are highly useful diagnostic tools. As phlebography (resting and manoeuvres) is an invasive technique, is relegated as a secondary diagnosis option[35,40-42].

Treatment: although initial standard treatment is anticoagulation (3 months), direct fibrinolytics via catheter is indicated for thromboses with less than 14 days of development, in young patients, and those with low risk of haemorrhaging. Later, in selected cases, a surgical technique can be performed of decompressing the sub-clavicle vein4; however, this is a controversial issue that is not part of the objective of this review. The filter of the superior vena cava may be indicated in situations in which anticoagulation is contraindicated[44].

The treatment purpose should be two-fold: a) Preventing the risk of PE, and b) Preventing PTS. Various actions have been trialled: 1) Regarding the thrombus: anticoagulant (not very effective); thrombectomy (classic or percutaneous); systemic or local fibrinolytics. The latter options appear to be the most useful, but for maximum effectiveness it is essen-

Figure 4. Pathogens of the Paget-Schroetter Syndrome. Abduction position of the arm whilst playing paddle tennis.

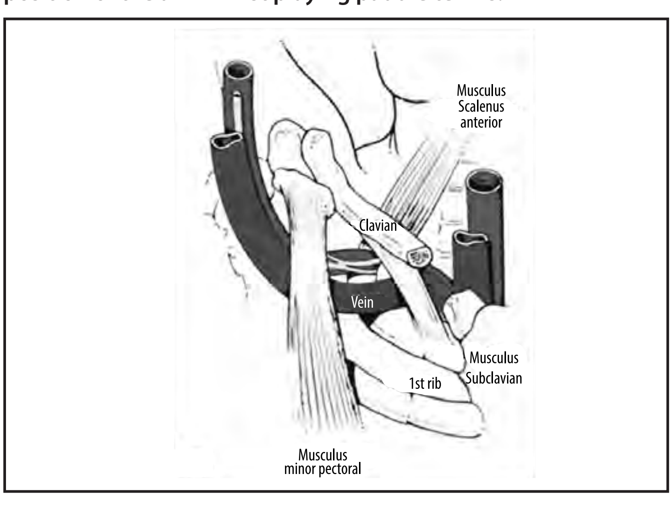
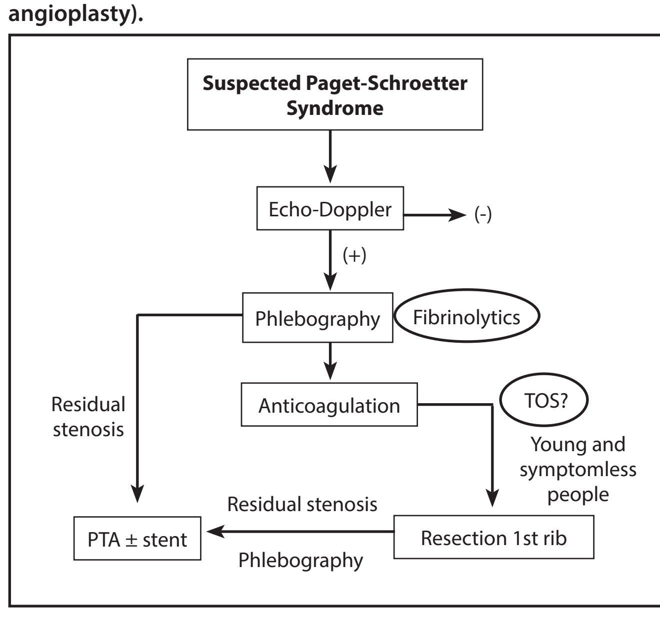


Figure 5. Therapeutic algorithm of Paget-Schroetter Syndrome (TOS, thoracic outlet syndrome; PTA, percutaneous transluminal angioplasty).



tial for the thrombus to be around 7 days old (Figure 1); 2) Regarding compression (diverse techniques, e.g. Resection of the first rib); and 3) Regarding residual stenosis: Percutaneous transluminal angioplasty (PTA) with/without stent. This therapeutic action is usually gradual. Figure 5 displays a simplification of the algorithm we use in our service.

As a treatment appendix, there are publications that make specific recommendations for the anticoagulant treatment of DVT in athletes[45,46].

Development: PE appears in 5-9% of cases (30% in DVT that affects the LE). PTS appears in 20% (40-50% in LE). Venous rethrombosis is also lower compared to LE DVT[35, 40-42].

Prognosis: early and correct diagnostic-therapeutic handling of the syndrome proffers excellent results and allows for a return to sporting activity, as observed in professional players from some of the four major American leagues (baseball, basketball, American football and ice hockey)[3]. During the anticoagulant (and antiaggregate) treatment, practising sport is completely contraindicated. Despite paddle tennis not being a contact sport, is does entail the risk of falls and trauma (e.g. "Tennis leg"). In any case, the recovery period may extend to 3-6 months.

Conclusion

Basic recommendations: 1) Think about this entity, especially for young, active and healthy patients; 2) Treat the thrombosis with anticoagulation and in select situations with fibrinolytics; and 3) Aim, and on select cases, to treat the anatomic cause.

Adendum

After this drafting of this study, the Angiology and Vascular Surgery Department of the University of Salamanca Healthcare Complex treated a 54-year old male patient who was a regular paddle tennis player and doctor, who had come from Avila with a provisional diagnosis of hamstring-tear syndrome or deep vein thrombosis (DVT). In our department we performed an Echo-Doppler and confirmed thrombosis in the muscular veins (calf muscles) of the lower right extremity, without progression to the popliteal vein, and without signs of bruising or muscle tearing. Anticoagulation was recommended with low molecular weight heparin (LMWH) (1-3 months) and elastic compression stockings. Given his position as a doctor, he opted to continue follow-up in his home city.

Comments: 1) Remember that the muscular veins (calves and soleus) belong to the deep vein system of the lower extremities; 2) In these situations it is very important to differentiate between a fibre tear (tennis leg) and DVT (though it may be distal and confined to the calf); however, occasionally both entities may be present; 3) Only an exact diagnosis facilitates correct decision making, so whilst in the first case (fibrillar tear) the administration of LMWH would possibly increase the symptoms (more bleeding), in the DVT - despite being distal and isolated - LMWH may be recommendable, especially when the thrombus is extensive (> 5 cm in length) and when it affects more than one muscle vein, such as in this case. If in doubt, the clinical development of the patient can be observed and serial Echo-Doppler sessions (weekly) can be carried out. Anticoagulation can be chosen only if the thrombus progresses to the popliteal vein; however, distal and isolated DVT can - infrequently - also cause pulmonary embolisms[46-47].

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Conflict of interest

The authors claim to have no conflict of interest whatsoever.

Bibliography

1. Sánchez-Alcaraz Martínez BJ. Historia del pádel. *Materiales para la historia del deporte* 2013:11:57-60.
2. Courel Ibañez J, Sánchez-Alcaraz Martínez BJ, García Benítez S, Echegaray M. Evolución del pádel en España en función del género y edad de los practicantes. *Ciencia CDC* 2017;12:39-46.
3. Makhni EC, Buza JA, Byram I, Ahmad CS. Sports reporting: a comprehensive review of the medical literature regarding north American professional sports. *Phys Sportsmed* 2014;42:154-62.
4. Bishop M, Astolfi M, Padegimas E, DeLuca P, Hammoud S. Venous thromboembolism within professional American sport leagues. *Orthop J Sports Med* 2017;5: 2325967117745530.
5. Pluim BM, Staal JB, Windler GE, Jayanthi N. Tennis injuries: occurrence, etiology, and prevention. *Br J Sports Med*. 2006;40:415-23.
6. Gutiérrez García D, Esparza Ros F. Lesiones en el tenis. Revisión bibliográfica. *Apunts Medicina de l'Esport*. 2011;46:189-204.
7. Parrón Sevilla E, Nestares Pleguezuelo T, De Teresa Galván C. Valoración de los hábitos de vida saludables en jugadores de pádel. *Rev Andal Med Deporte*. 2015;8:184.
8. Priego Quesada JI, Sanchís Almenara M, Kerr ZY, Alcantara E. Examination of the risk factors associated with injured recreational padel players in Spain. *J Sports Med Phys Fitness.* 2018;58:98-105.
9. García-Fernández P, Guodemar-Pérez J, Ruiz-López M, Rodríguez-López ES, García-Heras A, Hervás-Pérez JP. Epidemiología lesional en jugadores españoles de pádel profesionales y amateur. *Rev Int Med Cienc Act Fis Deporte*. 201x;10.
10. Chard MD, Lachmann SM. Racquet sports--patterns of injury presenting to a sports injury clinic. *Br J Sports Med*. 1987;21:150-3.
11. Lozano Sánchez FS. Deporte y patología vascular. En: *Cuadernos de patología vascular*. Vol. 5. Aran Ed. Madrid, 2007.
12. Perlowski AA, Jaff MR. Vascular disorders in athletes. *Vasc Med*. 2010;15:469-79.
13. Menon D, Onida S, Davies AH. Overview of venous pathology related to repetitive vascular trauma in athletes. *J Vasc Surg Venous Lymphat Disord.* 2019 Jun 20.
14. Menon D, Onida S, Davies AH. Overview of arterial pathology related to repetitive trauma in athletes. *J Vasc Surg.* 2019;70:641-50.
15. Coon WW, Willis PW 3rd. Thrombosis of axillary and subclavian veins. *Arch Surg.* 1967;94:657-63.
16. Brunner U. Effort thrombosis of the athlete. *Z Unfallmed Berufskr.* 1968;61:42-6.
17. Languasco GB, Haimovici N, Cacciatore E. "Colpo di frusta" and tennis leg" synonyms or not?. *Angiologia*. 1988;40:87-92.
18. Priest JD. The shoulder of the tennis player. *Clin Sports Med.* 1988;7:387-402.
19. Gilbert T, Ansari A. A tennis player with a swollen calf. *Hosp Pract (Off Ed).* 1991;26:209-10, 212.
20. Capek P, Holcroft J. Traumatic ischemia of the hand in a tennis player: successful treatment with urokinase. *J Vasc Interv Radiol.* 1993;4:279-81.
21. Koga Y, Seki T, Caro LD. Hypothenar hammer syndrome in a young female badminton player. A case report. *Am J Sports Med.* 1993;21:890-2.

22. Stubington SR, Rigg KM. Traumatic arteriovenous fistula of the superficial temporal vessels: a case for protective headgear when playing squash?. *Br J Sports Med.* 1995; 29:275-6.

23. Nakamura T, Kambayashi J, Kawasaki T, Hirao T. Hypothenar hammer syndrome caused by playing tennis. *Eur J Vasc Endovasc Surg*. 1996;11:240-2.

24. Weber AB, Churchill JO. Compartment syndrome after squash. *Aust N Z J Surg.* 1996;66: 771-2.

25. Caiati JM, Masters CM, Todd EJ, Benvenisty AI, Todd GJ. Symptomatic axillary artery dissection in a tennis player. Case report. *Am J Sports Med.* 2000;28:411-2.

26. Noël B, Hayoz D. A tennis player with hand claudication. *Vasa*. 2000;29:151-3.

27. Zell L, KIndermann W, Marschall F, Scheffler P, Gross J, Buchter A. Paget-Schroetter syndrome in sports activities-case study and literature review. *Angiology.* 2001;52:337-42.

28. Vasdekis SN, Kakisis JD, Lazaris AM, Panayiotides JG, Angeli AA, Karkaletsis KG. Common femoral artery injury secondary to tennis ball strike. *J Vasc Surg.* 2006;44:1350-2.

29. Kohen D, Hanhan S, Bellah R. Paget-Schroetter syndrome in a lacrosse player. *Del Med J.* 2013;85:77-9.

30. Ise T, Iwase T, Masuda S, Yagi S, Akaike M, Nishio S, *et al*. Acute pulmonary thromboembolism from deep vein thrombosis induced by trauma to the popliteal vein with a tennis racket. *J Cardiol Cases.* 2014;9:162-4.

31. Tracy A, Klinge P, Morrison J, Jayaraman MV, Kriz PK. Traumatic superficial temporal artery pseudoaneurysm in a helmeted lacrosse player. *Curr Sports Med Rep.* 2016;15:13-5.

32. Abe Y, Fujii K. Chronic compartment syndrome of the mobile wad: A case report. *J Hand Surg Asian Pac Vol.* 2017;22:516-8.

33. Bhatia M, Maurya V, Debnath J, Gupta P. Tennis leg: A mimic of deep venous thrombosis. *Med J Armed Forces India.* 2019;75:344-6.

34. Lozano Sánchez FS. Síndrome de Paget-Schroetter. *Rev Esp Invest Quir.* 2003;6:154-6.

35. Illig KA, Doyle AJ. A comprehensive review of Paget-Schroetter syndrome. *J Vasc Surg*. 2010;51:1538-47.

36. Paget J. *Clinical lectures and essays*. London: Longmans, Green & Co, 1875.

37. von Schroetter L. *Erkrankungen der gefasse, in nathnagel handbuch der pathologie und therapie*. Wein: Holder, 1884.

38. Hughes ESR. Venous obstruction in the upper extremity (Paget-Schroetter's syndrome). A review of 320 cases. *Int Abst Surg.* 1949;88:89-127.

39. McGlinchey PG, Shamsuddin SA, Kidney JC. Effort-induced thrombosis of the subclavian vein--a case of Paget-Schroetter syndrome. *Ulster Med J.* 2004;73:45-6.

40. Butros SR, Liu R, Oliveira GR, Ganguli S, Kalva S. Venous compression syndromes: Clinical features, imaging findings and management. *Br J Radiol.* 2013;86:20130284.

41. White JM, Comerota AJ. Venous compression syndromes. *Vasc Endovasc Surg.* 2017;51: 155-68.

42. Zucker EJ, Ganguli S, Ghoshhajra BB, Gupta R, Prabhakar AM. Imaging of venous compression syndromes. *Cardiovasc Diagn Ther.* 2016;6:519-32.

43. Constans J, Salmi LR, Sevestre-Pietri MA, Perusat S, Nguon M, Degeilh M, *et al.* A clinical prediction score for upper extremity deep venous thrombosis. *Thromb Haemost.* 2008;99:202-7.

44. Owens ChA, Bui JT, Knuttinen G, Gaba RC, Carrillo TC. Pulmonary embolism from upper extremity deep vein thrombosisand the role of superior vena cava filters: A review of the literatura. *J Vasc Interv Radiol*. 2010;21:779-87.

45. Nazha B, Pandya B, Spyropoulos AC, Kessler CM. Treatment of venous thromboembolism in elite athletes: A suggested approach to individualized anticoagulation. *Semin Thromb Hemost.* 2018;44:813-22.

46. Drobnic F, Pineda A, Escudero JR, Soria JM, Souto JC. Guía de práctica clínica para la prevención, diagnóstico y tratamiento de la enfermedad tromboembólica venosa en el deporte. *Apunts. Medicina de l'Esport.* 2015;50:147-59.

47. Fernández-Rodríguez T, Oviedo-García A, Tolmos-Estefanía MT, Rodríguez Lorenzo A. Trombosis venosa profunda tras tennis leg. Papel de la ecografía en atención primaria. *Semergen.* 2014;40:157-9.

48. Lozano FS, Valverde S, Rubio C, Peña R, Salvador R, Carnicero JA. *Diagnóstico y tratamiento de la trombosis venosa profunda distal aislada.* Guía de la Sociedad Castellano-Leonesa de Angiología y Cirugía Vascular (SOCLACIVAS). Mata digital. Valladolid, 2018:47-70.

Tailored exercise as a protective tool in cardio-oncology rehabilitation: a narrative review

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Summary

Cardiovascular disease is the leading cause of long-term morbidity and death among cancer survivors, after second malignancies. Preventing cancer treatment-induced cardiotoxicity (CTC) constitutes a crucial endpoint in oncology, from oncology treatment implementation. The American Association of Clinical Oncology has recently highlighted the role of physical exercise as an essential component of co-adjuvant cancer treatment and cancer survivor care programs. Exercise training may protect from cardiotoxicity on a molecular and physiological basis. Two major types of training in this field are: cardiovascular and resistance/strength training. Little is known about the effects of these modalities of exercise on CTC. This narrative review aimed to gather evidence and extract conclusions about the effectiveness of exercise training on CTC. To do so, we reviewed scientific literature under a sophisticated approach in line with the PRISMA project guidelines. Studies on physical training exercise effects and cardiac-related measures throughout the cancer stages (cancer treatment and survivorship) were selected. Data collection comprised extracting information of study features, exercise training characteristics and related effects. As a result, 1087 studies were retrieved from database search and 33 studies were selected, comprising 2778 participants. Most of the studies (n = 29) examined the effects of cardiovascular training on CTC. No studies analysed the effects of resistance-based training. We observed a lack of systematic effect of exercise across studies due to the high heterogeneity (e.g., many studies did not follow the guidelines for training interventions in cancer settings). However, studies combining both cardiovascular and resistance components showed promising results. To sum up, higher adherence to clinical guides should be encouraged to implement physical exercise interventions in medical settings and to ensure intervention effectiveness. Moreover, personalized protocols and routines should be implemented in Cardio-Oncology Rehabilitation Units. Finally, it is mandatory to avoid physical inactivity in patients with cancer.

Key words:
Cardiovascular disease. Cancer. Cardiotoxicity. Exercise & Cardio-Oncology Rehabilitation.

Ejercicio individualizado como herramienta protectora en la rehabilitación cardio-oncológica: revisión narrativa

Resumen

La patología cardiovascular es la primera causa de morbilidad y muerte entre los pacientes supervivientes de cáncer, después de segundas neoplasias. La prevención de cardiotoxicidades inducidas por tratamientos oncológicos constituye una meta en la Oncología. La Asociación Americana de la Oncología Clínica recientemente ha destacado la importancia del ejercicio físico como componente co-adyuvante esencial en el tratamiento contra el cáncer. El ejercicio físico puede dar protección en la cardiotoxicidad desde un punto de vista molecular y fisiológico. Dos tipos de entrenamiento destacan: entrenamiento cardiovascular y de fuerza. Esta revisión pretende recoger evidencia y extraer conclusiones sobre la efectividad del ejercicio físico ante la cardiotoxicidad. Para ello revisamos la literatura científica bajo criterios PRISMA. Estudios basados en el efecto del ejercicio físico y mediciones cardiacas a lo largo de procesos oncológicos (tratamiento oncológicos y supervivientes) fueron seleccionados. Como resultado, 1087 estudios fueron recuperados y 33 estudios fueron seleccionados, comprendiendo 2778 sujetos. La mayoría de los estudios (n=29) examinaron el efecto del entrenamiento cardiovascular en la cardiotoxicidad. No hubo estudios que analizaran exclusivamente el entrenamiento de Fuerza. Observamos una escasez de efecto sistémico a lo largo debido a la alta heterogeneidad. De cualquier modo, los estudios combinando entrenamiento cardiovascular y de fuerza parecen demostrar resultados prometedores. En resumen, las guías clínicas deberían animar a implementar programas de ejercicio físico en el entorno médico y garantizar intervenciones efectivas. Asimismo, deberían implementarse protocolos individualizados en unidades de Rehabilitación Cardio-Oncológica. Finalmente, resulta imperativo promover el mensaje de evitar la inactividad física en el paciente oncológico.

Palabras clave:
Patología cardiovascular. Cáncer. Cardiotoxicidad. Ejercicio & Rehabilitación Cardio-Oncológica.

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Introduction

Nowadays in the United States of America, cancer is the second cause of death. It is expected that in the years 2025-2030, cancer will exceed cardiovascular diseases as the principal cause of death[1]. In turn, cardiovascular disease (CVD) is the leading cause of long-term morbidity and death among cancer survivors, after second malignancies[2].

Cardiotoxicity is defined by the National Cancer Institute as "toxicity that affects the heart". No single, universally definition is accepted at present. Traditionally and thematically cardiotoxicity has been linked with a decline in the Left Ventricular Ejection Fraction (LVEF). According to the European Society of Cardiology, cardiotoxicity leading to heart failure is defined as a decrease in the LVEF >10% points to a value below the lower limit of normality on an echocardiograph, and a relative reduction in global longitudinal strain of >15% from baseline[3]. Heart structure disfunction, haemodynamic flow alterations, hypertension, valvular disease, arrhythmias, thrombotic events and peripheral vascular disease are related with this Cardio-Oncology concept.

By and large, there is a strong connection between cancer treatment-induced cardiotoxicity (CTC) and CVD over treatment and cancer survivorship[4,5]. For instance, congestive heart failure because of cancer therapy has been linked to a 3.5-fold increased mortality risk compared with idiopathic cardiomyopathy[6].

Preventing CTC constitutes a crucial endpoint in oncology. Nowadays, an increasing interest in CTC exists in order to encourage individualized treatment planning and the promotion of quality of life across cancer treatment and survivorship. Thus, several studies have provided new insight on the relationship between chemotherapy agents[7,8], adjuvant endocrine therapy[8], and monoclonal antibodies and CTC[8]. Likewise, some studies have stress the association of radiotherapy exposure (Figure 1) and CTC[7-10].

Based on experience in the area of cardiac rehabilitation and exercise oncology units, the potential use of physical exercise as a co-adjuvant treatment has been endorsed[11]. Mounting evidence has proved that physical exercise improves cardiovascular function and facilitates cardiac rehabilitation[12,13]. The American Association of Clinical Oncology (ASCO) has recently highlighted the role of physical exercise as an essential component of cancer survivor care programs[14]. In this line, the American Heart Association (AHA) suggests the implementation of tailored exercise for Cardio-Oncology Rehabilitation[15].

Figure 1. Left Breast Cancer Radiotherapy with Volume Modulated Arc (VMAT) and 6-10 MV.

Exercise training may protect from cardiotoxicity on a molecular basis. In this sense, exercise promotes effective regulation of calcium channel in ryanodine receptors, which are involved in heart contractile function[16]. Moreover, physical exercise may contribute antioxidant agents to be produced and mitochondrial function be improved[17-19]. From a patient point of view, physical exercise has significant benefits to tackle CTC. Several modalities of exercise training are present in rehabilitation contexts, two major types of training in this field are: cardiovascular and resistance/strength training. The bulk of studies have concentrated on cardiovascular programs and their effectiveness to prevent CTC[20-22]. Some studies have reported the benefits of resistance physical training on cardiovascular and musculoskeletal systems and its potential protective effects, specifically in Sprague- Dawley rats which were induced CTC through doxorubicin[23,24]. Little is known about the effects of these interventions in cancer patients and survivors. Moreover, integrated programs (i.e., programs combining cardiovascular and resistance components) have been scarcely studied.

This narrative review aimed to examine the scientific literature in order to explore and gather studies focused on physical training applications as adjuvant interventions to tackle CTC. Moreover, we intended to describe the main features of interventions that have been proven effective to deal with CTC (e.g., treatment duration, training components, outcomes to consider). Finally, we aimed at providing recommendations and some guidelines to design physical training interventions in cancer settings, considering their cardioprotective benefits.

Methods

Search strategy and article selection criteria

This narrative review relied on a comprehensive protocol, covering an ascendant and descendant approach to gather evidence on the effects of physical training to prevent from CTC. Four renowned electronic databases were searched: Medline PubMed, PEDro, Scopus and Web of Science. Also, the list of references of three reference reviews on physical training and cardiotoxicity was reviewed[4,20,21] as well as the list of references of all the articles included in this study (descendant approach).

Electronic databases were searched in October 5th 2018. A broad-scope and inclusive initial search strategy was carried out with no restrictions in specie, population or age, in order to identify a wide collection of studies on training exercise effects. Thus, search queries included 'cancer' (or 'neoplasms'), 'cardiotoxicity' and 'exercise' as keywords (as well as their related thesaurus terms: for cardiotoxicity, 'cardiac toxicity', or 'heart toxicity'; and for exercise, 'physical training', 'physical activity', 'physical exercise', 'acute exercise', or 'exercise training').

Inclusion criteria for studies were: a) studies analyzing the effects of a physical training- based intervention on human adults samples;

b) studies comprising cancer patients or survivors; c) studies reporting comparative results (i.e., between-group or pre-post test) regarding cardiovascular markers or cardiopulmonary exercise test (e.g., heart rate, cardiopulmonary volume, left ventricular ejection fraction, VO_2peak); d) being an empirical study published in scientific journals; e) article written in English. The exclusion criteria were: a) non-human samples; b) studies combining physical-training treatments and other types of interventions different than usual care (e.g., a surgical intervention, nutritional supplementation, pulmonary/breathing physical therapy protocols, yoga); c) descriptive studies or qualitative studies; d) studies comprising patients without a history of cancer.

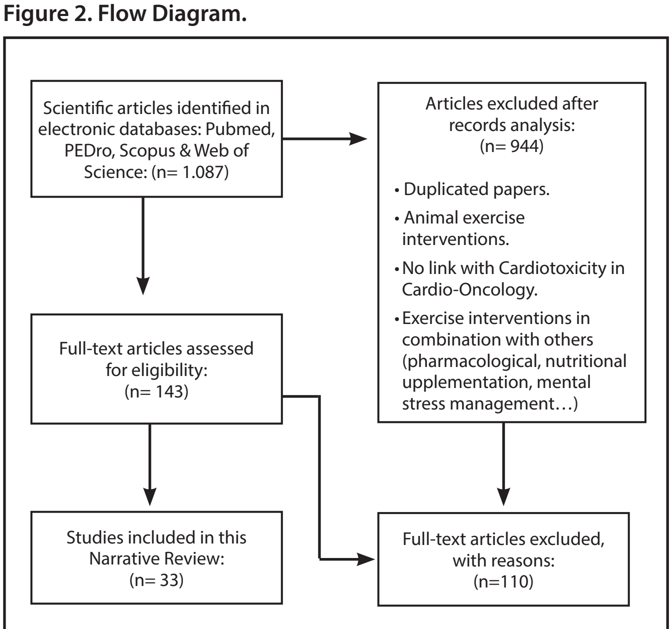
Data extraction and quality assessment

Articles were screened for a reviewer on an initial review of title, abstract, and keywords. Pre-selected papers were fully read to ratify the selection. An independent peer reviewer confirmed the appropriateness of every paper to be included in this study. Discrepancies on paper selection were resolved by discussion.

Relevant data was extracted using a coding manual. An independent reviewer supervised data entered in the data collection form. Data collected from every study were: a) sample size and composition (i.e., type of cancer participants, cancer stage); b) age range; c) country of recruitment; d) study design; e) VO_2peak and/or cardiac outcome; f) type of exercise training intervention (i.e., aerobic, resistance training, and combined); g) treatment duration and number of sessions; h) intensity of training; i) results of the intervention; j) side effects derived from the interventions; k) and quality of studies based in four criteria described below.

1087 studies were identified through database searching. Studies excluded after screening titles and abstracts (n=944). Titles and abstracts identified (n=143). Studies included in narrative review (n=33) (Figure 2).

Figure 2. Flow Diagram.



Quality of studies was assessed by four criteria: a) type of study design (according to, cohort studies or randomized controlled trial show a higher level of evidence, than case- controlled studies or descriptive ones); b) random assignation to interventions; c) confounding control (control of potential confounders); d) repeated measures (whether the study had pre-post tests assessments and follow-up). Two reviewers independently assessed all the studies included in this review. Discrepancies were resolved by discussion.

Results

Intervention programs by means of physical exercise in cancer patients

Thirty-three studies were included in this review (n=2778 patients). Table 1 displays the main features of these studies. Mean age of participants was 47.1 years, and the most common diagnosis was breast cancer. Sample size of the studies was 84.18 patients on average. Most of studies was based in North America (15 from EEUU and 10 from Canada); 6 from Europe, and 2 from the rest of the world. Regarding study design, interventions during treatment vs. survivors vs. both; Exercise during treatment: 16 studies. Exercise design in survivors: 15. Both: 2 studies.

Most studies were randomized controlled trials (72.72% of articles); 45.45% of them controlled for confounding factors (mainly type of oncology treatment, age and free- cancer time) in randomization or data analysis. On the other hand, most of articles assessed outcomes pre-post tests (60.61% of manuscripts) and 39.39% included follow- up. In terms of type of exercise programs, the bulk of studies used cardiovascular training. Four studies delivered programs integrating cardiovascular and strength modalities (intervention exercise group). Finally, there was a trend towards 3 days/week exercise sessions (45-50 mints. per session): 20 studies. With these 3 weekly exercise sessions, the 150 mints/week, cardiovascular exercise recommendations of American and Australian oncological Societies are fulfilled[25,26].

Cardiovascular training in human

The intervention by means of physical exercise in humans extrapolates the type of cardiovascular physical exercise, times and intensities used in the research carried out on rodents[27-31].

In the study of Kirkham *et al*[32], the intensity of the exercise to try to diminish the cardiotoxicity associated with the use of doxorubicin was 70% of the cardiac frequency of reserve of each patient, similar in exercise intervention: Acute (1 single bout) & Intensity seen in rat model[30].

Haykowsky *et al*[33] shows that initiation of trastuzumab is associated with left ventricular cavity dilation and reduced ejection fraction despite aerobic training. Although this important study doesn't count with a control non-exercise group.

Resistance training (strength) in human

Nowadays, there are no exclusive strength interventions in humans trying to reduce CTC in oncological patients (measuring specifically cardiac biomarkers). This could provide new research opportunities.

Table 1. Main features of studies selected in this review.

Study	Sample size	Mean age	Cancer site	Severity	Type of intervention	Intervention particularities	Outcome	Results
Patient samples								
Courneya *et al*	242	49.2	Breast	I-IIIA	CV vs. ST	Aerobic Exercise Group: 3 days/w; intensity: 60-80% from maximal VO_2 per 15-45 min. Resistance Training: 3days/w + 9 exercises x 2 sets of 8-12 rep.; intensity: 60-80% (one repetition maximum).	VO_2 Peak.	VO_2 peak increased by 0.2% in aerobic exercise group and decreased by 5% in the resistance training group.
Courneya *et al*	122	53.2	Lym-phoma	All stages	CV	Three days/w with 12 weekly sessions, 15-45 min a session.	VO_2 Peak	VO_2 peak increased by 17% in the exercise group.
Courneya *et al*	301	50	Breast	I-IIIC	CV vs. combined	Standard Aerobic Exercise: 3 days/w x 25-30 min; intensity: 55-75% from VO_2 max. High Aerobic Exercise Group: 3 days/w x 50-60 min; intensity: 55-75% from VO_2 peak. Combined Exercise: 3 days/w of CV training with sessions of 25-30 min (intensity: 55-75% from VO_2 peak) + 2 sets x 10-12 rep (intensity: 60-75% one-repetition maximum).	VO_2 Peak	VO_2 peak decreased by 12% in the standard aerobic exercise group, 9% in the high aerobic exercise group, and by 13% in the combined exercise group.
Dolan *et al*	242	49.2	Breast	II-IIIA	CV vs. ST	Aerobic Exercise Group: 3 days/w, with sessions of 15-45 min (intensi-ty: 60-80% from VO_2 peak). Resistance Training Group: 3 days/w x 2 sets of 8-12 rep and 9 exercises (intensity: 60-70% of one-repetition maximum).	VO_2 Peak.	The resistance training (and the usual care group) showed increase in VO_2 peak. Both exercise groups showed moderate correlation between VO_2 peak change and hemoglobin.
Haykowsky *et al*	17	53	Breast with HER2	All stages	CV	Three days/w x 16 weeks x 30-60 min (intensity: 60-90% from VO_2 peak).	VO_2 Peak. LV volume and LVEF. HR. BP.	VO_2 peak positively co-rrelated with exercise adherence. Interven-tion led to resting BP volume increase and ejection function decrease.
Hornsby *et al*	20	48.5	Breast	IIB-IIIC	CV	Three days/w and sessions of 15-45 min (intensity: 60-100% from VO_2 peak). The program lasted 12 wee-ks (last two with higher intensity: 100% from VO_2 peak).	VO_2 Peak. HR. BP. LVEF.	VO_2 peak increased by 13% in the exercise group. No significant between-group diffe-rences in terms of HR, BP and LVEF.
Jones *et al*	20	48.5	Breast	II-IIIC	CV	Aerobic Exercise Group: 3 days/w x 12 weeks x 30-45 min (intensity: 60-100 from VO_2 peak).	VO_2 Peak. Brachial artery flow-mediated dilation. Circula-ting endothelial progenitor cell count (VEGFR-2, CD-133/VE-GFR-2, ALDH^{br}).	VO_2 peak increased by 13% in the exercise group. Higher levels of circulating progenitor cell in the exercise group in comparison to controls, as well as greater brachial dilation.

(Continued)

Study	Sample size	Mean age	Cancer site	Severity	Type of intervention	Intervention particularities	Outcome	Results
Kim *et al*	41	49.8	Breast	I-III	CV	Three days/w and sessions of 30 min (intensity: 60-70% from VO_2 peak or HR reserve).	VO_2 Peak. HR. BP.	The exercise group showed significant increases in maximum systolic BP volume and VO_2 peak, as well as decreses in resting HR and resting systolic BP.
Kirkham *et al*	24	50.5	Breast	I-III	CV	A single session of 45-min treadmill exercise (intensity: 70% from HR reserve).	Cardiac biomarkers (NT-proBNP, cTnT). HR. Systemic vascular resistance. LV volume and LVEF.	VO_2 peak increased by 15% in the exercise group. Higher levels of cardiac biomarkers in the exercise group. LVEF increased by 3% after intervention in the exercise group.
Kolden *et al*	40	55.3	Breast	I-III	Combined + stretching	Three days/w with 20-min aerobic exercise (intensity: 40-70 from VO_2 peak) + 20-min strength training (not reported intensity) + Stretching.	VO_2 Peak. Resting HR and BP.	VO_2 Peak increased at post-intervention assessment and follow-up. Resting systolic BP across assessment points.
Ligibel *et al*	41	47	Breast	I-III	CV	An aerobic exercise program with sessions of 150 min/w.	VO_2 Peak.	VO_2 peak increased by 4% in the exercise group.
MacVicar	45	45.1	Breast	II	CV	Usual Care + Stretching + cardiovascular training (3sessions/w; intensity: 60-85% from resting HR).	VO_2 Peak	IG increased 40% of functional capacity and maximum workload.
Scott *et al*	65	54	Breast	IV (metastatic)	CV vs. Others	Aerobic Exercise Group: 3 days/w x 20-45 min (intensity: 55-80 from VO_2 peak). Stretching Group: 3 days/w x 20-45 min (12-20 positions).	VO_2 Peak. BP.	No significant differences between groups.
Segal *et al*	123	50.9	Breast	I-II	CV	Supervised Group: 3 days/w + 2 days/w at home during 26 weeks. Home Based Group: 5 days/w of exercise at home (26 weeks).	VO_2 Peak.	VO_2 peak increased by 3.5% in supervised exercise group and 2.4% in the home-based group.
Segal *et al*	121	66.3	Prostate	All stages	CV vs. ST	Aerobic Exercise Group: 3 days/w x 15-45 min sessions during 24 weeks (intensity: 50-75% from VO_2 peak). Resistance Training: 3 days/w with 10 exercises of 8-12 rep.; intensity: 60-70% from VO_2 peak (one repetition maximum).	VO_2 Peak	VO_2 peak increased by 0.1% in the aerobic exercise group and 0.5% in the resistance training group.
Van Waart *et al*	230	50.7	Breast & colon	II-III	CV vs. combined	Onco Move Group (CV program): 5 days/w x 30 min/day; intensity: BORG Scale of 12-14. On Track Group (combined program): 3 days/w x 30 min (intensity: 50-80% based on Steep Ramp Test) + 2 days/w x 20 min x 2 sets x 8 rep. x 80% of one-repetition maximum.	VO_2 Peak	VO_2 peak decreased by 18% in the Onco Move group and by 12% in the On Track group.
Vincent *et al*	34	49	Breast	I-III	CV	Home-based walking aerobic exercise (3 days/w of 30-40 min sessions, with 50-60% from HR max intensity).	VO_2 Peak. Resting HR. Resting BP	VO_2 peak increased by 11% in the exercise group. No significant between-group differences in terms of HR and BP.

(Continued)

Study	Sample size	Mean age	Cancer site	Severity	Type of intervention	Intervention particularities	Outcome	Results
Survivor samples								
Adams *et al*	63	43.7	Testicular	Not reported	CV	Supervised treadmill program consisted of 3 days/w x 12 weeks, 35-min sessions and interval training (Ventilatory Threshold +4x4 min and intensity 75-95% from VO_2 peak).	VO_2 Peak. HR. BP. Cardiovascular disease risk. Carotid arteria morphology. Brachial arteria flow-mediated dilation	VO_2 peak increased by 11% in the exercise group. The exercise group showed higher carotid distensibility and brachial arteria diameter, and lower carotid intima-media thickness.
Brdareski *et al*	18	50.5	Breast	I-IIIA	CV	Group 1: Two days/w x 3 weeks and 15-min sessions (intensity: 45-65% VO_2 max). Group 2: Two days/w x 3 weeks and 15-min sessions (intensity: Borg Scale scores between 4-6).	VO_2 Peak.	VO_2 peak increased by 11% in the Group 1 and 18% in the Group 2.
Courneya *et al*	53	59	Breast	All stages	CV	Three days/w x 15-35 min (intensity: 70-75% from VO_2 peak).	VO_2 Peak.	VO_2 peak increased by 15% in the exercise group.
Herrero *et al*	16	50.5	Breast	I-II	Combined	Aerobic training: 3 days/w (intensity: 70-80% from HR max). Resistance Training: 3 days/w x 1-3 sets of 11 exercises and 8-15 rep. (intensity: 8-15 one-repetition maximum).	VO_2 Peak.	VO_2 peak increased by 8% in the exercise group.
Herrero *et al*	11	47	Breast	I-II	Combined	Training period: 3 days/w during eight w, 90-min sessions. After the intervention, participants were instructed to return following their sedentary lifestyle.	VO_2 Peak.	VO_2 peak decreased significantly after returning to sedentary lifestyle routines.
Hsieh *et al*	96	57.9	Breast	All	Combined	A program consisted of 2-3 weekly sessions of 60 min (intensity: 45-75% from HR reserve; not specified for resistance training).	VO_2 Peak. HR. BP.	The exercise group showed increases in VO_2 volume (over 16%) and resting HR.
Hutnick *et al*	49	50.4	Breast	All	Combined	Three days/w of 40-90 min. sessions. Aerobic Exercise: 10-20 min with intensity 60-70% from functioning capacity. Resistance training: Four upper & lower exercise x 1-3 sets of 8-12 rep.	HR peak.	HR peak increased in the exercise group from the 3-month follow-up after the intervention.
Jones *et al*	90	66	All (Cancer patients with heart failure)	II-IV	CV	A 3-Month program comprising supervised Exercise + home Sessions until 12 months. 3 days/w x 20-45 min (intensity: 60-70% from HR reserve).	VO_2 Peak. Cardiovascular risk profile.	VO_2 peak increased by 9% in the exercise group. No between-group differences in cardiovascular risk profile.
Jones *et al*	50	Not reported	Prostate	I-II	CV	Aerobic walking Exercise of 5 days/w x 30-45 min, a session (intensity: 55-100 from VO_2 peak).	VO_2 Peak. Brachial artery flow mediated dilation.	VO_2 peak increased by 9% in the exercise group. Higher brachial arterial diameter after the intervention only in the exercise group.

(Continued)

Study	Sample size	Mean age	Cancer site	Severity	Type of intervention	Intervention particularities	Outcome	Results
Musanti *et al*	42	50.5	Breast	I-IIIB	CV vs. ST vs. Combined vs. Others	Aerobic exercise Group: 3 days/w (intensity: 40-85% from HR reserve). Resistance Training Group: 3 days/w x 1 set of 10-12 rep (intensity: 3-8 from one-repetition maximum). Combined Exercise Group: 4-5 days/w aerobic training + 2 days/w resistance training.	VO_2 Peak.	No significant between-group differences reported.
Pinto *et al*	46	57.3	Colorectal	I-III	CV	12-week home-based physical activity counselling (2-5 days/w x 10-30 min, with intensity 64-76% from maximal HR).	VO_2 peak.	VO_2 peak: Conrol Group =Increased 15%. Exercise Group =Increased 32%
Rahnama *et al*	29	Range: 50-65 years old	Breast	I-IIIB	Combined	Aerobic Exercise: 2 days/w x 25-45 min sessions (intensity: 45-65% from HR maximum) + Resistance training: 2 days/w consisting of 3 sets x 10-14 rep. x 9 exercises.	VO_2 Peak. Resting HR. BP.	VO_2 peak increased by 15% in the exercise group. The exercise group showed significant decrease in resting HR and resting BP after intervention.
Rogers *et al*	41	53	Breast	I-IIIA	CV	Combined individual and collective group aerobic exercise group.	VO_2 Peak.	No significant between-group differences reported.
Rogers *et al*	222	54.4	Ductal Carcinoma & breast	I-IIIA	CV	Twelve sessions of supervised Exercise + 6 group discussion and individual Sessions. 3-5 days/w x 15-50 min.	VO_2 Peak.	VO_2 peak increased by 12% in the exercise group.
Schneider *et al*	113	55.9	Breast	Not reported	Combined	Combined individual aerobic + resistance exercise: 2-3 days/w of 60-min sessions. Aerobic exercise lasted 40 min (intensity: 40-75% from HR reserve). Resistance training lasted 10 min (intensity not specified).	VO_2 Peak. BP. Resting HR.	BP decreased while exercise intervention was delivered. Resting HR and BP decreased at post-intervention. Also, V02 peak increased by 13% in this condition.
Thorsen *et al*	111	39.1	Lymphoma, testicular, breast and other gynecologic Cancers	All stages	CV	Home-based program: 2 days/w x 30 min (13-15 based on BORG Scale).	VO_2 Peak	VO_2 peak: Control Group =Increased 3,1 ml/kg/min. Home Exercise Group =Increased 6,4 ml/kg/min

Note: The 33 bibliographic references included in Table 1 can be found online in Annex 1.

CV: cardiovascular training; ST: Strength; HR: heart rate; w: weeks; rep.: repetitions; VO_2 : Volume of oxygen consumed; BP: Blood pressure; LV: Left ventricle; LVEF: left ventricular ejection function; NT-proBNP: B-type natriuretic peptide; cTnT: Cardiac Troponin T.

Discussion

Our narrative review aimed to fill the research gap on how physical exercise may contribute to reduce cardiotoxicities associated with oncological treatments (chemotherapy, radiotherapy, hormonotherapy and / or immunotherapy).

Current diagnostic techniques are important to keep in mind when talking about cardiotoxicity: Diagnostic imaging and Biomarkers in cardio-oncology. Traditionally, left ventricular ejection fraction (LVEF) has been used (i.e., a 2D echocardiogram) to quantify cardiotoxicity (Figure 3). However, a cardiac injury may exist underlying an apparently 'normal' heart's ejection (i.e., without a decrease in the LVEF), as some authors have demonstrated significant false-positive rates of LVEF-based tools[34]. Cardiac Magnetic Resonance Imaging is considered as the gold standard for the assessment of systolic and diastolic cardiac function and allows for direct imaging of the myocardium[7] (Figure 4). Lately, cardiac biomarkers (e.g., troponin I, natriuretic peptide B-type) have emerged as a promising alternative to study cardiotoxicity.

However, inconsistent evidence and limited predictive value have found so far[7]. More recently, Galán-Arriola *et al.*,[35] have identified by serial multiparametric cardiac Magnetic Resonance, intracardiomyocyte edema in T2 mapping as the earliest marker of anthracycline cardiotoxicity, in the absence of T1 mapping, extracellular volume or left ventrical motion defects.

It seems to be that key elements behind any carcinogenic process is the dysregulation of signs controlling the proliferation of cellular division and inflammation[36]. By means of the regulation of certain proteins and hormonal levels in the bloodstream, physical exercise might prevent some chemical signs associated with cancer.

Reviewing the available evidence, it becomes evident that the etiology of cardiotoxicity is multifactorial. Nevertheless, it is clear that in the scientific literature, the following mechanisms related to molecular and cellular biology are repeated:

- Disorder and dysfunction of the Ryanodine receptors (RyR)[16,37].
- Disorder and dysfunction, both at a structural and contractile level, of the Myosin heavy chain (MHC)[24,38,39].
- Disorder and Dysfunction in the Tyrosine Kinase protein[40,41].
- Excess of production of Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS)[18,19].
- Deficiency and mitochondrial dysfunction[17,42,43].

Figure 3. 2D Echocardiography showing aberrant movement and hypokinesia of inferior wall and septum in a patient diagnosed of dilated myocardiopathy as a consequence of doxorubicin, trastuzumab and radiotherapy treatment for breast cancer.

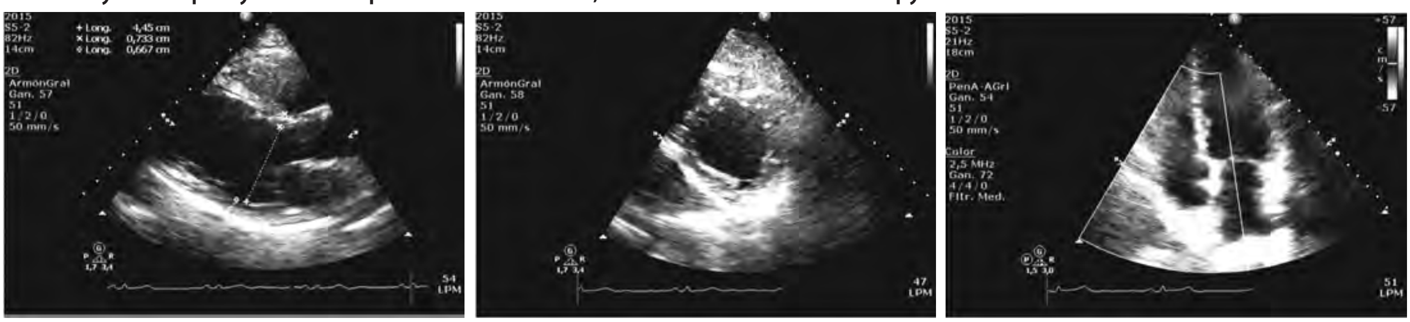
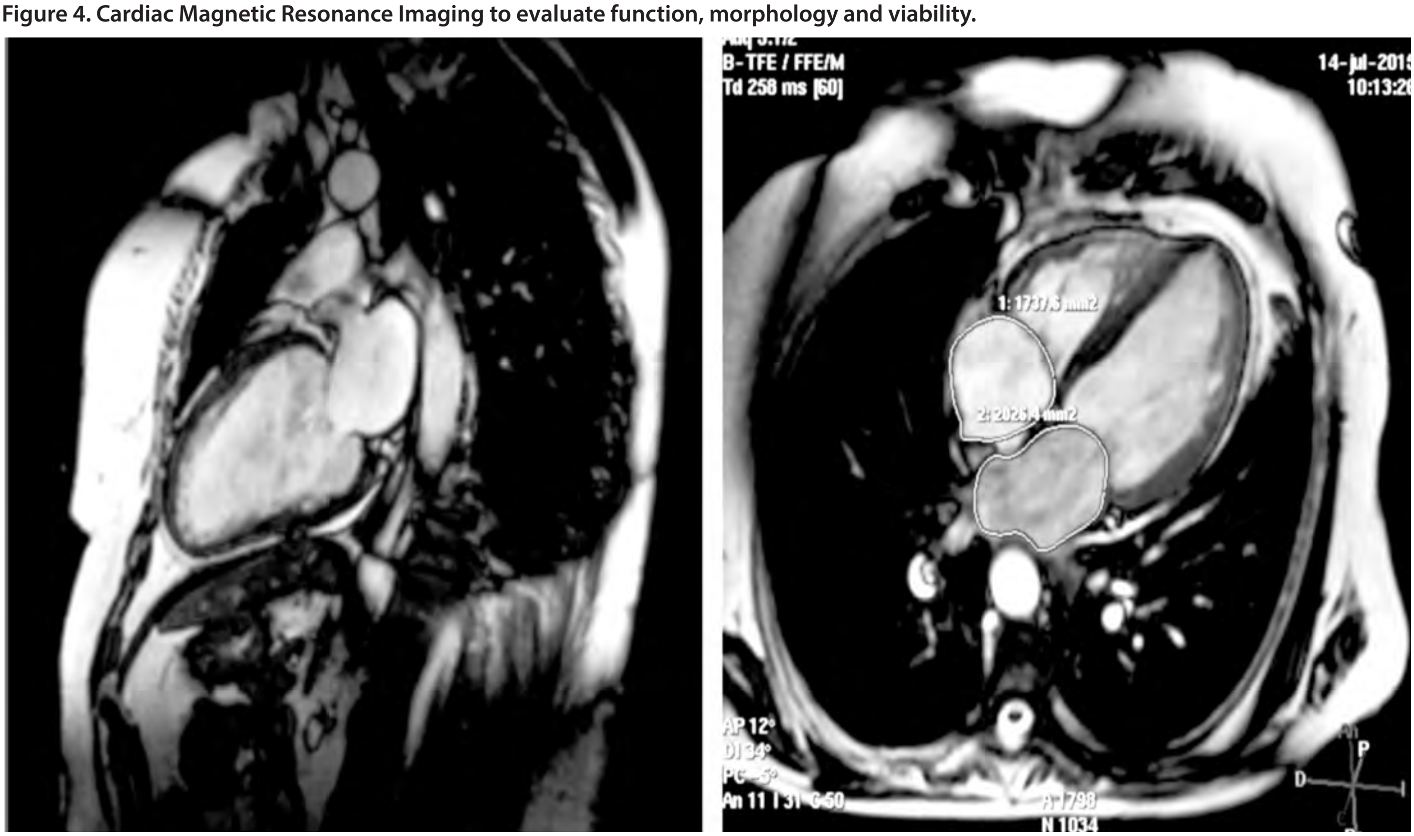


Figure 4. Cardiac Magnetic Resonance Imaging to evaluate function, morphology and viability.



Left ventricle lightly dilated and global hypokinesis with LVEF 31%, in a patient diagnosed with Hodgkin lymphoma 30 years before treated with radiotherapy.

The improvement of the vascularization tissue seems to improve not only the tissue oxygenation but also the action of the antitumor treatments. In the case of treatment with anthracyclines, physical exercise lightens these products in order to not be stored in the organism and generate toxic effects in the cardiovascular system[44,45].

It is important to emphasize the role accumulation of doxorubicin in muscular tissues of rats. This accumulation would explain the dysfunctions associated not only with the cardiovascular system, but also with the skeletal muscle system. Research literature found a reduction in the tumor size linked to exercise. Through physical exercise, the bioavailability of anthracyclines may improve, as well as the efficiency of the drug in its antitumor aspect.

Moreover, Pedersen *et al.*[46], demonstrated the immunological protective effect of exercise in mice. The interaction between epinephrine, muscular interleukin 6 and Natural Killer cells generated marked reductions in tumor incidence, growth and metastasis.

Exercise improves the vessel reactivity before the treatment of anthracyclines. In the group where physical exercise was carried out, vasoreactivity obtained values significantly better than the sedentary group.

Exercise interventions have been obtained results of improvement in cardiac function and cardiac damage markers during treatments with anthracyclines[30,32]. Perhaps with the knowledge that is currently available, said cardiac dysfunction may have been reduced or prevented by physical exercise before or during anthracycline treatments.

There are no exclusive strength interventions in humans trying to reduce CTC in oncological patients.

The fact to do a special mention of the strength training in this article, is related with the tumoral disease and with the consequences with respect to the organ we have focused: the heart. In cardiotoxicity with oncological origin 2 types of patients could be found from a medical point of view: one will be seen from the oncology focus, and the other from the pathology and functionality of cardiology.

The studies by Bredahl *et al.*[23] and Pfannenstiel *et al.*[24] focused on interventions using resistance exercise on Sprague-Dawley rats which cardiotoxicity were induced by doxorubicin. The intervention through physical exercise is done prior to the administration of doxorubicin. The resistance exercise allows to maintain levels of strength and prevent muscle mass loss induced by doxorubicin; one of the most common side effects in chemotherapy. Pfannenstiel *et al.*[24], shows that this muscle- protective effect could not only be quantified with respect to a greater muscle mass, but also in a lower mortality rate: 13% mortality in the strength group *vs* 27% sedentary group. The strength group also had a cardioprotective effect with respect to heart mass and function.

Although Cardiac Rehabilitation Units (CRU) are doing an excellent work, we based our proposal of strength training in Cardio-Oncology on 2 aspects:

– The levels of strength developed by the patients outside the CRU are higher to those developed inside the hospital units[47]. Thus, the goal of minimize the risk of accident by performing the higher intensity strength work into the CRU is questioned and encourages us to promote individualized exercise units that include strength exercise in cancer patients.
– Defining Repetition Maximum (RM) as the maximal weight that can be lifted once with correct lifting technique[48]. It is also considered the gold standard for assessing muscle strength in non-laboratory situations[48]. There are some examples in the literature in patients with heart disease in which the strength training was performed at intensities of 80-90% of 1 Repetition Maximum (1RM), in coronary patients[49-51], intensities up to 60% 1RM in bilateral work (both members), and up to 80% 1RM in unilateral work, in patients with heart failure with an ejection fractions of 20% according to NYHA Classification (New York Heart Association)[52]. This could be extrapolated to oncological patients with risk of CTC due to the treatments.

The World Health Organization[53] included specific strength work in its guides on Global Recommendations on Physical Activity for Health.

Traditionally, cardiovascular training has been considered as the most protective physical exercise applied in medicine. In the 80s of the twentieth century, exercise- based interventions in oncological patients have already been used[54]. Later on, the first guide that linked physical exercise and oncology was developed[54]. More recently, the experts in the delivery of exercise-based interventions in cancer patients recommend combined interventions, comprising cardiovascular and strength training[55].

Strength training components may yield very beneficial effects in cancer patients[56-58] improvements in cardiovascular function, increases in VO_2peak, a decrease in fatigue levels, increases in muscular strength and density of osseous mass, improvement in the quality of life, prevention of sarcopenia and dynapenia, and a decrease in the percentages of fat mass.

From early studies in exercise oncology until today, many advances linked to the clinical exercise physiology have been made. It has even been discovered that the skeletal muscle is an endocrine, exocrine and paracrine organ[59], and produced proteins (including different cytokines and peptides) are known as myokines.

At present, it is starting to be considered that physical exercise might generate, in each training session, peaks of chemical components, which could be used not only as co-adjuvant anticarcinogenic treatment[60], but also for 26 different chronic diseases[61]. We propose combined exercise interventions to reduce the risks of Cardiotoxicity in cancer patients as co-adjuvant treatment: Cardiovascular Training in combination with Strength Training. Recently, the AHA has confirmed this combined tailored exercise in his Cardio-Oncology Rehabilitation Statement[15].

Conclusions

Cancer treatments cause dysfunction in muscular tissue (cardiac, skeletal and smooth muscle) and loss of muscular strength. Physical exercise can offset the side effects of cancer treatments. There are biological reasons (cellular, molecular and biochemical release) that explain the cardiovascular and muscular protective effect of exercise in Exercise Oncology. It is advisable to introduce intervention programs with personalized physical exercise in cancer patients for the protective effects that it generates. Training interventions should comprise cardiovascular and muscular strength exercise with personalized frequencies, intensities and specific durations for every patient. It is necessary to avoid physical inactivity in patients with cancer.

References

1. Velásquez CA, González M, Berrouet MC, Jaramillo N. Cardiotoxicidad inducida por la quimioterapia desde las bases moleculares hasta la perspectiva clínica. *Rev Colomb Cardiol*. 2016;23:104-11.
2. Daher IN, Daigle TR, Bhatia N, Durand JB. The prevention of cardiovascular disease in cancer survivors. *Tex Hear Inst J.* 2012;39:190-8.
3. Shah CP, Moreb JS. Cardiotoxicity due to targeted anticancer agents: A growing challenge. *Ther Adv Cardiovasc Dis.* 2019; 13:1753944719843435.
4. Conway A, McCarthy AL, Lawrence P, Clark RA. The prevention, detection and management of cancer treatment-induced cardiotoxicity: A meta-review. *BMC Cancer.* 2015;15:366.
5. Coumbe BGT, Groarke JD. Cardiovascular autonomic dysfunction in patients with cancer. *Curr Cardiol Rep.* 2018;20:69.
6. Han X, Zhou Y, Liu W. Precision cardio-oncology: Understanding the cardiotoxicity of cancer therapy. *NPJ Precis Oncol.* 2017;1:31.
7. Levis BE, Binkley PF, Shapiro CL. Cardiotoxic effects of anthracycline-based therapy: What is the evidence and what are the potential harms? *Lancet Oncol.* 2017;18:e445–e456.
8. Valachis A, Nilsson C. Cardiac risk in the treatment of breast cancer: Assessment and management. *Breast Cancer Targets Ther.* 2015;7:21-35.
9. Heidenreich PA, Kapoor JR. Radiation induced heart disease. *Heart*. 2009;95:252-8.
10. Filopei J, Frishman W. Radiation-induced heart disease. *Cardiol Rev.* 2012;20:184-8.
11. Campia U, Barac A. Exercise and aerobic fitness to reduce cancer-related cardiovascular toxicity. *Curr Treat Options Cardiovasc Med*. 2016;18-44.
12. Sandercock G, Hurtado V, Cardoso F. Changes in cardiorespiratory fitness in cardiac rehabilitation patients: A meta-analysis. *Int J Cardiol.* 2013;167:894-902.
13. Van Deel ED, Octavia Y, de Waard MC, de Boer M, Duncker DJ. Exercise training has contrasting effects in myocardial infarction and pressure overload due to divergent endothelial nitric oxide synthase regulation. *Int J Mol Sci.* 2018;19.
14. Armenian S, Bhatia S. Predicting and preventing anthracycline-related cardiotoxicity. *Am Soc Clin Oncol Educ Book*. 2018;38:3-12.
15. Gilchrist SC, Barac A, Ades PA, Alfano CM, Franklin BA, Jones LW, *et al.* Cardio-oncology rehabilitation to manage cardiovascular outcomes in cancer patients and survivors: A scientific statement from the american heart association. *Circulation*. 2019; 139:e997-e1012.
16. Lu L, Mei DF, Gu AG, Wang S, Lentzner B, Gutstein DE, *et al.* Exercise training normalizes altered calcium-handling proteins during development of heart failure. *J Appl Physiol.* 2002;92:1524-30.
17. Marques-Aleixo I, Santos-Alves E, Torrella JR, Oliveira PJ, Magalhaes J, Ascensao A. Exercise and doxorubicin treatment modulate cardiac mitochondrial quality control signaling. *Cardiovasc Toxicol.* 2018;18:43-55.
18. Roy K, Wu Y, Meitzler JL, Juhasz A, Liu H, Jiang G, *et al*. NADPH oxidases and cancer. *Clin Sci*. 2015;128:863-75.
19. Szatrowski TP, Nathan CF. Production of large amounts of hydrogen peroxide by human tumor cells. *Cancer Res.* 1991;51:794-8.
20. Scott JM, Khakoo A, MacKey JR, Haykowsky MJ, Douglas PS, Jones LW. Modulation of anthracycline-induced cardiotoxicity by aerobic exercise in breast cancer: Current evidence and underlying mechanisms. *Circulation*. 2011;124:642-50.
21. Chen JJ, Wu PT, Middlekauff HR, Nguyen KL. Aerobic exercise in anthracycline-induced cardiotoxicity: A systematic review of current evidence and future directions. *Am J Physiol Circ Physiol.* 2016;312:H213-H222.
22. Scott JM, Nilsen TS, Gupta D, Jones LW. Exercise therapy and cardiovascular toxicity in cancer. *Circulation.* 2018;137:1176-91.
23. Bredahl EC, Pfannenstiel KB, Quinn CJ, Hayward R, Hydock DS. Effects of Exercise on doxorubicin-induced skeletal muscle dysfunction. *Med Sci Sport Exerc.* 2016;48:1468-73.
24. Pfannenstiel K, Hayward R. Effects of resistance exercise training on doxorubicin-induced cardiotoxicity. *J Cardiovasc Pharmacol.* 2018;71:332-9.
25. Rock CL, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya KS, Schwartz AL, *et al.* Nutrition and physical activity guidelines for cancer survivors. *CA Cancer J Clin.* 2012;62:242-74.
26. Cormie P, Atkinson M, Bucci L, Cust A, Eakin E, Hayes S, *et al.* Clinical oncology society of australia position statement on exercise in cancer care. *Med J Aust*. 2018;209:184-7.
27. Ascensao A, Magalhaes J, Soares JM, Ferreira R, Neuparth MJ, Marques F, *et al.* Moderate endurance training prevents doxorubicin-induced in vivo mitochondriopathy and reduces the development of cardiac apoptosis. *Am J Physiol Heart Circ Physiol.* 2005;289:H722-H731.
28. Chicco AJ, Schneider CM, Hayward R. Exercise training attenuates acute doxorubicin-induced cardiac dysfunction. *J Cardiovasc Pharmacol.* 2006;47:182-9.
29. Smuder AJ, Kavazis AN, Min K, Powers SK. Doxorubicin-induced markers of myocardial autophagic signaling in sedentary and exercise trained animals. *J Appl Physiol.* 2013;115:176-85.
30. Wonders KY, Hydock DS, Schneider CM, Hayward R. Acute exercise protects against doxorubicin cardiotoxicity. *Integr Cancer Ther*. 2008;7:147-54.
31. Jacquinot Q, Meneveau N, Chatot M, Bonnetain F, Degano B, Bouhaddi M, *et al.* A phase 2 randomized trial to evaluate the impact of a supervised exercise program on cardiotoxicity at 3 months in patients with her2 overexpressing breast cancer undergoing adjuvant treatment by trastuzumab: Design of the cardapac study. *BMC Cancer.* 2017;17425.
32. Kirkham AA, Shave RE, Bland KA, Bovard JM, Eves ND, Gelmon KA, *et al.* Protective effects of acute exercise prior to doxorubicin on cardiac function of breast cancer patients: A proof-of-concept rct. *Int J Cardiol*. 2017;245:263-70.
33. Haykowsky MJ, Mackey JR, Thompson RB, Jones LW, Paterson DI. Adjuvant trastuzumab induces ventricular remodeling despite aerobic exercise training. *Clin Cancer Res.* 2009;15:4963-7.
34. Todaro MC, Oreto L, Qamar R, Paterick TE, Carerj S, Khandheria BK. Cardioncology: State of the heart. *Int J Cardiol.* 2013;168:680-7.
35. Galán-Arriola C, Lobo M, Vílchez-Tschischke JP, López GJ, de Molina-Iracheta A, Pérez-Martínez C, *et al.* Serial magnetic resonance imaging to identify early stages of anthracycline-induced cardiotoxicity. *J Am Coll Cardiol.* 2019;73:779-91.
36. Ruiz-Casado A, Martín-Ruiz A, Pérez LM, Provencio M, Fiuza-Luces C, Lucia A. Exercise and the hallmarks of cancer. *Trends in Cancer.* 2017;3:423-41.
37. Hanna AD, Lam A, Tham S, Dulhunty AF, Beard NA. Adverse effects of doxorubicin and its metabolic product on cardiac r y r2 and serca2a. *Mol Pharmacol.* 2014; 86: 438-49.
38. Hydock DS, Lien C-Y, Schneider CM, Hayward R. Effects of voluntary wheel running on cardiac function and myosin heavy chain in chemically gonadectomized rats. Am *J Physiol Circ Physiol*. 2007;293:H3254–H3264.
39. Hydock DS, Lien CY, Schneider CM, Hayward R. Exercise preconditioning protects against doxorubicin-induced cardiac dysfunction. *Med Sci Sport Exerc*. 2008;40:808-17.
40. Orphanos GS, Ioannidis GN, Ardavanis AG. Cardiotoxicity induced by tyrosine kinase inhibitors. Acta Oncol Madr. 2009;48:964-70.
41. Vermaete N, Wolter P, Verhoef G, Gosselink R. Physical activity, physical fitness and the effect of exercise training interventions in lymphoma patients: A systematic review. *Ann Hematol.* 2013;92:1007-21.
42. Zhou S, Starkov A, Froberg MK, Leino RL, Wallace KB. Cumulative and irreversible cardiac mitochondrial dysfunction induced by doxorubicin. *Cancer Res*. 2001;61:771-7.
43. Wallace KB. Adriamycin-induced interference with cardiac mitochondrial calcium homeostasis. *Cardiovasc Toxicol.* 2007;7:101-7.
44. Gibson NM, Greufe SE, Hydock DS, Hayward R. Doxorubicin-induced vascular dysfunction and its attenuation by exercise preconditioning. *J Cardiovasc Pharmacol.* 2013;62:355-60.
45. Jensen BT, Lien CY, Hydock DS, Schneider CM, Hayward R. Exercise mitigates cardiac doxorubicin accumulation and preserves function in the rat. *J Cardiovasc Pharmacol.* 2013;62:263-9.
46. Pedersen L, Idorn M, Olofsson GH, Lauenborg B, Nookaew I, Hansen RH, *et al.* Voluntary running suppresses tumor growth through epinephrine- and il-6-dependent nk cell mobilization and redistribution. *Cell Metab.* 2016;23:554-62.
47. Adams J, Cline M, Reed M, Masters A, Ehlke K, Hartman J. Importance of resistance training for patients after a cardiac event. *Proc Bayl Univ Med Cent.* 2006;19:246-8.
48. Seo DI, Kim E, Fahs CA, Rossow L, Young K, Ferguson SL, *et al.* Reliability of the one-repetition maximum test based on muscle group and gender. *J Sports Sci Med.* 2012;11:221-5.
49. Crozier Ghilarducci LE, Holly RG, Amsterdam EA. Effects of high resistance training in coronary artery disease. *Am J Cardiol.* 1989;64:866-70.
50. Beniamini Y, Rubenstein JJ, Zaichkowsky LD, Crim MC. Effects of high-intensity strength training on quality-of-life parameters in cardiac rehabilitation patients. *Am J Cardiol.* 1997;80:841-6.
51. Karlsen T, Helgerud J, Støylen A, Lautitsen N, Hoff J. Maximal strength training restores walking mechanical effeciency in heart patients. *Int J Sport Med.* 2009;30:337-42.
52. Volaklis KA, Tokmakidis SP. Resistance Exercise training in patients with heart failure. *Sport Med.* 2005;35:1085-103.

53. World Health Organization. World recommendations on physical activity for health. 2010.

54. Winningham ML, MacVicar MG, Burke CA. Exercise for cancer patients: guidelines and precautions. *Phys Sportsmed.* 1986;14:125-34.

55. De Backer IC, Schep G, Backx FJ, Vreugdenhil G, Kuipers H. Resistance training in cancer survivors: A systematic review. *Int J Sport Med*. 2009;30:703-12.

56. Volaklis KA, Halle M, Meisinger C. Muscular strength as a strong predictor of mortality: A narrative review. *Eur J Intern Med.* 2015;26:303-10.

57. Strasser B, Steindorf K, Wiskemann J, Ulrich CM. Impact of resistance training in cancer survivors: A meta-analysis. *Med Sci Sport Exerc.* 2013;45:2080-90.

58. Serra MC, Ryan AS, Ortmeyer HK, Addison O, Goldberg AP. Resistance training reduces inflammation and fatigue and improves physical function in older breast cancer survivors. *Menopause*. 2018;25:211-6.

59. Giudice J, Taylor JM. Muscle as a paracrine and endocrine organ. *Curr Opin Pharmacol.* 2017;34:49-55.

60. Dethlefsen C, Pedersen KS, Hojman P. Every exercise bout matters: Linking systemic exercise responses to breast cancer control. *Breast Cancer Res Treat.* 2017;162:399-408.

61. Pedersen BK, Saltin B. Exercise as medicine – Evidence for prescribing exercise as therapy in 26 different chronic diseases. *Scand J Med Sci Sports.* 2015;25:1-72.

Annex 1. List of 33 studies references included in the Narrative Review.

- MacVicar MG, Winingham ML, Nickel JL. Effects of aerobic interval training on cancer patient´s functional capacity. *Nurs Res.* 1989;38(6):348-51.
- Segal R, Evans W, Johnson D, Smith J, Colletta S, Gayton J, *et al*. Structured exercise improves physical functioning in women with stages I and II breast cancer: Results of a randomized controlled trial. *J Clin Oncol.* 2001;19(3):657-65.
- Courneya KS, Segal RJ, Mackey JR, Gelmon K, Reid RD, Friedenreich CM, *et al*. Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: A multicenter randomized controlled trial. *J Clin Oncol.* 2007;25(28):4396-404.
- Courneya KS, Sellar CM, Stevinson C, McNeely ML, Peddle CJ, Friedenreich CM, *et al.* Randomized controlled trial of the effects of aerobic exercise on physical functioning and quality of life in lymphoma patients. *J Clin Oncol*. 2009;27(27):4605-12.
- Segal RJ, Reid RD, Courneya KS, Sigal RJ, Kenny GP, Prud`Homme DG, *et al.* Randomized controlled trial of resistance or aerobic exercise in men receiving radiation therapy for prostate cancer. *J Clin Oncol.* 2009;27(3):344-51.
- Courneya KS, McKenzie DJ, Mackey JR, Gelmon K, Friedenreich CM, Yasui Y, *et al.* Effects of exercise dose and type during breast cancer chemotherapy: Multicenter randomized trial. *J Natl Cancer Inst.* 2013;105(23):1821-32.
- Jones LW, Fels DR, West M, Allen JD, Broadwater G, Barry WT, *et al*. Modulation of circulating angiogenic factors and tumor biology by aerobic training in breast cancer patients receiving neoadjuvant chemotherapy. *Cancer Prev Res (Phila)*. 2013;6(9):925-37.
- Van Waart H, Stuiver MM, Van Harten WH, Geleijn E, Kieffer JM, Buffart LM, *et al.* Effect of low-intensity physical activity and moderate- to high-intensity physical exercise during adjuvant chemotherapy completion rates: Results of the paces randomized clinical trial. *J Clin Oncol.* 2015;33(17):1918-27.
- Scott JM, Nilsen TS, Gupta D, Jones LW. Exercise therapy and cardiovascular toxicity in cancer. *Circulation.* 2018;137(11):1176-1191.
- Kirkham AA, Shave RE, Bland KA, Bovard JM, Eves ND, Gelmon KA, *et al.* Protective effects of acute exercise prior to doxorubicin on cardiac function of breast cancer patients: A proof of concept RCT. *Int J Cardiol.* 2017;245:263-270.
- Courneya KS, Mackey JR, Bell GJ, Jones LW, Field CJ, Fairey AS. Randomized controlled trial of exercise training in postmenopausal breast cancer survivors: Cardiopulmonary and quality of life outcomes. *J Clin Oncol*. 2003;21(9):1660-8.
- Thorsen L, Skovlund E, Stromme SB, Hornslien K, Dahl AA, Fossa SD. Effectiveness of physical activity on cardiorespiratory fitness and health-related quality of life in young and middle-aged cancer patients shortly after chemotherapy. *J Clin Oncol.* 2005;23(10):2378-88.
- Pinto BM, Papandonatos GD, Goldstein MG, Marcus BH, Farrell N. Home-based physical activity intervention for colorectal cancer survivors. *Psychooncology.* 2013;22(1):54-64.
- Jones LW, Douglas PS, Khouri MG, Mackey JR, Wojdyla D, Kraus WE, *et al.* Safety and efficacy of aerobic training in patients with cancer who have heart failure: An analysis of the hf-action randomized trial. *J Clin Oncol.* 2014;32(23):2496-502.
- Jones LW, Hornsby WE, Freedland SJ, Lane A, West MJ, Moul JW, *et al.* Effects of nonlinear aerobic training on erectile dysfunction and cardiovascular function following radical prostatectomy for clinically localized prostate cancer. *Eur Urol.* 2014;65(5):852-5.
- Rogers LQ, Courneya KS, Anton PM, Hopkins-Price P, Verhulst S, Vicari SK, *et al.* Effects of the BEAT cancer physical activity behavior change intervention on physical activity, aerobic fitness, and quality of life in breast cancer survivors: A multicenter randomized controlled trial. *Breast Cancer Res Treat.* 2015;149(1):109-19.
- Adams SC, Delorey DS, Davenport MH, Stickland MK, Fairey AS, North S, *et al.* Effects of high-intensity aerobic interval training on cardiovascular disease risk in testicular cancer survivors: A phase 2 randomized controlled trial. *Cancer.* 2017;123(20):4057-4065.
- Haykowsky MJ, Mackey JR, Thompson RB, Jones LW, Paterson DI. Adjuvant trastuzumab induces ventricular remodeling despite aerobic exercise training. *Clin Cancer Res*. 2009;15(15):4963-7.
- Hornsby WE, Douglas PS, West MJ, Kenjale AA, Lane AR, Schwitzer ER, *et al.* Safety and efficacy of aerobic training in operable breast cancer patients receiving neoadjuvant chemotherapy: A phase II randomized trial. *Acta Oncol.* 2014;53(1):65-74.
- Kim CJ, Kang DH, Smith BA, Landers KA. Cardiopulmonary responses and adherence to exercise in women newly diagnosed with breast cancer undergoing adjuvant therapy. *Cancer Nurs*. 2006;29(2):156-65.
- Brdareski Z, Djurovic A, Susnjar S, Zivotic-Vanovic M, Ristic A, Konstantinovic L, *et al.* Effects of a short-term differently dosed aerobic exercise on maximum aerobic capacity in breast cancer survivors: A pilot study. *Vojnosanit Pregl.* 2012;69(3):237-42.
- Dolan LB, Gelmon K, Courneya KS, Mackey JR, Segal RJ, Lane K, *et al.* Hemoglobin and aerobic fitness changes with supervised exercise training in breast cancer patients receiving chemotherapy. *Cancer Epidemiol Biomarkers Prev.* 2010;19(11):2826-32.
- Herrero F, San Juan AF, Fleck SJ, Balmer J, Pérez M, Cañete S, *et al.* Combined aerobic and resistance training in breast cancer survivors: A randomized, controlled pilot trail. *Int J Sports Med.* 2006;27(7):573-80.
- Herrero F, San Juan AF, Fleck SJ, Foster C, Lucía A. Effects of detraining on the functional capacity of previously trained breast cancer survivors. *Int J Sports Med*. 2007;28(3):257-64.
- Hsieh CC, Sprod LK, Hydock DS, Carter SD, Hayward R, Schneider CM. Effects of a supervised exercise intervention on recovery from treatment regimens in breast cancer survivors. *Oncol Nurs Forum*. 2008;35(6):909-15.
- Hutnick NA, Williams NI, Kraemer WJ, Orsega-Smith E, Dixon RH, Bleznak AD, *et al.* Exercise and lymphocyte activation following chemotherapy for breast cancer. *Med Sci Sports Exerc.* 2005;37(11):1827-35.
- Kolden GG, Strauman TJ, Ward A, Kuta J, Woods TE, Schneider KL, *et al.* A pilot study of group exercise training (GET) for women with primary breast cancer: Feasibility and Health benefits. *Psychooncology.* 2002;11(5):447-56.
- Ligibel JA, Partridge A, Giobbie-Hurder A, Campbell N, Shockro L, Salinardi T, *et al.* Physical and psychological outcomes among women in a telephone-based exercise intervention during adjuvant therapy for early stage breast cancer. *J Womens Health (Larchmt)*. 2010;19(8):1553-9.
- Musanti R. A study of exercise modality and physical self-esteem in breast cancer survivors. *Med Sci Sports Exerc*. 2012;44(2):352-61.
- Rahnama N, Nouri R, Rahmaninia F, Damirchi A, Emami H. The effects of exercise training on maximum aerobic capacity, resting heart rate, blood pressure and anthropometric variables of postmenopausal women with breast cancer. *J Res Med Sci*. 2010;15(2):78-83.
- Rogers LQ, Hopkins-Price P, Vicari S, Pamenter R, Courneya KS, Markwell S, *et al*. A randomized trial to increase physical activity in breast cancer survivors. *Med Sci Sports Exerc*. 2009;41(4):935-46.
- Schneider CM, Hsieh CC, Sprod LK, Carter SD, Hayward R. Effects of supervised exercise training on cardiopulmonary function and fatigue in breast cancer survivors during and after treatment. *Cancer.* 2007;110(4):918-25.
- Vincent F, Labourey JL. Leobon S, Antonini NT, Lavau-Denes S, Tubiana-Mathieu N. Effects of a home-based walking training program in cardiorespiratory fitness in breast cancer patients receiving adjuvant chemotherapy: A pilot study. *Eur J Phys Rehabil Med.* 2013;49(3):319-29.

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Campaña de aptitud física, deporte y salud

La **Sociedad Española de Medicina del Deporte**, en su incesante labor de expansión y consolidación de la Medicina del Deporte y, consciente de su vocación médica de preservar la salud de todas las personas, viene realizando diversas actuaciones en este ámbito desde los últimos años.

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

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