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Summary / Sumario

Have dietary recommendations really changed in the 21st century? Are there any new challenges?

¿Han cambiado realmente las recomendaciones dietéticas en el siglo XXI? ¿Tenemos nuevos retos?

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The evolution of standardised food models manifests from the classic concept of clinical symptom prevention in its earliest stages (1802 Smith, 1919 Royal Society London, 1933 British Medical Association, 1941 National Research Council United States, 1945 FAO)[1] to the current concept in the prevention and risk reduction of chronic illnesses, improvement and maintenance of an optimum state of health.

The first recommended energy and nutrient intakes for the Spanish populations date back to 1994, with the proposal of the Nutrition Department of the Complutense University of Madrid (Varela G). That very same year, unified recommendations were edited in Europe[2], and in the USA the first publication is from 1989 (Recommended Dietary Allowances - RDA)[3].

Since the start of 2000, changes in lifestyle, with increased physical inactivity, chronic illnesses and life expectancy, along with trends of consuming enriched or fortified, functional and diet foods, that may positively or negatively influence the daily intake of nutrients, and the rapid advance of scientific knowledge in the fields of nutrition and health, have forced each country to regularly review and update the standards for their populations. In Europe, the European Food Safety Authority (EFSA) is the body that edits the unified recommendations via regular communications[4-7].

Therefore, currently the terminology has been consolidated internationally to distinguish the different concepts used. The Estimated Average Requirement (EAR), the Low Threshold Intake (LTI), the Tolerable Upper Intake Levels (UL)[8-10] and the Dietary Reference Intakes (DRIs) in the USA or Dietary Reference Values (DRVs) in Europe[4,5].

Dietary Reference Values are recommendations for the daily intake of energy and the most important nutrients for healthy populations by age, sex and physiological situation, which cover the requirements of 97%-98% of the population. They are developed from clinical, epidemiological and experimental data, with the aim of responding to physiological needs and of reducing the risk of chronic and/or degenerative illnesses (cardiovascular illnesses, diabetes, osteoporosis, cancer and others). They are adapted to both sexes with age ranges spanning from the first months of life to over 60 years of age, through situations of pregnancy, breastfeeding and regular physical efforts of light and high intensity. They can also be used as a reference in individual NV adjustments.

It is intended for the average population to cover the established reference intakes - DRIs-DVRs - with as few people as possible below the nutritional requirements and with no one falling below or above the two extremes (LTI) and the safety limit (UL).

The recommended energy and nutrient intakes for the Spanish population comprise: energy (light - 10%, high +20%), proteins, minerals (calcium, iron, iodine, zinc, potassium, selenium), vitamins (Group B, C, A, D, K). They also include reference values for carbohydrates, fats (linoleic acid, linolenic acid), fibre and water, just as in the EFSA and the US equivalent[4-7, 11].

The interpretation and use of the DRIs-DVRs requires intervention from qualified professionals from the health field, both on an individual and collective level (preventive, clinical, research), education (training and dissemination programmes), health authorities and particularly in public health (dietary and eating guides), the agro-food and hospitality industry (labelling and nutritional information)[3, 8]. From the perspective of health professionals, they can be used as reference values, not only to plan diets for specific groups or communities (diabetics, athletes, etc.) and to identify populations at risk, but also to create individual diets after performing a nutritional assessment.

The practical way of transmitting scientific recommendations in healthy eating habits to the general public, including athletes, are eating and/or dietetic guides edited by national entities, scientific societies, the World Health Organisation (WHO), and the United Nations Food and Agriculture Organisation (FAO)[11-19].

From what we have been able to establish up to now, in the 21st century we have established guidelines for keeping the reference intake values actively updated in a more agile and quicker way, with scientific

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knowledge, clinical, epidemiological and experimental data, for sharing healthy dietary habits and for reaching a stable level of maintaining an optimal state of health in the population.

Do we not have any new challenges? Of course we do, mainly aimed at obtaining more assessment data regarding individual needs to adjust the dietary reference values, reaching the average citizen and establishing correct eating habits to have a positive repercussion on the state of health:

To obtain the largest possible amount of epidemiological data from individual needs, achieved through nutritional assessments considering metabolic and physiological adaptation, food availability and the customised dietary adjustments that should be used to correct errors and to introduce healthy habits and to prevent doping[3,20].

For those responsible for health policies to promote the study of food consumption models, to design campaigns and food and dietary guides, as well as assessing and following them up[5].

To get citizens used to keeping good eating habits, facilitating research and the harmonisation between the different professionals in the field of nutrition, dietetics and food.

References

1. Vivanco F, Palacios JM, García Almansa A. Necesidades calóricas o energéticas. Alimentación y nutrición. Ministerio de Sanidad y Consumo. Bilbao 1982;128-9.
2. Comité scientifique pour l'alimentation humaine (CSAH). Substances nutritives et consommation énergétique (avis émis le 11 décembre 1992). Commission européenne. Direction générale de l'industrie. Luxembourg: Office des publications officielles des communautés européennes, 1994.
3. Martin, G. Potier de Courcy. Besoins nutritionnels et apports conseillés pour la satisfaction de ces besoins. EMC - *Endocrinologie-Nutrition* 2012:1-26 [Article 10-308-A-10].
4. Moreiras Tuni O, Carbajal A, Cabrera Forneiro L, Cuadrado Vives C. *Ingestas recomendadas de energía y nutrientes para la población española (revisadas y ampliadas 2016)* Departamento de Nutrición Universidad Complutense Madrid. Tablas de composición de alimentos. Guía de prácticas, 18ª ed. Madrid: Pirámide. 2015;257-9.
5. EFSA sets European dietary reference values for nutrient intakes (2010-03-26). Disponible en: https://www.efsa.europa.eu/en/press/news/nda100326
6. United States Department of Agriculture (USDA). National Agricultural Library https://www.nal.usda.gov/fnic/dietary-reference-intakes
7. Food and Nutrition Board, Institute of Medicine, National Academies Washington DC: National Academy Press. Dietary Reference Intakes for Calcium, Phosphorous, Magnesium, Vitamin D, and Fluoride (1997); Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline (1998); Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000); Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2001); Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate (2005); and Dietary Reference Intakes for Calcium and Vitamin D (2011). These reports may be accessed via www.nap.edu.
8. Scientific Opinion on principles for deriving and applying Dietary Reference Values. *EFSA Journal* 2010; 8(3):1458 [30 pp.]. doi: 10.2903/j.efsa.2010.1458. Disponible en: https://www.efsa.europa.eu/en/print/efsajournal/pub/1458
9. Dietary Reference Intakes: Tolerable Upper Intake Level Values for Vitamins and Elements NAS. IOM. Food and Nutrition Board. Comprehensive DRI tables for vitamins, minerals and macronutrients; organized by age and gender. Includes the 2011 updated recommendations for calcium and vitamin D. These reports may be accessed via www.nap.edu.
10. European Food Safety Authority (EFSA). Tolerable Upper Intake Levels for Vitamins and Minerals by the Scientific Panel on Dietetic products, nutrition and allergies (NDA) and Scientific Committee on Food (SCF). European Food Safety Authority 2006. Disponible en: https://www.efsa.europa.eu/sites/default/files/assets/ndatolerableuil.pdf
11. Moreiras Tuni O, Carbajal A, Cabrera Forneiro L, Cuadrado Vives C. *Calidad de la dieta y objetivos nutricionales para la población española.* Departamento de Nutrición Universidad Complutense Madrid. Tablas de composición de alimentos. Guía de prácticas, 18ª ed. Madrid: Pirámide. 2015; 274-81.
12. Ministerio de Agricultura Alimentación y medio Ambiente. Disponible en: http://www.alimentacion.es/es/campanas/
13. Ministerio De Sanidad Asuntos Sociales e Igualdad. Agencia Española de Consumo, Seguridad Alimentaria y Nutrición (AECOSAN). Disponible en: http://www.aecosan.msssi.gob.es/AECOSAN/web/home/aecosan_inicio.htm
14. Organización Mundial de la Salud (OMS) - World Health Organization (WHO) Disponible en: http://www.who.int/mediacentre/factsheets/fs394/es/
15. Organización de las Naciones Unidas para la Alimentación y la Agricultura - Food and Agriculture Organization (FAO). Disponible en: http://www.fao.org/nutrition/educacion-nutricional/food-dietary-guidelines/home
16. Dietary guidelines for americans. Disponible en: https://health.gov/dietaryguidelines/2015/guidelines/
17. Academy of Nutrition and Dietetic. Disponible en: http://www.eatright.org/
18. Health Canada. Disponible en: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php
19. Dietitians of Canad. Disponible en: http://www.dietitians.ca/
20. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *J Acad Nutr Diet.* 2016 Mar;116(3):501-28. doi: 10.1016/j.jand.2015.12.006.

The effect of weekly low frequency exercise on body composition and blood pressure of elderly women

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Summary

Introduction: Regular physical activity can provide several benefits for human health, including improvements in cardiovascular, muscular and endocrine systems as well as in body composition. The aim of this pilot study was to analyze the effect of low frequency exercise (once *vs.* twice per week) on the body composition and blood pressure of elderly women who participated in a public exercise program.
Methods: Fifty-five sedentary elderly women, aged between 60 and 80 years, were evaluated by weight, stature, anthropometric measures (waist, abdomen, and hip) and systolic and diastolic blood pressure. The participants were divided into two groups: G1 performed exercise once a week and G2 performed exercise twice a week. Over six months the participants performed a combined program of aerobic exercise (walking and gymnastic aerobics) and strength exercise (using elastic bands, balls and bats). All exercise sessions lasted 60 minutes.
Results: The results showed body composition improvements for both groups in waist (G1: p= 0.002; G2: p= <0.001) and abdomen (G1: p= 0.014; G2: p= 0.001) measurements, percentage body fat (G1: p= 0.010; G2: p= 0.007) and waist–hip ratio (G1: p= 0.037; G2: p= <0.001) as well as in systolic (G1: p= <0.001; G2: p= <0.001) and diastolic blood pressure (G1: p= 0.001; G2: p= 0.014), except in fat free mass which was found only in G1 (p= 0.001). However, there were no significant differences between the groups in any variables.
Conclusion: It was concluded that this exercise, independent of the frequency (once or twice a week), resulted in improvements in body composition variables and blood pressure; however, no differences were found in the percentage of variation between both groups.

Key words:
Blood pressure.
Body composition.
Elderly women.
Weekly frequency.

El efecto de baja frecuencia semanal del ejercicio sobre la composición corporal y la presión arterial de las mujeres ancianas

Resumen

Introducción: La actividad física regular puede proporcionar varios beneficios para la salud humana, incluyendo mejoras en el sistema cardiovascular, muscular y endocrino, y en la composición corporal. El objetivo de este estudio piloto fue analizar el efecto de la frecuencia semanal del ejercicio (una vez vs. dos veces) sobre la composición corporal y la presión arterial de las mujeres ancianas que participaron en un programa público del ejercicio.
Métodos: Se evaluaron 55 mujeres ancianas sedentarias, con edades comprendidas entre 60 y 80 años, por la masa corporal, estatura, medidas antropométricas (de la cintura, el abdomen y cadera) y la presión arterial sistólica y diastólica. Las participantes fueron divididas de acuerdo con sus posibilidades en dos grupos: G1 (realizada una vez a la semana de ejercicio) y G2 (realizado dos veces a la semana de ejercicio) y durante 6 meses las participantes realizaron un entrenamiento combinado compuesto de ejercicio aeróbico (caminar y gimnasia) y ejercicio de fuerza usando bandas elásticas, pelotas y canes de un programa de ejercicios. Todas las sesiones de ejercicio tuvieran una duración de 60 minutos.
Resultados: Los resultados mostraron que ambos grupos tuvieron mejoras en la composición corporal de la cintura (G1: p = 0,002; G2: p = <0,001), el abdomen (G1: p = 0,014; G2: p = 0,001), porcentaje de grasa corporal (G1: p = 0,010; G2: p = 0,007) y la relación cintura cadera (G1: p = 0,037; G2: p = <0,001) la presión arterial sistólica (G1: p = <0,001; G2: p = <0,001) y en la sangre diastólica presión (G1: p = 0,001; G2: p = 0,014), excepto en la masa libre de grasa que se encuentra sólo en el grupo uno (p= 0,001). Sin embargo, no hubo diferencia significativa entre los grupos en todas las variables.
Conclusión: Se concluye que independientemente de la frecuencia de ejercicio (una o dos veces a la semana), se observaron mejoras en las variables de composición corporal y la presión arterial. Y, sin embargo, no encontramos diferencias en la variación porcentual entre ambos grupos.

Palabras clave:
Tensión arterial.
Composición corporal.
Mujeres ancianas.
Frecuencia semanal.

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Introduction

The aging process can lead to impairment in women's health, particularly when they are sedentary. A decrease in cardiorespiratory capacity can be observed, increasing risk factors associated with coronary heart disease[1,2], increased fat mass and weight[3,4], decreased strength and muscle mass[5,6], decreased bone mineral density[7], decreased dynamic stability[8,9] and decreased functional capacity[10,11]. Thus, the sum of all these cited factors leads to a worsening of the quality of life[12,13].

The number of sedentary people in the world is high, mainly among the elderly[14]. This condition, associated with a diet rich in carbohydrates and saturated fats, leads to increased fat mass, weight and body mass index, causing several health problems[15,16]. Normally, this population takes medication for several diseases, such as diabetes, hypertension, high cholesterol and other pathologies; however the inclusion of exercise in daily routines could modify this situation.

There is some evidence that exercise and lifestyle change (moderation of alcohol consumption, dietary changes, weight reduction, smoking cessation) is a sufficient nonpharmacological way to reduce the risk of morbidity, mainly in hypertensive subjects, even at an advanced age[17]. Exercise can produce significant hemodynamic changes and increase muscle blood flow, nitric oxide production and alpha 1 and 2 adrenergic receptor density in skeletal muscles[18]. Mota *et al.*[19] found a significant decrease in the blood pressure of elderly sedentary women who took part in a resistance training protocol three times per week over 16 weeks. In relation to the other variable, Aragão *et al.*[7] found significant differences in the total body fat, muscle mass and lean mass of elderly women who performed a multicomponent exercise training program three times per week for 12 months. These improvements in blood pressure and body composition may decrease the risk of morbidity.

To enable an increase in muscle strength and cardiorespiratory capacity in adults, ACSM[20] guidelines recommend 30 minutes or more of physical activity, preferably every day of the week or, if that frequency is not possible, at least 20 minutes of vigorous intensity exercise three times per week. However, with this population it is difficult to carry out physical activity programs with a frequency of three times per week or more, because of the lack of adherence. Studies have shown low adherence when an exercise program greatly increases in volume or intensity[21,22].

It is known that exercise of an appropriate volume can cause changes to body composition and some haemodynamic variables; however can this also be observed with weekly training of a low frequency?

Thus, this pilot study aimed to analyze the effect of weekly exercise frequency (once vs. twice) on the body composition and blood pressure of elderly women who participated in a public exercise program for six months.

Material and method

Study design

This was an experimental pilot study involving six months of intervention within the public program "Live Well". This program was introduced in the state of Rio Grande do Sul (southern region of Brazil).

Participants

Before the start of the program, different advertising methods (visits within the community, newspapers, internet, posters, radio, etc.) were used to invite the elderly to participate. The inclusion criteria were as follows: elderly sedentary women; aged 60–80; not suffering from chronic diseases or musculoskeletal disorders; no uncontrolled hypertension (systolic arterial pressure >200 mmHg and diastolic arterial pressure >105 mmHg); no use of β-blockers or antiarrhythmic medication; and no positive responses to the seven questions of the Physical Activity Readiness Questionnaire (PAR-Q) which relate to their health status. However, as some participants were over 69 years old, they were advised to check with their doctor, even if they had negative responses. If the participants answered "yes" to any of the questions, they were excluded from the program[23,24].

One hundred and fourteen participants enrolled in the program; however due to the exclusion criteria (uncontrolled hypertension and diabetes = 17; positive responses to questions of the PAR-Q = 5), 22 of the women could not participate in the program and were advised to seek medical attention. After screening, all of the 92 selected participants were informed by telephone about their random allocation in one of the two exercise protocol groups (once or twice a week). The first group (G1) was composed of 41 participants who performed one session of exercise per week. The second group (G2) was composed of 51 participants who performed two sessions per week. They agreed to maintain their baseline level of physical activity for the duration of the study.

Before starting the exercise program, some participants were already taking diuretics, statins and insulin sensitizers; all medicaments were unchanged until the end of the program. The research design was developed according to the Declaration of Helsinki. All volunteers signed a form consenting to participate in the study.

All participants completed a three day food intake questionnaire before intervention. These three days included two nonconsecutive weekdays and one weekend and were overseen by a nutritionist. They were instructed to maintain their usual diet for the duration of the program[25].

After participant recruitment and admission, data were collected in the initial stage of the program and six months after. Only 55 of the 92 volunteers who began the program finished the six months of training because of health problems or low frequency (attending less than 80% of the total classes). Therefore, only the data of these 55 participants were used for analysis, comprising 25 subjects in G1 (once a week) and 30 subjects in G2 (twice a week); the average age and education level (years of schooling) in the two groups were 67.32 ± 6.27, 8.14 ± 1.0 and 65.57 ± 5.21, 9.96 ± 2.85 for G1 and G2, respectively.

Data collection

In the first two weeks all participants were evaluated. On arrival, they remained seated in a quiet room for 30 minutes, to assess blood pressure. Blood pressure was evaluated with an ambulatory blood pressure device (Micromed, model ABPM-04, Porto Alegre, Brazil) placed on the subjects' non-dominant arm. The cuff was completely wrapped, covering at least two thirds of the upper arm. The participants were instructed to avoid caffeine on the day of their visit and not to perform physical activities for at least 24 hours prior to the evaluation[26]. This procedure was in accordance with the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC7)[27].

After blood pressure evaluation, the participants were moved to another room for anthropometric measurements (body mass, height and circumference of waist, abdomen and hip) to be taken. Body mass was measured in kilograms (kg) using a Plena scale (model MEA-07420) with an accuracy of 100 g and a range of 150 kg. Using the Frankfurt plane as a reference, height was measured in centimeters (cm) using a stadiometer (Sanny Medical) with a precision of millimeters (mm). From these measurements were obtained body mass index values (weight/height^2). Waist, abdomen and hip circumferences were determined using a flexible steel tape (Cescorf) graduated in (mm). Waist circumference was taken at the mid-point between the lower costal (12th rib) border and the iliac crest. Abdominal circumference was measured on the umbilicus, and hip circumference was taken at the level of the greatest posterior protuberance of the buttocks, which usually corresponds anteriorly to about the level of the symphysis pubis.

Anthropometric measures (circumferences) were used to estimate fat percentage (% fat) because this allows for less technical error from evaluators than assessment by skinfolds[28] and because elderly people have morphological changes such as body fat distribution, elasticity and thickness of the skin[29,30]. All measurements were performed twice by an experienced evaluator trained by the International Society of Advancement of Kinanthropometry (ISAK)[31]. These same procedures and protocols were used in the initial and final evaluations.

Exercise program

The exercise program was performed over six months according to the weekly frequencies assigned to the two groups. In the initial three weeks of training, participants were familiarized with and adapted to the multicomponent exercise training program (combined aerobic and resistance exercise training) and also to the OMNI Res scale. For the duration of the training program there was incremental progress in the duration of the training sessions, beginning with 20–30 minutes initially and 60 minutes at the end of the program. All the sessions had the same structure: (i) warming-up 5–10 minutes, (ii) main part 40–45 minutes, involving walking different routes, exercises for lower (squats, lunges, calf rises) and upper limbs (shoulder abductions, biceps curls, triceps and abdominal extension), using elastic bands, balls and bats and (iii) return to calm, with stretching and/or relaxation activities. The main characteristics of the load and structure of the training program and the progression of the exercises during the six months are presented in Table 1. To equalize the exercise intensity for each participant, the Resistance Exercise Scale (OMNI Res)[32] was used for the active muscles. All activities were supervised by two trained instructors and all sessions, for both groups, were conducted by the same instructors.

Statistical analysis

The data distribution was verified by the Kolmogorov-Smirnov test with reference to the Gaussian curve. Average and standard deviation were used to characterize the sample. Student's t-test for paired samples was used to compare the two points of evaluation for each variable, and Student's t-test for independent samples was used to compare the percentage of all variables between groups. All analyses were performed using SPSS (Statistical Package for Social Sciences) version 21.0. The significance level was set at 5% (p <0.05).

Results

Table 2 shows all body composition measurements, as well as blood pressure values for the two groups. Significant differences within G1 were found in waist and abdominal measurements, percentage body fat, fat free mass, waist–hip ratio and systolic and diastolic blood pressure, wherein these same variables were also significantly different within G2, except for fat free mass which was found only in G1. In Table 2, it can be observed that no significant differences between the groups were found for any of the variables; this was also the case when the percentage variations of each variable for both groups were compared (Table 3).

Discussion

It is well known that several changes in body composition, including the reduction of fat free mass and the increase of fat mass occur within the aging process, particularly in sedentary people. The purpose of this

Table 1. Exercise training program.

Variables	1º Mesocicle		2º Mesocicle		3º Mesocicle	
Week	1-4	5-8	9-12	13-16	17-20	21-25
Aim	Familiarization of Scale OMNI Res	Muscular endurance	Muscular Hypertrophy	Maximal strength	Power	Loss weight
Type	Aerobic and resistance exercise, flexibility					
Mode	Walking, weight training, recreational games					
Duration	20-30 minutes	30-50 minutes	40-50 minutes	50-60 minutes	60 minutes	60 minutes
Intensity (Scale OMNI Res)	2-Easy 4-Somewhat easy	4-Somewhat easy/ 6-Somewhat hard	4-Somewhat easy/ 6-Somewhat hard	6-Somewhat hard/ 8-hard	6-Somewhat hard/ 8-hard	8-9 Hard
Frequency	1 or 2 days/week (non-consecutive)					

Table 2. General anthropometric characteristics of the participants in the once week exercise (G1) and twice week exercise (G2). Data are given as mean ± standard deviation.

Variables	Once a week (n=25)			Twice a week (n=30)		
	Before	After	*P* value	Before	After	*P* value
Body weight (kg)	73.40 ± 10.33	73.72 ± 10.65	0.473	68.10 ± 9.59	67.33 ± 9.20	0.227
Body mass index (kg/m^2)	29.36 ± 4.11	29.54 ± 4.32	0.333	26.60 ± 4.08	26.49 ± 4.33	0.693
Fat mass (%)	44.23 ± 4.48	43.43 ± 4.81*	0.010	39.96 ± 5.68	39.06 ± 6.13*	0.007
Fat mass (kg)	32.80 ± 7.38	32.37 ± 7.58	0.245	27.58 ± 7.27	26.67 ± 6.97*	0.040
Fat-free mass (kg)	40.60 ± 3.94	41.35 ± 4.28*	0.001	40.52 ± 4.26	40.67 ± 4.38	0.630
Circumference abdomen (cm)	97.16 ± 8.98	95.48 ± 8.59*	0.014	91.06 ± 8.29	89.13 ± 8.68*	0.001
Circumference waist (cm)	93.40 ± 8.77	91.24 ± 8.82*	0.002	87.03 ± 8.58	84.73 ± 8.91*	<0.001
Circumference hip (cm)	105.80 ± 7.96	104.92 ± 7.92	0.080	100.60 ± 7.46	100.13 ± 7.44	0.363
Waist-hip ratio (cm)	0.884 ± 0.073	0.870 ± 0.072*	0.037	0.865 ± 0.058	0.845 ± 0.059*	<0.001
Blood pressure systolic (mmHg)	132.80 ± 10.90	128.40 ± 11.87*	<0.001	129.00 ± 12.06	124.33 ± 12.50*	<0.001
Blood pressure diastolic (mmHg)	85.00 ± 6.45	82.00 ± 7.77*	0.001	80.00 ± 6.43	77.66 ± 8.06*	0.014

Significant difference from before to after intervention: * ($p < 0.05$).

Table 3. Comparation of percentage variation (Δ) of variables in study between groups.

Variables (%)	Group 1 n (25) Mean ± SD	Group 2 n (30) Mean ± SD	*P* value
Body weigth (kg)	0,42 ± 3.00	-0,99 ± 4.87	0.195
Body mass index	0,58 ± 3.15	-0,41 ± 4.89	0.390
% fat	-1,85 ± 3.48	-2,40 ± 4.52	0.622
Fat mass	-1,37 ± 5.88	-3,26 ± 8.06	0.335
Fat free mass	1,80 ± 2.21	0,40 ± 4.02	0.110
Circumference abdomen	-1,66 ± 3.27	-2,15 ± 3.10	0.574
Circumference waist	-2,28 ± 3.48	-2,65 ± 3.53	0.697
Circumference rip	-0,81 ± 2.27	-0,44 ± 2.71	0.586
Waist-rip ratio	-1,46 ± 3.50	-2,21 ± 3.14	0.409
Blood pressure systolic	-3,32 ± 3.86	-3,55 ± 5.00	0.851
Blodd pressure diastolic	-3,57 ± 5.00	-2,93 ± 6.12	0.676

study was to determine body composition changes in sedentary elderly people who performed a multicomponent exercise training program once or twice a week for six months. The primary findings of the study show that a periodic exercise program, even performed with low weekly frequency, can provide significant improvements in waist and abdominal measurements, percentage body fat, fat free mass, waist–hip ratio and systolic and diastolic blood pressure; however there were no significant differences for these variables between groups. These differences may have occurred due to different volumes and intensities within the exercise periodization, as well as due to alterations in training goals and aims (muscular endurance, hypertrophy, maximum strength or power).

When the effects of the two weekly frequencies (once or twice a week) on body composition were compared, a significant change in variables of waist and abdomen measurements, percentage body fat and waist–hip ratio were observed in both, except fat free mass which was observed only in G1. Our results corroborate partially with Izquierdo *et al.*[21] who also reported that once per week combined strength and aerobic exercise can induce a similar increase in fat free mass of elderly people, when compared with training alone (twice per week strength or endurance exercise). However, the aims of the two studies were different because the present study compares once and twice weekly combined training, while Izquierdo *et al.*[21] compared combined training with strength or endurance per se. In addition, Sillanpää *et al.*[33] found improvements in body composition of elderly men who performed low frequency (twice a week) combined training. These studies show that low weekly frequency (once or twice per week) training can provide improvements in body composition and allow for an easier adherence to exercise, since it involves less time each week[21].

On the other hand Mynarski *et al*.[34] analyzed the effect of different physical exercise programs (strength training, functional and gymnastic) on anthropometric measures and the functional autonomy of elderly people at risk of fracture in the southern region of Brazil. The participants performed 35 training sessions with a duration of 60 minutes per session, twice a week. The study showed that these sessions, independent of training type, were not sufficient to provide significant changes in body mass index and body composition. One fact that may explain the absence of change in anthropometric measures in this study is the lack of load in strength training.

We did not find statistical differences when the percentage variation of all variables was compared between the two frequency groups (once or twice per week). These results are in accordance with the results of Fisher *et al*.[35] study which evaluated 63 women between 60 and 77 years of age who participated in 16 weeks of combined aerobic and strength training. The elderly women were divided into three physical training groups: the first performed strength and aerobic training once per week, the second performed two sessions per week and the third performed three sessions per week. Anthropometric and body composition results showed that body fat percentage, body fat, fat free mass and body mass index were not significantly different between groups.

A study developed by Nakamura *et al.*[36] evaluated elderly women using a different training methodology (exclusively aerobic) and more training groups (three groups plus a control group); significant differences were not found between the three exercise groups. In others words, elderly women that exercised once, twice or three times per week did not have significantly different changes in body composition.

Relative to blood pressure, there was a significant decrease in the level of systolic and diastolic blood pressure in both groups after six months of intervention. These results were also found in a study by Liu *et al.*[37] that evaluated 17 sedentary 45–60-year-old subjects during an eight week exercise program. However, the methods used differ from the present study, because this study used aerobic and strength exercises with a once or twice per week frequency, while Liu *et al*.[37] used exclusively aerobic exercises, with a frequency of four times per week. The significant decrease in blood pressure may be associated with central and peripheral adaptations for improving oxygen consumption (VO_2), although these variables were not evaluated.

Limitations of this study are the lack of control group, the impossibility of monitoring and controlling the other daily activities of the study sample and of not monitoring biochemical variables such as cholesterol, triglycerides and glucose.

Conclusion

It can be concluded that even low weekly frequency (once or twice per week) exercise over a sustained period of time can substantially modify or maintain the body composition of elderly women, as well as decreasing their systolic and diastolic blood pressure.

These results can also provide important information for this population, showing that it is not necessary to engage in high weekly frequency exercise to have satisfactory outcomes.

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Bibliography

1. Blair SN, Kampert JB, Kohl HW, Barlow CE, Macera CA, Paffenbarger RS, Gibbons LW. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *Jama*. 1996;276:205-10.
2. Rantanen T. Muscle strength, disability and mortality. *Scand J Med Scie Sports.* 2003;13:3-8.
3. Van Pelt R, Evans E, Schechtman K, Ehsani A, Kohrt W. Contributions of total and regional fat mass to risk for cardiovascular disease in older women. *Amer J Physiol Endocr Metabol.* 2002;282:E1023-E8.
4. Kraemer WJ, Nindl BC, Ratamess NA, Gotshalk LA, Volek JS, Fleck SJ, Newton RU, Hakkinen K. Changes in muscle hypertrophy in women with periodized resistance training. *Med Scie Sports Exerc.* 2004;36:697-708.
5. Wilhelm EN, Rech A, Minozzo F, Radaelli R, Botton CE, Pinto RS. Relationship between quadriceps femoris echo intensity, muscle power, and functional capacity of older men. *Age*. 2014;36:1113-22.
6. Sirola J, Rikkonen T. Muscle performance after the menopause. *Brit Menop Soc J.* 2005;11:45-50.
7. Aragão F, Abrantes C, Gabriel R, Sousa M, Castelo-Branco C, Moreira M. Effects of a 12-month multi-component exercise program on the body composition of postmenopausal women. *Climacteric.* 2014;17:155-63.
8. Bento PCB, Pereira G, Ugrinowitsch C, Rodacki ALF. Peak torque and rate of torque development in elderly with and without fall history. *Clin Biomech*. 2010;25:450-4.
9. Rogers ME, Fernandez JE, Bohlken RM. Training to reduce postural sway and increase functional reach in the elderly. *J Occup Rehabil.* 2001;11:291-8.
10. Suzuki T, Bean JF, Fielding RA. Muscle power of the ankle flexors predicts functional performance in community-dwelling older women. *J Amer Ger Soc*. 2001;49:1161-7.
11. Kobayashi H, Koyama Y, Enoka R, Suzuki S. A unique form of light-load training improves steadiness and performance on some functional tasks in older adults. *Scand J Med Scie Sports.* 2014;24:98-110.
12. Chodzko-Zajko WJ. Exercise and physical activity for older adults. *Kinesiol Rev.* 2014; 3:101-6.
13. Katula JA, Sipe M, Rejeski WJ, Focht BC. Strength training in older adults: an empowering intervention. *Med Scie Sports Exerc.* 2006;38:106-11.
14. Organization WH. World health statistics 2010: World Health Organization; 2010.p.59.
15. Clark BC, Manini TM. What is dynapenia? *Nutr.* 2012;28:495-503.
16. Bann D, Hire D, Manini T, Cooper R, Botoseneanu A, McDermott MM, Pahor M, Glynn NW, Fielding R, King AC. Light intensity physical activity and sedentary behavior in relation to body mass index and grip strength in older adults: Cross-sectional findings from the lifestyle interventions and independence for elders (LIFE) study. *PloS One.* 2015;e0116058:1-13.
17. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, Macera CA, Castaneda-Sceppa C. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Circulation.* 2007;116:1094-105.
18. Stamler JS, Meissner G. Physiology of nitric oxide in skeletal muscle. *Physiol Rev.* 2001;81:209-37.
19. Mota MR, Oliveira RJ, Terra DF, Pardono E, Dutra MT, de Almeida JA, Silva FM. Acute and chronic effects of resistance exercise on blood pressure in elderly women and the possible influence of ACE I/D polymorphism. *Inter J Gen Med.* 2013;6:6.581-7.
20. ACSM (American College of Sports Medicine). *Guidelines for exercise testing and prescription*. Lippincott Williams & Wilkins; 2013.p.162.
21. Izquierdo M, Ibanez J, Hakkinen K, Kraemer WJ, Larrion JL, Gorostiaga EM. Once weekly combined resistance and cardiovascular training in healthy older men. *Med Scie Sports Exerc*. 2004;36:435-43.
22. Singh MAF. Exercise comes of age rationale and recommendations for a geriatric exercise prescription. *J Gerontol Ser A: Biol Scie Med Scie*. 2002;57:M262-M82.
23. Chisholm D, Collis M, Kulak L, Davenport W, Gruber N, Stewart G. *PAR-Q Validation Report: The evaluation of a self-administered pre-exercise screening questionnaire for adults.* Victoria: Canada: BC Ministry of Health and Health and Welfare; 1978.
24. Shephard RJ, Thomas S, Weiler I. The Canadian home fitness test. *Sports Med*. 1991;11:358-66.

25. Lopes C, Aro A, Azevedo A, Ramos E, Barros H. Intake and adipose tissue composition of fatty acids and risk of myocardial infarction in a male Portuguese community sample. *J Amer Diet Assoc.* 2007;107:276-86.
26. Neves EB. Prevalence of overweight and obesity among members of the Brazilian army: association with arterial hypertension. *Ciê Saúde Col.* 2008;13:1661-8.
27. Chobanian A. Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. National Heart, Lung, and Blood Institute; National High Blood Pressure Education Program Coordinating Committee: Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertens.* 2003;42:1206-52.
28. Tran ZV, Weltman A. Predicting body composition of men from girth measurements. *Hum Biol.* 1988;167-75.
29. Heyward V. ASEP methods recommendation: body composition assessment. *J Exerc Physiol.* 2001;4:1-12.
30. Dey DK, Bosaeus I. Comparison of bioelectrical impedance prediction equations for fat-free mass in a population-based sample of 75 y olds: the NORA study. *Nutr.* 2003;19:858-64.
31. Marfell-Jones MJ, Stewart A, de Ridder J. International standards for anthropometric assessment; 2012. p. 25-32.
32. Colado JC, Triplett NT. Effects of a short-term resistance program using elastic bands versus weight machines for sedentary middle-aged women. *J Strength Cond Res.* 2008;22:1441-8.
33. Sillanpää E, Häkkinen A, Nyman K, Mattila M, Cheng S, Karavirta L, Laaksonen DE, Huuhka N, Kraemer WJ, Häkkinen K. Body composition and fitness during strength and/or endurance training in older men. *Med Scie Sports Exerc.* 2008;40:950-8.
34. Mynarski J, dos Santos L, Verffel A, de Mello D, Berticell M, Olkoski MM. Efeitos de diferentes programas de exercícios físicos sobre a composição corporal e a autonomia funcional de idosas com risco de fratura. *Rev Ed Fis/UEM.* 2014;25:609-18.
35. Fisher G, McCarthy JP, Zuckerman PA, Bryan DR, Bickel CS, Hunter GR. Frequency of combined resistance and aerobic training in older women. *J Strength Cond Res.* 2013;27:1868-76.
36. Nakamura Y, Tanaka K, Yabushita N, Sakai T, Shigematsu R. Effects of exercise frequency on functional fitness in older adult women. *Arch Gerontol Geriatr.* 2007;44:163-73.
37. Liu S, Goodman J, Nolan R, Lacombe S, Thomas SG. Blood pressure responses to acute and chronic exercise are related in prehypertension. *Med Scie Sports Exerc.* 2012;44:1644-52.

Cardiac autonomic responses of trained cyclists at different training amplitudes

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Summary

Purpose: The aim of this study was to evaluate the effect of different training amplitudes on the autonomic nervous system (ANS) responses and recovery through heart rate (HR), heart rate variability (HRV) and rate of perceived effort (RPE).
Methods: In a counterbalanced design, male trained cyclists (24.8 ± 6.9 years old) performed three training sessions matched by total duration (20 min) and by mean power (55% of maximal power output,), but with different effort:pause ratio and different amplitudes. Continuous training (CT) was composed by efforts of 55% of maximal power (Pmax). The low amplitude training (LAT) was composed by efforts with 80% of Pmax and pauses of 30% of Pmax, and high amplitude training (HAT) with efforts of 110% of Pmax and passive pauses (0% of Pmax). Data were analyzed using a two-way ANOVA with repeated measures or non parametric correspondent.
Results: HAT promoted superior RPE (9.0 ± 1.0 au) in comparison to the LAT (3.8 ±2.8 au), and CT (2.8 ± 1.5 au) with p <.01, and higher increments in the maximal HR (172.8 ± 11.8 bpm) in comparison to the CT (140.8 ± 14.2 bpm, p = .001). Regarding HRV, the three protocols had similar results, except by the CT, which did not return to baseline levels after 24h of rest.
Conclusions: The HAT showed higher impact on the RPE and in maximum HR at the end of the session and the HRV variables showed similar responses despite the difference in the training protocols.

Key words:
Heart rate. Cycling.
Physical effort. Recovery.
Autonomous nervous system.

Respuesta del sistema cardiaco autónomo en ciclistas entrenados con diferentes amplitudes de entrenamiento

Resumen

Objetivo: El objetivo de este estudio fue evaluar el efecto de diferentes amplitudes de entrenamiento sobre las respuestas y recuperación del sistema nervioso autónomo (SNA) por medio de la frecuencia cardíaca (FC), variabilidad de la frecuencia cardíaca (VFC) y tasa de esfuerzo percibido (RPE).
Métodos: En diseño contrabalanceado, ciclistas masculinos entrenados (24.8± 6.9 años de edad) realizaron tres sesiones de entrenamiento emparejados con duración total (20 min) y promedio de potencia (55% de la potencia máxima), pero con diferentes tasas de esfuerzo-pausa y diferentes amplitudes. El entrenamiento continuo (EC) fue compuesto por esfuerzos de 55% de la máxima potencia (Pmax). El ejercicio con baja amplitud de entrenamiento (EBA) fue compuesto por esfuerzos de 80% de la Pmax con pausas de 30% de la Pmax, y en entrenamiento en alta amplitud (EAA) con esfuerzos de 110% de la Pmax y pausas passivas (0% de la Pmax. Los datos fueron analizados mediante ANOVA de dos vías con medidas repetidas o su correspondiente no paramétrico.
Resultados: EAA promovió RPE superiores (9.0 ± 1.0 u.a) en comparación con EBA (3.8 ± 2.8 au), y EC (2.8 ± 1.5 u.a) con p<.01, con elevados incrementos en la FC máxima (172.8 ± 11.8 bpm) en comparación con EC (140.8 ± 14.2 bpm, p=.001). Considerándose la VFC, los tres protocolos tuvieron resultados similares, excepto por el EC, pues no volvió a los niveles basales después de 24h de descanso.
Conclusiones: El EAA presentó mayor impacto en la RPE y en la FC máxima al final de la sesión y las variables de VFC mostraron respuestas similares a pesar de la diferencia en los protocolos de entrenamiento.

Palabras clave:
Frecuencia cardíaca. Ciclismo.
Esfuerzo físico. Recuperación.
Sistema nervioso autónomo.

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Introduction

Cycling is characterized as an endurance cyclical modality; in the competition different procedures were used, ranging from time trials, from 4 km to very high durations, lasting days[1,2]. Because of this, the training usually involves continuous efforts applied with moderate to high intensity and long duration, and as well as in other ways, usually using heart rate (HR) to the intensity prescription and control[3].

The HR is a physiological variable intrinsically controlled by the autonomic nervous system (ANS), under the equilibrium between sympathetic and parasympathetic activity[4]. Another parameter observed in the evaluation of cardiac activity and its modulators is the heart rate variability (HRV), which indicates the HR oscillations[5]. In this context, during physical exercise, the sympathovagal balance, and its regulation, are altered as a result of the increased need for blood oxygen distribution[6]. The HRV is also used to control the training load assessment on a daily basis of its parameters after, before, and specifically 24 h hours before training[4,7,8] because of its relations with the ANS stress and recovery patterns of the HR control[4]. Constant loads with high intensity could induce a delay in the HRV recovery but few studies have reported how ANS responds immediately and after 24 hours of exercise using different training amplitudes of the effort: pause ratio[6-9].

With the intention of promoting improvements in these mechanisms, the high intensity interval exercise (HIIE) is a temporally efficient strategy in the development of autonomic regulation and performance determinants in cycling[9,10], which is organized with different protocols[11,12]. In the HIIE, beyond the volume and intensity, one of its variable to training prescription, which have not been common focus of study, is called amplitude between efforts and recoveries[13,14]. Although the intensity seems to be the most important variable that determines, almost alone, the adaptations and their type with training[15], the amplitude that this intensity is involved is guided by the individuality principle, which proposes that the load should be applied considering the functional capacity of each individual, and this response to the training[9]. Trainings with lower or average amplitude can promote similar adaptations on HR, HRV, and performance variables[12,13], different from training sessions with wide amplitude, which promotes higher impact on HR and HRV parameters[8]. In this sense, coaches and trainers can choose trainings with the same mean intensity but different in the amplitude of the effort: recovery ratio, considering the use of wider amplitudes to promote higher impact in their athletes organism[8]. HIIE protocols could be used with high effort intensities, but with same mean intensity of the low continuous trainings, helping the coaches to recognize and to control the training load over the season[8]. The aim of this study was to evaluate the responses and recovery of the ANS through HR and HRV, and the rate of perceived effort (RPE) in trained cyclists after three sessions with different training amplitudes.

Material and method

In this study five highly trained cyclists (between 18 and 33 years old), with weekly training of 4±1 days and weekly total time of training about 11.4 ± 4.4 hours were involved in the study period. They showed, at least, one year of practice in the road cycling, and self-related competitive level of 5.4±0.914 years and were injury free. They were part of a local cycling team selected by a nonprobability sample, considering training status and competitive level, and signed an informed consent (the project has obtained approval from the local ethics committee, protocol 005/2012).

This is an experimental counterbalanced study, with repeated measures. Training amplitude was considered an independent variable and, general and local lower limbs RPE, HR, and HRV parameters as dependent variables.

The study had four separate sessions intercepted by 48 hours. At first, each cyclist filled a questionnaire with medical history and individual habits and realized incremental test to estimate maximal power output (Pmax). In the next three visits, they were submitted to three different training sessions with different amplitudes each, with the execution order determined randomly. All sessions occurred at the same time of day, between 4 and 8 pm, and were previously scheduled with the subjects involvement.

To estimate Pmax in watts (W), the maximal progressive test was applied in lower limb cycle-ergometer (Ergo Cycle 167, Ergo-Fit, Germany), compound by 5-min warm-up with fixed load of 50 W and free cadence. In the sixth minute the power was maintained, but, the cadence was increased to 85 rpm and was controlled until the end of the test, with a possible deviation of ±10 rpm. At each minute 50 W was added until overload of 200 W. Afterwards were the adopted increments of 15 W per minute until the cyclist could not complete the stage due to reported or observed fatigue by the evaluators[16]. In the latter case, the athlete does not support the minimum cadence of 75 rpm for more than five seconds[17].

The athletes were instructed not to perform vigorous exercise in the 24 hours preceding the Pmax test, in addition to not ingesting caffeine to prevent stimulatory effect and HRV modification[12]. These guidelines also were used in training sessions. In addition, they were asked to keep their routines without food, hydration and sleep changes during the data collection period.

The cyclists performed three training sessions with the same total duration (20 minutes), mean power (55% of Pmax) and the same cycle-ergometer used in the Pmax test to avoid ergonomic differences. The characteristic of differentiation in the protocols was the amplitude of the effort: pause relationship, shown in the equation: amplitude = exercise intensity – average intensity / average intensity x 100%[8,13].

The training sessions involved a continuous training (CT) and two interval protocols, with low (LAT) and high (HAT) amplitude. All sessions had the same warm-up procedure from Pmax test day. Table 1 describes and summarizes the training session protocols.

Height and body mass were measured in test session after the anamnesis in a digital scale accurate to 100 g (Filizola™, model ID-1500) with an anthropometer attached, with 0,1 cm precision.

For each subject, heart rate monitoring and recording were performed for five minutes before starting the training sessions, five minutes after the end of the sessions and 24 hours after each one. Previously, it was showed that five minutes of recording is considered valid and sufficient to obtain the desired information about HRV parameters[18]. All the samples were collected with athletes at rest, sitting on the cycle

Table 1. General characteristics of continuous and intermittent training sessions.

	CT	LAT	HAT
Stimulus total duration (min)	20	20	20
Effort: pause relationship	NA	1:1	1:1
Effort intensity (% Pmax)	55	80	110
Recovery intensity (% Pmax)	NA	30	0
Mean training intensity (% Pmax)	55	55	55
Training amplitude (%)	0	45.45	100

CT: Continuous training; LAT: Low amplitude interval training; HAT: High amplitude interval training; %Pmax: Percent value from maximal incremental test; NA: Do not apply.

ergometer and in pedaling position, because it faithfully represents the effort position taken during the cycling competitions[19].

The HRV parameters were registered with portable equipment (Polar™ RS800CX, Polar Electro, Finland) and filtering data procedures[20]. This equipment have its validity tested and aproved against ECG signal, as a gold standard, and other portalbe devices for HRV parameters[21,22]. Also, its HRV data reproducibillity was prooved to be reliable[23]. The HRV parameters were organized in two domains: time and frequency[4]. As to the time domain variables, the following were collected and analyzed: i) the mean of RR intervals (MeanRR); ii) standard deviation normal RR interval (SDNN); iii) root mean square of successive differences squared (RMSSD); and iv) percentage of successive RR intervals with a difference greater than 50 ms (pNN50). In the frequency domain variables, the following was considered of the spectral components: i) very low frequency component (VLF); ii) low frequency component (LF); iii) high frequency component (HF); and iv) LF/HF ratio[4].

The HR and HRV data were collected with heart rate monitor, transferred to Polar ProTrainer 5™ software and analyzed in Kubios HRV 2.0 software (University of Kuopio, Finland). To the HRV frequency domain, the limits were fixed in 0.15 – 0.40 Hz intervals to the HF, 0.05 – 0.14 Hz to the LF and 0.03 – 0.04 Hz to VLF. To the HR, mean and maximum values were considered, in beats per minute (bpm), obtained in each collected moment. To the frequency domain, data from pre- and 24h-post efforts were considered because conventional spectral analysis could not be used during the initial phase of recovery, because the RR intervals are not stationary[11].

With concern to RPE, identified by 0-10 Borg scale[24], in arbitrary units (au), information about general and local lower limb effort perception, 30 min after the training session was collected.

Data analysis was conducted with OriginPro 8.5. For descriptive statistics, mean ± standard deviation (sd) were used. The Mauchly test was employed to check the data sphericity, and the Greenhouse-Geiser correction was used when necessary[25]. Two-way analysis of variance (training protocol and moment), was conducted with repeated measure. When identified significance, Bonferroni post-hoc test was used to identify differences[26]. For the RPE, Kruskal-Wallis non parametric analysis of variance was applied and, when identified differences between moments or conditions a Dunn's post-hoc was conducted to identify differences. Significance level was set in $p \leq .05$.

Results

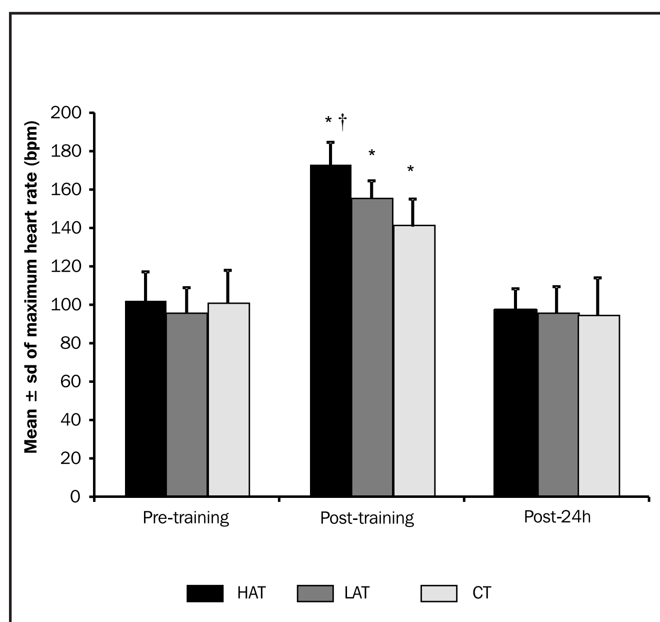
Concerning the descriptive characteristics, the athletes were shown to be 24.8 ± 6.9 years old, with a height of 1.8 ± 0.1 meters, 71.9 ± 5.9 kg of body mass and body mass index of 23 ±1.4. In the Pmax test, they showed a performance of 350 ± 26 W. So, the loads to the training sessions were: i) 192.5 ± 14.3 W in the CT; ii) 280 ± 20.8 : 105 ± 7.8 W in the LAT; and iii) 385 ± 28.6 : 0 W in the HAT.

Regarding the acute changes in cardiac level promoted by training, the mean HR reached higher values with statistical difference in the post-training (HAT: 123.2 ± 15.1 bpm; LAT: 111.2 ± 14.9 bpm; CT: 106.0 ± 15.9 bpm) compared to the pre-training moment (HAT: 81.2 ± 15.8 bpm; LAT: 78.2 ± 14.3 bpm; CT: 79.8 ± 10.8 bpm) and after 24h (HAT: 81.0 ± 12.8 bpm; LAT: 75.8 ± 12.6 bpm; CT: 77.6 ± 17.1 bpm), all $p <.001$. However, no significant differences were observed between training types.

For maximum HR, the three training protocols promoted similar response, with pre-training values (HAT: 102.0 ± 15.1 bpm; LAT: 95.6 ± 13.3 bpm, CT: 100.8 ± 17.1 bpm) significantly lower than the post-training values (HAT: 172.8 ± 11.8 bpm; LAT: 155.4 ± 9.1 bpm; CT: 140.8 ± 14.2 bpm, all $p <.001$) and return to resting levels after 24h (HAT: 96.6 ± 11.7 bpm; LAT: 95.6 ± 13.8 bpm; CT: 94.8 ± 19.2 bpm, all $p <.001$). However, we found a difference between HAT and CT in post-training moment, respectively 172.8 ± 11.8 bpm and 140.8 ± 14.2 bpm, with $p = .001$ (Figure 1).

The HRV results in the time and frequency domains are shown in Table 2. Among all comparisons, just the significant difference is highlighted between moments in LF, with the post-24h values being inferior to pre-training ($F = 6.94$; $p = .02$).

Figure 1. Descriptive measures of maximum HR to the three training types.



*: Statistically different from the pre-training and post 24h, in the same training protocol, with p<.001. †: Statistically different from CT in the same moment, with p:.001. CT: Continuous training. LAT e HAT: Low and high amplitude interval training protocols, respectively.

Table 2. Descriptive values (mean ± sd) of HRV in time and frequency domains, according training protocol.

	HAT	LAT	CT
MeanRR (ms)			
Pretraining	763.9 ± 155.7*	787.58 ± 135.58*	762.4 ± 103.3*
Posttraining	492.5 ± 59.3	546.32 ± 67.83	490.8 ± 256.8
Post-24h	757.1 ± 119.9*	807.50 ± 133.26*	801.3 ± 166.7†
SDNN (ms)			
Pretraining	66.4 ± 16.5	70.86 ± 23.30	76.4 ± 20.9
Posttraining	65.2 ± 23.8	78.84 ± 21.52	54.9 ± 14.1
Post-24h	54.2 ± 12.8	68.66 ± 29.83	60.1 ± 18
RMSSD (ms)			
Pretraining	38.1 ± 16*	44.74 ± 18.96*	50 ± 10.3†
Posttraining	7.2 ± 5.4	12.68 ± 6.49	13 ± 7.3
Post-24h	37.6 ± 15.4*	43.54 ± 24.09*	35.5 ± 16.2
pNN50 (%)			
Pretraining	18.1 ± 15.4†	21.82 ± 17.15†	26 ± 10.3†
Posttraining	0.6 ± 1.2	1.70 ± 1.34	1.4 ± 1.9
Post-24h	18.7 ± 12†	21.12 ± 19.50†	15.3 ± 14.5†
VLF (ms^2)			
Pretraining	1577.2 ± 713	1800.80 ± 808.04	2098.6 ± 886
Post-24h	1353.2 ± 846.2	1830 ± 1470.39	2090.2 ± 2099.9
LF (ms^2)			
Pretraining	1638.6 ± 811.5	2714.4 ± 2038.6	3693.2 ± 3875.8
Post-24h	1055 ± 608.4	1596 ± 1242.2	1270.4 ± 753.5
HF (ms^2)			
Pretraining	554.6 ± 268.2	696 ± 677.7	666.6 ± 305.9
Post-24h	621 ± 420.6	756.2 ± 849.2	431.4 ± 342.5
LF/HF (%)			
Pretraining	3.4 ± 1.7	5 ± 3.3	5.3 ± 4.5
Post-24h	3.2 ± 3.4	3.4 ± 2.6	3.8 ± 1.9

* and †: Statistically different from the post-training moment, in the same protocol, respectively p<.05, p<.01. CT: Continuous training. LAT e HAT: Low and high amplitude interval training protocols, respectively.

The general RPE values presented in HAT (9.0 ± 1.0 au) were statistically superior to LAT (3.8 ± 2.8 au; p = .002). Considering the local RPE, the results resemble those general RPE. In the HAT, differences were observed between moments (H = 9.47; p = .008), with the post-training moment (8.8 ± 1.3 au) being higher than pre- and post-24h (respectively 1.4 ± 1.3 and 1.2 ± 1.6 au; p < .05). Differences between moments were also observed in LAT (H = 8.82; p = .01), with the post-training (4.2 ± 2.2 au) higher than post-24h (1.0 ± 0.2 au; p < .05), but not than pre-training (RPE = 0.8 ± 1.1 au). The continuous training not provided were RPE post-training values (2.8 ± 1.5 points; H = 2.31; p = .31) different from the pre-training (2.4 ± 2.6 au) and post-24h (1.2 ± 1.1 au). Between trainings, the only difference observed was in RPE post-training, with values of the HIIT with higher amplitude greater than the continuous training (H = 9.64; p = .008).

Controlled by type of training and time, significant correlations were between general RPE (local an general) and HR and HRV variables (Table 3).

The comparative between subjects for the variables with statistical significance in HR and HRV parameters are presented in Table 4. Values from variables with no statistical significance are presented in supplementary document.

Discussion

In the present study, which aimed to evaluate the effects of different training programs in HRV, HR and RPE, the amplitude between effort and recovery loads was the variable adopted to differentiate the protocols. The main finding of the study was that the HAT provided greater local and general RPE than the CT protocol, and that this training has generated greater HR at the end of the stimuli when compared to CT. Furthermore, to the knowledge of the authors, this is the first time that three different training protocols, with different training amplitude, but with same mean intensity, were tested and modified the HRV relative to resting levels, and showed similar returns to resting values after 24h.

In another investigation with running, involving three training types with the same distance, but different effort intensity and duration, the authors observed that the protocols with wide variation between effort and pause loads (higher amplitude) produced the greatest impact on ANS, obtaining statistically significant correlations between RPE and HR with studied HRV parameters[11]. These data corroborate with the present study results, since for RPE and maximum HR, the values found at the time of the post-training HAT have greater impact on ANS in relation to the other two protocols.

In concerning to RPE, the training load appears to be a determinant factor of the values obtained immediately after training[11]. Indeed, the increased values after training were confirmed by observing the maximum HR at the same moment; this is information that ensures the relationship between the physiological and psychological impacts of training sessions[27]. Regarding cardiac responses to exercises, it was observed that, although the mean HR have remained similar between the types of training, the maximum HR reached higher values, and with

Table 3. Significant correlations between RPE (local and general), HR, and HRV variables.

	maxHR	meanHR	MeanRR	RMSSD	pNN50
General RPE	r = .47 p = .002	r = .44 p = .003	r = -.44 p = .003	r = -.45 p = .003	r = -.35 p = .02
Local RPE	r = .48 p = .001	r = .45 p = .002	r = -.46 p = .002	r = -.46 p = .002	r = -.36 p = .02

maxHR: maximum heart rate; meanHR: mean heart rate; MeanRR: the mean of RR intervals; RMSSD: root mean square of successive differences squared; pNN50: percentage of successive RR intervals with a difference greater than 50 ms.

Table 4. Individual values between moments, for variables with statistical significance in the three training protocols.

Subjects	maxHR		meanHR		MeanRR		RMSSD		pNN50	
	pre	post	pre	post	pre	post	pre	post	pre	post
HAT										
Subject 1	86	169	69	104	874.9	576.2	51.3	10.6	29.7	0.2
Subject 2	120	192	99	146	608.4	410	25.7	2.6	6.1	0
Subject 3	112	173	92	125	653.5	479.6	30.4	4.4	8.3	0
Subject 4	87	170	61	121	976.2	495.5	59	3.5	39.4	0
Subject 5	105	160	85	120	706.7	501.2	24	15.1	7	2.8
LAT										
	pre	post	pre	post	pre	post	pre	post	pre	post
Subject 1	88	153	66	96	905	624.6	48.3	16.9	24.6	2.5
Subject 2	113	169	99	135	608.6	445.1	22.5	3	3.6	0
Subject 3	105	153	84	107	714.9	560.4	46.5	19.5	19.3	2.6
Subject 4	80	158	64	115	936.6	520.8	73	9.8	49.1	0.5
Subject 5	92	144	78	103	772.8	580.7	33.4	14.2	12.5	2.9
CT										
	pre	post	pre	post	pre	post	pre	post	pre	post
Subject 1	84	131	68	89	881.4	673.3	48.2	22.3	23.5	4.7
Subject 2	112	158	91	125	659.5	48.9	34	3.3	12.9	0
Subject 3	125	147	91	111	657	540.6	50.2	11.7	25.1	1.1
Subject 4	93	146	71	115	844.5	522.5	57.6	10.1	27	0.5
Subject 5	90	122	78	90	769.7	668.9	60.2	17.6	41.6	0.9

maxHR: maximum heart rate; meanHR: mean heart rate; MeanRR: the mean of RR intervals; RMSSD: root mean square of successive differences squared; pNN50: percentage of successive RR intervals with a difference greater than 50 ms.

statistical differences, in the HAT. This fact demonstrates the increased demand for blood supply in short duration and with intensity activities[28], like that applied in HAT.

For HRV, three variables representing the parasympathetic way showed similar patterns of change (MeanRR, RMSSD and pNN50), with a significant decrease in the post-training compared to the two rest moments. This represents predominant influence of the sympathetic component during exercise, characterized by the lower values found in the resting moments in all training protocols for these three variables[4]. A recent study showed that only intense continuous running (95% versus 75% of VO_2max) change HRV variables in post-exercise assessment, and that 24h can be sufficient to HRV recovery[29]. The present study showed that the same behavior is observed in HIIE protocols with different amplitudes. Here, the three training protocols similarly stimulate the ANS activation, and the HRV responding so close between them, showing that 24 hours of rest can be sufficient to organic recovery, at least, from the autonomic control (HRV) viewpoint. However, additional studies need to be conducted to analyze its impact on cardiovascular and neuromuscular variables[28,30,31].

As a study limitation, the authors pointed to the cycle ergometer used, because it has different dimensions than cyclists' equipment, allowing a few adjustments in order to find the better position of the athlete on it. Additionally, there was no record of the total distance fulfilled in each training session. It is indicated then that further studies consider these two points and, when possible, to test higher number of competitive cyclists with different fitness level.

From the results of this case series, it can be concluded that in the HAT, the training session with large amplitude, the impact promoted in RPE, and maximum HR was superior to continuous training protocol. Regarding the time-domain variables of HRV, a statistically significant difference of immediately post-training in relation to at least one of the rest values (pre-training and post-24h) in all protocols was found, but no observed differences were found in all HRV variables between the rest values. Therefore, it is considered that these training protocols have similar impact on the cardiac control by ANS and recovery pattern for the present study group and with these training conditions applied.

Bibliography

1. Lucia A, Hoyos J, Perez M, Santalla A, Chicharro JL. Inverse relationship between VO2max and economy/efficiency in world-class cyclists. *Med Sci in Sports and Exerc.* 2002;34(12):2079-84.
2. Diefenthaeler F, Vaz MA. Aspects related with fatigue during cycling: a biomechanical approach. *Rev Bras Med Esporte.* 2008;5:472-7.
3. Bezerra MA. Heart rate and exercise: an evidence based interpretation. *Rev Bras Cineantropom Desempenho Hum.* 2007;9(2):196-202.
4. Fronchetti L, Aguiar C, Aguiar A, Nakamura FY, Oliveira F. Modificações da variabilidade da freqüência cardíaca frente ao exercício e treinamento físico. *Rev Min Educ Fis.* 2007;15(2):101-29.

5. Rumenig E, Bertuzzi RCM, Nakamura FY, *et al*. Cinética e variabilidade da freqüência cardíaca mediante exercício físico predominantemente aeróbio: influência da intensidade e do tempo de análise. *Rev Bras Educ Fis Esp.* 2007;21(3):205-18.
6. Polito M, Farinatti P. Heart-rate, blood pressure, and rate pressure product during resistive exercises: a review of the literature. *Port J of Sport Sci.* 2003;3(1):79-91.
7. Perini R, Veicsteinas A. Heart rate variability and autonomic activity at rest and during exercise in various physiological conditions. *Eur J of Appl Physiol.* 2003;3:317-25.
8. Vaz MS, Picanco LM, Del Vecchio FB. Effects of different training amplitudes on heart rate and heart rate variability in young rowers. *J Strength Cond Res.* 2014;28(10):2967-72.
9. Seiler S, Haugen F, Kuffel E. Autonomic recovery after exercise in trained athletes: intensity and duration effects. *Scand J Med and Sci in Sports.* 2007;8:1366-73.
10. Stepto NK, Martin D, Fallon K, Hawley JA. Metabolic demands of intense aerobic interval training in competitive cyclists. *Med Sci in Sports and Exerc.* 2001;33(2):303-10.
11. Kaikkonen P, Hynynen E, Mann T, Rusko H, Nummela A. Heart rate variability is related to training load variables in interval running exercises. *Int J of Sports Med.* 2012;112(3):829-38.
12. Karapetian GK, Engels HJ, Gretebeck KA, Gretebeck RJ. Effect of caffeine on LT, VT and HRVT. *Int J of Sports Med.* 2012;33(7):507-13.
13. Billat LV. Interval training for performance: a scientific and empirical practice. Special recommendations for middle- and long-distance running. Part I: aerobic interval training. *Sports Med*. 2001;31(1):13-31.
14. Guiraud T, Nigam A, Gremeaux V, Meyer P, Juneau M, Bosquet L. High-intensity interval training in cardiac rehabilitation. *Sports Med*. 2012;42(7):587-605.
15. Ortiz MJ, Denadai SB, Stella S, Mello MT. Efeitos do treinamento aeróbio de alta intensidade sobre a economia de corrida em atletas de endurance. *Rev Bras Cien Mov.* 2003;11(3):53-6.
16. Cottin F, Lepretre PM, Lopes P, Papelier Y, Medigue C, Billat V. Assessment of ventilatory thresholds from heart rate variability in well-trained subjects during cycling. *Int J of Sports Med.* 2006;27(12):959-67.
17. Manning JT, Taylor RP. Second to fourth digit ratio and male ability in sport: implications for sexual selection in humans. *Evol and Hum Behav*. 2001;22(1):61-9.
18. Task Force. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. *Eur Heart J.* 1996;17(3):354-81.
19. Alonso DO, Forjaz CLM, Rezende LO, *et al.* Heart rate response and its variability during different phases of maximal graded exercise. *Arq Bras Cardiol.* 1998;71(6):787-92.
20. Quintana DF, Heathers JAJ, Kemp AH. On the validity of using the Polar RS800 heart rate monitor for heart rate variability research. *Eur J of Appl Physiol.* 2012;112(12):4179-80.
21. Barbosa MPCR, *et al.* Comparison of Polar® RS800G3TM heart rate monitor with Polar S810i and electrocardiogram to obtain the series of RR intervals and analysis of heart rate variability at rest. *Clin Physiol Funct Imaging.* 2016; ahead of print.
22. Montaño A, *et al.* Telemetry-derived heart rate variability responses to a physical stressor. *Clin Physiol Funct Imaging.* 2016; ahead of print.
23. Willians DP, *et al.* Two week test-retest reliability of the Polar® RS800CXTM to record heart rate variability. *Clin Physiol Funct Imaging*; ahead of print.
24. Borg GA. Psychophysical bases of perceived exertion. *Med Sci in Sports and Exerc.* 1982;14(5):337-81.
25. Maia J, Garganta R, Seabra A, Lopes V, Prista A, Freitas D. A didactical note on the use of statistical procedures for longitudinal data. A guide for researchers in Sport Sciences. *Rev Port Cien Desp.* 2004;4(3):115-33.
26. Field A. *Discovering Statistics Using SPSS*. Vol 2. Porto Alegre: Artmed; 2009. p. 28.
27. Foster C, Florhaug JA, Franklin J, et al. A new approach to monitoring exercise training. *J Strength Cond Res*. 2001;15(1):109-15.
28. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle. Part II: anaerobic energy, neuromuscular load and practical applications. *Sports Med.* 2013;43(10):927-54.
29. James DV, Munson SC, Maldonado-Martin S, De Ste Croix MB. Heart rate variability: effect of exercise intensity on postexercise response. *Res Quart Exerc Sport.* 2012;83(4):533-39.
30. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: cardiopulmonary emphasis. *Sports Med.* 2013;43(5):313-38.
31. Plews DJ, Laursen PB, Stanley J, Kilding AE, Buchheit M. Training adaptation and heart rate variability in elite endurance athletes: opening the door to effective monitoring. *Sports Med.* 2013;43(9):773-81.

Original article

Preventive exercises after warming up help to reduce injuries in football

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Summary

Injuries are a major problem in professional and amateur soccer. Most of them occur in the lower limbs (89.6%), specifically in thigh (31.4%), ankle (12.5%), groin (10.9%), and, to a lesser extent, knee and calves. There are several studies focusing on the effectiveness of preventive methods but, nevertheless, the prevalence of injuries, mainly muscular, remains alarming. The International Football Federation designed the program FIFA 11+, which has proven to be effective in preventing knee injuries, but not thigh or groin injuries. Therefore, the aim of this study was to assess the effectiveness of a prevention program to reduce lower extremity injuries in amateur soccer. A total of 84 amateur footballers volunteered to participate (experimental group (GE) = 40 players (age: 23.1 ± 3.8 years) and control (GC) = 44 players (age: 24.7 ± 4.1 years)). The number and type of injuries that occurred during the first phase of the 2015/16 season was recorded. The GE completed a preventive protocol after the warm up, while the GC did not perform any specific work. A total of 42 injuries was recorded, 83.4% of which in lower extremities, specifically: thigh (35.7%), ankle (23.8%), adductors (14.3%), knee (4.8%) and calves (4.8%). The number of injuries in lower limbs was higher in the group that did not perform the preventive work (82.9%) than in the group that performed it (17.1%). Therefore, including a preventive program after warm up helps reduce the risk of injury in the lower limbs in amateur soccer players.

Key words:
Injuries. Soccer. Strength. Proprioception.

Los ejercicios preventivos tras el calentamiento ayudan a reducir lesiones en fútbol

Resumen

Las lesiones suponen un gran problema en el fútbol profesional y amateur. La mayoría se localizan en las extremidades inferiores (89,6%), concretamente en: muslo (31.4%), tobillo (12.5%), ingle (10.9%), y en menor medida rodilla y gemelos. Son varios los estudios sobre la eficacia de los métodos para prevenir lesiones; sin embargo, la prevalencia de éstas, sobre todo musculares, sigue siendo alarmante. La Federación Internacional de Fútbol creó el FIFA 11+, que ha demostrado ser eficaz en la prevención de lesiones de rodilla, pero no para lesiones en muslo, ingle... Por ello, el objetivo de este estudio fue comprobar la eficacia de un programa de prevención para reducir lesiones en las extremidades inferiores en el fútbol amateur. Se realizó un seguimiento de un total de 84 futbolistas amateur (GE = 40 jugadores [edad: 23,1 ± 3,8 años] y GC = 44 jugadores [edad: 24,7 ± 4,1 años]). Se registró el número y tipo de las lesiones que se produjeron durante la primera vuelta de la temporada 2015/16. El grupo experimental llevó a cabo un plan preventivo tras el calentamiento, mientras que el grupo control no realizaba ningún trabajo de este tipo. Se registraron un total de 42 lesiones, el 83,4% en las extremidades inferiores, concretamente: muslo (35,7%), tobillo (23,8%), aductores (14,3%), rodilla (4,8%) y gemelos (4,8%). El número de lesiones en las extremidades inferiores fue mayor en el grupo que no realizaba trabajo preventivo (82,9%) que en el grupo que sí lo realizaba (17,1%). Por tanto, incluir un programa preventivo tras el calentamiento ayuda a reducir el riesgo de sufrir lesiones en las extremidades inferiores en futbolistas amateur.

Palabras clave:
Lesiones. Fútbol. Fuerza. Propiocepción.

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Introduction

Injuries are a limiting factor in performance, and appear frequently in the world of sport, especially in football, in which they pose a particularly major problem in both professional and amateur football[1].

The majority of the injuries acquired are located in the lower limbs (89.6%), specifically in the: thigh (31.4%), ankle (12.5%), groin (10.9%) and in lesser measure in the knee and calves[2]. Therefore it is not surprising that various studies have been conducted regarding the efficiency of different injury-preventing methods[3]. However, the prevalence of these injuries continues to be alarming[4]. Specifically, muscle-type injuries constitute one of the main problems to affect football players and to most concern the teams, with between 20-37% of injuries forcing professional players off the pitch for a certain amount of time, and 18-23% of amateur-level players[5,6]. In fact, the latest epidemiological studies reveal that muscle injuries constitute over 30% of all injuries, representing an average of 12 muscle injuries per season in a professional football team, which represent over 300 days of player absence from the pitch[7-10]. A study performed in professional Spanish football affirms that around 6-9 injuries occur for every 1,000 hours of football play[11].

Furthermore, these injuries that occur in football entail quite high economic costs. In the Netherlands, for example, losses of up to 4.5 million euros occur each year[12], but even more alarming are these figures in England, where losses have reached up to 118 million euros each year[13].

For these reasons, it comes as no surprise that one of the main concerns within the world of football is to find strategies to prevent the appearance of injuries and to reduce the incidence rate. Specifically, the International Federation of Association Football (FIFA) designed an injury prevention programme, entitled FIFA 11+, to try and solve this issue. Despite this programme being proven to be effective in the prevention of injuries in female footballers' knees, it is not applicable to muscle injuries in the thigh, groin, etc.[14].

Another of the aspects proposed to contribute to the advancement of the search for solutions to this issue is to assess the epidemiology of the injuries, establishing the risk of suffering from them and the circumstances in which they occur[15]. This data could be very useful because it could provide a good definition of which are the main injuries that occur in football and therefore, the path that should be taken to orientate planned preventive strategies. Despite the frequency with which they occur, the understanding of the factors that predispose players to suffering from a muscle injury is limited[16], and there is little scientific evidence regarding the prevention and treatment of these injuries.

Considering the aforementioned, the aim of this study was to check the efficiency of a preventive exercise programme in the reduction of injuries in muscle groups and joints of the lower limbs in amateur football.

Material and method

A total number of 84 amateur footballers constituted the sample of this study. The experimental group (EG) was composed of 40 players (age: 23.1 ± 3.8 years) and 44 players in the control group (CG) (age: 24.7 ± 4.1 years). The number and type of injuries suffered by the players was recorded, during the first round of the season 2015/16, as well as the minutes of training and play in each session and match, and the role of the player and the player substitute in each day. An injury is considered to be the alteration or damage caused to a part of the body due to a blow, illness, etc., which impedes the player from participating in competitions or some training sessions[17].

Moreover, an intervention was performed on the EG, consisting of the inclusion of a preventive exercise plan after warming up, twice a week, which included strength and proprioception exercises of the main leg muscle groups. To carry out individual follow-up on each player, an Excel Sheet was designed.

The exercises included in the programme were the following:

- Face-down plank resting on the elbows. 2 x 30-second repetitions with 10 seconds recovery between sets.
- Lateral plank resting on the forearm and raising one leg. 2 x 30-second repetitions with 10 seconds recovery between sets.
- Face-up lying hip lift. 2 x 20-second repetitions with 10 seconds recovery between sets.
- Face-down plank resting on the hands with trunk rotation and 3-second hold in lateral position. 1 set of 10 repetitions on each side, with a 2-second hold with the body stretched in a side position. 10-second recovery time whilst changing sides.
- 90º isometric squat with the back resting against a wall. In the event there are no walls, perform the exercise between two people back to back, keeping a straight back. 2 x 30-second repetitions with 10 seconds recovery between sets.
- Nordic hamstring exercise. 2 sets of 8 repetitions with 30 seconds recovery between sets.
- Lifting the bent leg on all fours with the back straight and the stomach tight. 1 set of 10 repetitions on each side.
- Leg abduction on all fours. 1 set of 10 repetitions on each leg (dynamic).
- Leg adduction lying on the side. 1 set of 10 repetitions on each leg (dynamic).
- Static proprioception tracing an asterisk with the free leg in monopodal support. 1 set of 20 repetitions on each leg (dynamic).
- Proprioception Circuit in all directions on a monopodal support holding balance for two seconds after each support. 1 repetition of 30 seconds on each leg. 10 seconds of recover between the repetition with each leg.

Results

A total number of 42 injuries were recorded, 83.4% of them to the lower limbs, specifically in the: thigh (35.7%), ankle (23.8%), adductor

(14.3%), knee (4.8%) and calves (4.8%). The number of injuries to the lower limbs was greater in the CG, comprising 82.9% compared to the 17.1% from the EG. Furthermore, when comparing the injuries in both groups depending on the muscle group or the joint, the same thing occurs: thigh (CG = 12 and EG = 3), ankle (CG = 7 and EG = 3), adductor (CG = 6 and EG = 0), knee (CG = 2 and EG = 0) and calf (CG = 2 and EG = 0) (Tables 1-3).

Moreover, upon calculating the number of injuries for every 1,000 hours of play in both groups, the EG also had much fewer injuries than the CG, with 8 against 41 injuries for every 1,000 hours of play, respectively (Table 4).

Table 1. Recorded injuries and their position.

Injuries - N = 42 (83.4% in LL)					
Position	Thigh	Ankle	Adductor	Knee	Calf
Percentage	35.70%	23.70%	14.30%	4.80%	4.80%

Table 2. Difference between groups in lower limb.

	Percentage injuries LL
Control group	82.9%
Experimental group	17.1%

Table 3. Difference in the number of injuries by position between groups.

	Thigh	Ankle	Adductor	Knee	Calf
Control group	12	7	6	2	2
Experimental group	3	3	0	0	0

Table 4. Comparison no. injuries every 1,000 hours of play between groups

	No. injuries/1000 hours
Control group	41.2
Experimental group	8.5

Discussion

The purpose of the study was to check if a preventive exercise programme applied after warming up could help reduce the number and risk of suffering injuries among amateur footballers. The results obtained reveal that the aforementioned programme can contribute to reducing the risk of the appearance and the number of injuries in amateur-level football players. These results align with those found in other studies, which reveal that performing a preventive programme after warming up reduces the risk of suffering injuries[4]. However, in contrary to the programme suggested by the International Federation of Association Football - FIFA 11+ - the results obtained in this study reveal that the programme proposed helps reduce the risk of suffering injuries, and the number of them in all the joints and muscle groups in the legs, and not just in the knees as observed in previous research studies with the approach proposed by FIFA[14].

Furthermore, considering the existing concern regarding muscle-type injuries, the results obtained in this study reveal the possibility that including the designed programme after warming up could contribute to reducing the number of muscle injuries that occur, given that the number of injuries in each muscle group is considerably lower in the group that performed preventive work compared to the group that did not include any work of this kind.

On the other hand, the results obtained in terms of the number of injuries that occur in every 1,000 hours of play coincide with other research studies performed in professional football - specifically in the Spanish First Division - in which it is revealed that around 6-9 injuries occur with every 1,000 hours of play[11], coinciding with the results for the EG of 8-9 injuries for every 1,000 hours of play in this study. However, the values obtained in this section for the CG in this research study differ considerably to those presented in the aforementioned study[11], being much higher, and presenting a value of 40-41 injuries for every 1,000 hours of play for the CG. This could, among other multiple factors, be due to the failure to include preventive exercises in the sessions developed throughout the season, given that both the EG of this study and professional teams in general include preventive work in various training sessions throughout the season, whilst the CG used in this study did not perform any work of this kind.

To conclude, we can affirm that including a preventive strength and proprioception exercise programme after warming up twice a week can help reduce the number and risk of suffering an injury in the lower limbs of amateur footballers.

In future research studies, it would be interesting to control the nutritional aspects of the different participants, as well as selecting a more homogeneous sample within the same group to see if the programme really is as effective when the participants perform the same type and volume of training and competing. It would also be interesting to perform follow up over various seasons, as well as to create a history of each player to take into account injury antecedents of each of them, in possible relapses. This way the search to achieve greater possible control over factors that influence the injury incidence rate could evolve, given the multi-factorial nature of injuries[18].

References

1. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in professional football: the UEFA injury study. *Br J Sports Med.* 2009;45(7):553-8.
2. Noya J, Gómez-Carmona P, Gracia-Marco L, Moliner-Urdiales D, Sillero-Quintana M. Epidemiology of injuries in First Division Spanish football. *J Sport Sci.* 2014;32(13):1263-70.
3. Verrall G. The effect of sports specific training on reducing the incidence of hamstring

injuries in professional Australian Rules football players. *Br J Sports Med*. 2005;39(6):363-8.

4. Ekstrand J, Healy J, Walden M, Lee J, English B, Hagglund M. Hamstring muscle injuries in professional football: the correlation of MRI findings with return to play. *Br J Sports Med*. 2011;46(2):112-7.
5. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc*. 1983;15:267-70.
6. Inklaar H. Soccer injuries, I: incidence and severity. *Sports Med*. 1994;18:55-73.
7. Junge A, Dvorak J, Graf-Baumann T. Football injuries during the World Cup 2002. *Sports Med*. 2004;32(suppl 1):23S-7S.
8. Waldén M, Hägglund M, Ekstrand J. UEFA Champions League study: a prospective study of injuries in professional football during the 2001-2002 season. *Br J Sports Med*. 2005;39:542-6.
9. Dvorak J, Junge A. F-MARC: Manual de Medicina del Fútbol. Zurich: Federación Internacional de Fútbol Asociación (FIFA); 2006. p.176.
10. Junge A, Langevoort G, Pipe A, Peytavin A, Wong F, Mountjoy M, *et al*. Injuries in team sport tournaments during the 2004 Olympic Games. *Sports Med*. 2006;34:565-76.
11. Noya J, Sillero M. Incidencia lesional en el fútbol profesional español a lo largo de una temporada: días de baja por lesión. *Apunts Med Esport*. 2012;47(176):115-23.
12. van Beijsterveldt A, Krist M, Schmikli S, Stubbe J, de Wit G, Inklaar H, *et al*. Effectiveness and cost-effectiveness of an injury prevention programme for adult male amateur soccer players: design of a cluster-randomised controlled trial. *Inj Prev*. 2010;17(1):e2.
13. Woods C. The Football Association Medical Research Programme: an audit of injuries in professional football-analysis of preseason injuries. *Br J Sports Med*. 2002;36(6):436-41.
14. Steffen K, Myklebust G, Olsen O, Holme I, Bahr R. Preventing injuries in female youth football - a cluster-randomized controlled trial. *Scand J Med Sci Sports*. 2008;18(5):605-14.
15. van Mechelen W, Hlobil H, Kemper H. Incidence, severity, aetiology and prevention of sports injuries. *Sports Med*. 1992;14:82-99.
16. Servicios Médicos del Futbol Club Barcelona. Guía de Práctica Clínica de las lesiones musculares: Epidemiología, diagnóstico, tratamiento y prevención. *Apunts Med Esport*. 2009;44(164):179-203.
17. Chomiak J, Junge A, Peterson L, Dvorak J. Severe injuries in football players influencing factors. *Sports Med*. 2000;28(suppl 5):S-58.
18. Mendiguchia J, Alentorn-Geli E, Brughelli M. Hamstring strain injuries: are we heading in the right direction? *Br J Sports Med*. 2012;46(2):81-5.

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.

Original article

Analysis of hip strength and mobility as injury risk factors in amateur women's football: a pilot study

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Summary

Objectives: The aims of the present study were to analize the incidence of overuse injuries of the lower limbs in an amateur women´s soccer club throughout a competitive season and to assess its relationship with hip abductors strength and hip external rotation mobility.
Material and methods: This research is an epidemiological, observational, analytical, prospective longitudinal study. The sample was selected by a non-random convenience sampling and it was composed of the 23 football players who made up the team of the E. F. Mareo in 2013-2014 season. Participant ages ranged between 14 and 33 years (x=22.5; s=5.7). The players were subjected to an evaluation of their hip abductors strength and hip external rotation mobility in preseason and, then, they were followed until the end of the competitive period recording the injuries that were appearing.
Results: Statistically significant differences were observed between the dominant and non dominant limbs in hip abductors strength and hip external rotation mobility ($p < 0.01$). Along the season, 52.2% of the participants experienced some kind of overuse injury affecting the lower extremities. Regarding the type of injury, 53.8% were ligamentous injuries mainly affecting the ankle, only one of them involved the knee (ACL tear), 15.4% were tendinous injuries affecting the knee and the remaining 30.8% were tendinous injuries affecting the hip. No significant relationship was observed between overuse injury incidence and player's hip abductors strength or hip external rotation mobility.
Conclusions: More research is needed to achieve concluding evidence about the influence of hip abductor strength and hip external rotation mobility on overuse injuries of the lower extremities in women's soccer.

Key words:
Hip abductors.
Hip external rotation. Injury risk.
Joint injury. Overuse injury.
Women soccer player.

Análisis de la fuerza y movilidad de la cadera como factores de riesgo de lesión en fútbol femenino amateur: un estudio piloto

Resumen

Objetivos: Los objetivos del presente estudio consisten en analizar la incidencia de lesiones no traumáticas de las extremidades inferiores en un equipo amateur femenino de fútbol y valorar su relación con la fuerza de la musculatura abductora y la movilidad en rotación externa de la cadera.
Material y método: La presente investigación consiste en un estudio epidemiológico, observacional, analítico, longitudinal prospectivo. La muestra se seleccionó mediante un muestreo por conveniencia quedando compuesta por las 23 jugadoras que compusieron la plantilla del E.F. Mareo en la temporada 2013-2014, equipo ubicado en la Segunda División Nacional Española. El rango de edad de las participantes fue de los 14 a los 33 años (x=22,5; s=5,7). Las jugadoras fueron evaluadas en pretemporada y posteriormente se las siguió hasta el final del período competitivo para registrar las lesiones aparecidas.
Resultados: Se apreciaron diferencias estadísticamente significativas entre la extremidad inferior dominante y la no dominante tanto en la fuerza de la musculatura abductora como en los rangos de movilidad en rotación externa de la cadera ($p < 0,01$). A lo largo de la temporada, el 52,2% de las participantes se vio afectado por alguna lesión no traumática en las extremidades inferiores. En cuanto a la tipología, el 53,8% fueron ligamentosas y afectaron principalmente al tobillo, con sólo una de ellas afectando a la rodilla (rotura de LCA), mientras que el 15,4% fueron lesiones tendinosas que afectaron a la rodilla y el 30,8% restante fueron lesiones tendinosas en la cadera. No se apreció relación de la fuerza de la musculatura abductora o de la movilidad en rotación externa de la cadera con la producción de lesiones.
Conclusiones: Resultan necesarias más investigaciones para alcanzar resultados concluyentes.

Palabras clave:
Abductores de la cadera.
Rotación externa de la cadera.
Riesgo lesional. Lesión articular.
Lesión no traumática.
Mujer futbolista.

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Introduction

The importance of women's football in the world sporting scene has seen a drastic increase over the past two decades[1]. During this period, both the number of players and the level of professionalisation have risen[2], and consequently, changes have occurred to the performance profile of the sport, with possible repercussions on the rate and patterns of injuries[1].

Based on existing scientific literature, it can be concluded that women's football has a high level of injury rate[3-9], which mainly affects the joints and muscles in the lower limbs[3,4,7,10-13], and that, despite a large proportion of injuries being caused by some kind of trauma[6,13,14], another large proportion arise with no contact whatsoever[6,15], which accentuates the relevance of preventive work.

Some research studies have aimed to objectify predisposing factors to suffering an injury that can constitute key variables when considering the prevention process[15], but evidence is still scarce and in particular deals with the professional field of women's football. As such, a link has been established between joint laxity and a greater risk of injury to the lower limbs[12,16]. Likewise, arthromuscular imbalances between the halves of the body may constitute a predisposing factor to non-traumatic injuries[17]. It has also been suggested that the injuries suffered to the lower limbs may be caused not only by existing problems in the local injured area, but also due to other alterations in nearby areas that transmit their influence via the kinetic chain to distal areas[18,19]. Finally, in studies that seek to explain the high tendency of females athletes to suffer anterior cruciate ligament injuries (ACL) in comparison with their male counterparts, anatomical and hormonal factors are indicated, as well as alterations in the dynamic of load distribution and the existing differences in the neuromuscular activation patterns as underlying mechanisms[19,20], particularly highlighting the heightened risk of knee valgus (because the Q angle of the knee is greater in women than in men) that occurs during rapid direction changes or when landing from a jump[21,22]. In this respect, it has been indicated that shortcomings in strength in the abductor muscles of the hips may predispose female footballers to dynamic knee valgus, and therefore they could be linked to the risk of injuries to the lower extremities[23].

As a result, this study aims to analyse the rate of non-traumatic injuries to the lower extremities throughout a season in an amateur women's football team and to assess the relationship between this incidence rate and the strength of the abductor muscles and the external rotation mobility of the hips.

Material and method

Study design and participants

This research study consisted in an epidemiological, observational, analytical and prospective longitudinal study. The sample was selected using a non-random convenience sample and was composed of 23 football players in the team of Mareo Football School during the 2013-2014 season, a team positioned in the Spanish National Second Division. The study was carried out following the principles, standards and procedures stipulated in the Helsinki Declaration.

Procedure

All the participants underwent a final assessment at the end of the pre-season, in which their abductor muscle strength and external rotation mobility of the hips on both lower limbs were assessed. In this assessment session data was also taken regarding the age, height and weight of the players. The assessments were performed in the Mareo Football School facilities, the club's training headquarters. All the assessment tests were preceded with 10-15 minutes of warm-up, consisting in a low-intensity jog and stretching exercises of the lower limb muscles. Likewise, all the participants had previously been suitably familiarised with the procedure and the assessment instruments, and had provided their informed written consent for their participation in the study.

To assess the isometric strength of the abductor muscles, a manual dynamometer was used (Chatillon CSD 300, Amteck, Inc., Largo, FL)[24]. Following the recommendations of Hislop *et al*.[25], the participants were positioned lying on their side with the extremity to be assessed facing up and completely extended. The hip and knee on the opposite lower extremity were bent to provide greater stability. To begin the test, the lower extremity to be analysed was positioned in abduction and was slightly extended compared to the average line, with the pelvis slightly rotated forwards. For this, participants were asked to lift their extremities in the air as far as possible and to hold this position, preventing the examiner from pushing the leg down. The examiner held the dynamometer against the leg near the lateral malleolus and pushed directly down. Participants received a verbal stimulus to hold a maximum contraction. All the participants were assessed this way by the same assessor and they were required to hold the contraction for 5 seconds. Three attempts with 1 minute rest were provided, so as to minimise the effect of fatigue, and the best attempt was recorded.

In terms of assessing the external rotation mobility of the hip, the measurements were carried out with a manual goniometer, positioning participants in the prone position on a bed with their hips straight and using a tape around the pelvis to stabilise it, fixing their position to the bed. The knee of the lower extremity assessed was positioned at a 90º bend. The assessor was positioned looking straight on at the knees and aligned the goniometric centre with the centre of the knee, with the fixed arm of the goniometer in the direction of the contra-lateral knee and the movable arm towards the ankle, following the front of the leg[26].

Next, the participants were followed-up during the entire competition season, recording the hours of individual exposure to the non-traumatic injuries that affected the joints of the lower extremities. This record was performed by the team doctor.

Data analysis

First a descriptive analysis was performed of the characterisation of the sample in terms of age, height, weight and exposure to competition.

Next a descriptive analysis was carried out of the strength values in the abductor muscles and of external rotation mobility of the hip displayed by the participants in each of the lower extremities, both dominant and non-dominant. The records of both sides were also compared to check for any differences between the sides of the body. With this objective, after checking the cases of normality and homoscedasticity, the Student t test was used for dependent samples, in the case of the abductor muscle strength, and a Wilcoxon signed-rank test to discover the external rotation mobility.

Thirdly, using percentages, the non-traumatic injury rate of the lower extremities was described, specifically noting the type of injury, its location and the laterality of the condition.

Finally, the values of the abductor muscle strength and the mobility in the external rotation of the hip were compared in players that had injuries against those without injuries. To do this, considering the result of the normality and homoscedasticity tests, a Student t test was used to check the hypothesis that strength in the abductor muscles in both lower extremities was the same in both groups of players. However, in terms of external rotation mobility of the hip, as the variable was not distributed normally, the alternative non-parametric Mann Whitney U test was used.

All the analyses were performed using the statistics package SPSS (v22.0; IBM SPSS Statistics for Macintosh, Armonk, NY) and the level of statistical significance was set at p <0.05.

Results

The study participants presented an age ranging between 14 and 33 years ($\bar{x}$ = 22.5; s = 5.7). Their weight oscillated between 1.54 and 1.77 m ($\bar{x}$ = 1.63; s = 0.05) and their weight between 48 and 93 kg ($\bar{x}$ = 61.5; s = 9.3). The football playing history of 23 of the players (92%) was over 10 years and the two other players had between 5 and 10 years of practice. In terms of exposure to competition, the total minutes played by each player varied from 900 to 2,195 ($\bar{x}$ = 1,626.1; s = 493.5).

The analysis of the tests carried out in the pre-season reveal that the strength values in the abductor muscles of the hip are distributed between 147 and 253 N ($\bar{x}$ = 190.8; s = 30.1) in the dominant lower extremity, and between 157 and 241 N ($\bar{x}$ = 169.9; s = 39.9) in the non-dominant lower extremity, with the differences between both lower extremities being statistically significant, t(22) = 3.452, p < 0.01, so that 2 players presented similar values in both sides of the body, 3 players displayed higher values in the non-dominant side of the body, and the 18 remaining players revealed greater strength in the muscles of the dominant side of the body. In terms of the external rotation mobility of the hip, the values of the dominant side oscillated between 40º and 45º ($\bar{x}$ = 43.0; s = 2.5) and those of the non-dominant side 45º and 50º ($\bar{x}$ = 47.8; s = 2.5), with the Wilcoxon signed-rank test revealing statistically significant differences between both sides (p < 0.01), in that 4 of the 23 players obtained similar external rotation mobility of the hip values, whilst the remaining 19 players displayed worse values in the dominant hip.

Table 1. Description of the non-traumatic injuries to the lower limb joints.

n	Type	Location	Laterality
3	Ligament	Ankle	Non-dominant
3	Ligament	Ankle	Dominant
1	Ligament	Knee	Dominant
2	Tendon	Knee	Dominant
1	Tendon	Hip	Non-dominant
3	Tendon	Hip	Dominant

Throughout the season, 52.2% of the team were affected by some kind of non-traumatic injury to the joints of the lower extremities, as 13 injuries occurred that affected 12 of the players (Table 1). In terms of typology, 53.8% were ligament injuries, and mainly affected the ankle, with only one of them affecting the knee (ACT rupture), whilst 15.4% were tendon injuries that affected the knee, and the remaining 30.8% were hip tendon injuries. In terms of laterality, the majority of the injuries - 69.2% - affected the dominant side, but the differences between both sides in the injury rate were not statistically significant (χ^2 = 1.923; p = 0.166).

Regarding the influence of strength of the hip abductor muscles on non-traumatic injuries in the lower extremities, no statistically significant differences were found in the values shown by the players that suffered injuries during the season when compared to their non-injured team-mates, both on the dominant and non-dominant side (Table 2).

Finally, regarding the influence of strength of the hip abductor muscles on non-traumatic injuries in the joints of the lower extremities,

Table 2. Differences in the strength of the abductor muscles of the hip in injured and uninjured players ($\bar{x}$ ± s).

	Injury (n=12)	No injury (n=11)	$t_{(21)}$	p	Effect size*
Strength of the hip abductors on the dominant side	193.64 ± 36.22	188.17 ± 24.55	0.43	0.674	0.18
Strength of the hip abductors on the non-dominant side	178.64 ± 34.95	161.83 ± 43.82	1.01	0.324	0.42

* *d* by Cohen.

Table 3. Differences in the external rotation mobility of the hip in injured and uninjured players ($\bar{x}$ ±s).

	Injury (n=12)	No injury (n=11)	U	*p*	Effect size*
External rotation mobility of the dominant hip	42.73 ± 2.61	43.33 ± 2.46	58.0	0.561	0.44
External rotation mobility of the non-dominant hip	47.73 ± 2.61	47.92 ± 2.57	63.5	0.858	0.48

** θ = U/m x n.*

no statistically significant differences were found in the values shown by the players that suffered injuries during the season when compared to their non-injured team-mates, both on the dominant and non-dominant side (Table 3).

Discussion

This study analysed the non-traumatic injury rate in the joints of the lower extremities in a women's football team, considering the strength of the abductor muscles of the hip and the external rotation mobility of this joint as potential intrinsic factors in the injury risk.

Among the main results obtained, a statistically significant difference was observed in the strength of the abductor muscle of the hip with higher values in the dominant side compared to the non-dominant side. This result contrasts with the lack of appreciable differences between the sides of the body in previously written literature about women's football[27]. Considering the possible implications of the differences in strength observed, some other works have indicated that the arthromuscular imbalances between the sides of the body may constitute a predisposing factor to non-traumatic injuries[11] and that shortcomings in strength in the abductor muscles of the hip could be linked to the risk of injury to the lower extremities[23], but no differences were observed in this study between the strength values of the injured players and those that did not suffer injuries. It has also been suggested that lateral dominance could represent a contributing factor to the differences between sexes in the non-traumatic injury risk to the ACL, as men tend to suffer from this kind of injury in the dominant leg and women in the non-dominant[26]. However, in this study, no significant differences were observed in the injury frequency in each of the sides. More studies are needed to draw conclusions regarding the importance of lateral dominance and strength imbalances between the sides of the body as predisposing factors to non-traumatic injuries in women's football.

In terms of the external rotation mobility of the hip, the values observed are higher than those reported in the literature for elite players[27]. Likewise, following the criteria of the American Academy of Orthopaedic Surgeons[29], which indicates 45º as the normal value for the external rotation of the hip, the average of the values observed in the dominant hip are below the normal value, in contrast to those of the values observed in the non-dominant hip, which are above. These lateral differences revealed statistical significance, but no differences at all were found between the mobility values of players that suffered injuries and those that did not. In previous studies a link has been established between players with joint laxity and a greater risk of injury to the lower extremities[12,16], and in accordance with this, it would be expected to see a greater number of injuries in the non-dominant side, but, as already mentioned, no significant differences were found in the number of injuries depending on laterality. It should be considered that as well as due to joint laxity, ligament injuries in footballers with a prolonged history of practice can also occur due to joint impingement.

Among the limitations of this study, particularly noteworthy are the reduced size of the sample and that exposure to training and competitions have not been considered as predisposing factors to injuries. Nor was there a control of the existence of previously existing injuries that could predispose relapse. Furthermore, only strength values of one isolated muscle group - the hip abductors - have been taken, making it impossible to consider agonist-antagonist imbalances as a predisposing factor to injury. In terms of the assessment time, it was undertaken at just one point in the season, at the end of the preparatory period, analogously to the procedure used in previous prospective studies[12]. The reason that justifies the choice of this sole time for assessment is that, in accordance with the training methodology of team sports, during the preparatory (pre-season) period, the aim is to increase physical condition to reach the optimum values for competing, and from there, during the competitive period, the aim of training is to maintain these values, therefore no major oscillations are expected in these values during the rest of the season. However, when performing control assessments over the competition period, it cannot be ensured that the strength and mobility values have remained unaltered during the injury recording period. Finally, when recording the non-traumatic injuries, only those that affected a joint were considered, excluding muscle injuries, which could have conditioned the results obtained.

To conclude, this study has enabled a preliminary exploration of the relationship between the external rotation mobility of the hip and abductor muscle strength in the occurrence of injuries in amateur female football players. More and better studies are required to achieve definitive results.

References

1. Datson N, Hulton A, Andersson H, Lewis T, Weston M, Drust B, *et al.* Applied physiology of female soccer: an update. *Sports Med.* 2014;44(9):1225-40.
2. Fahmy M. Increase participation and competitions. 5th FIFA Women´s Football Symposium; 15-17 July; Frankfurt 2011. Disponible en: https://www.fifa.com/mm/document/footballdevelopment/women/01/51/51/64/presentation_increaseparticipation_e.pdf

3. Jacobson I, Tegner Y. Injuries among Swedish female elite football players: a prospective population study. *Scand J Med Sci Sports.* 2007;17(1):84-91.
4. Tegnander A, Olsen OE, Moholdt TT, Engebretsen L, Bahr R. Injuries in Norwegian female elite soccer: a prospective one-season cohort study. *Knee Surg Sports Traumatol Arthrosc.* 2008;16(2):194-8.
5. Le Gall F, Carling C, Reilly T. Injuries in Young Elite Female Soccer Players An 8-Season Prospective Study. *Am J Sports Med.* 2008;36(2):276-84.
6. Faude O, Junge A, Kindermann W, Dvorak J. Injuries in female soccer players a prospective study in the german national league. *Am J Sports Med.* 2005;33(11):1694-700.
7. Giza E, Mithöfer K, Farrell L, Zarins B, Gill T. Injuries in women's professional soccer. *Br J Sports Med.* 2005;39(4):212-6.
8. Fuller CW, Dick RW, Corlette J, Schmalz R. Comparison of the incidence, nature and cause of injuries sustained on grass and new generation artificial turf by male and female football players. Part 1: match injuries. *Br J Sports Med.* 2007;41(suppl 1):i20-i6.
9. Fuller CW, Dick RW, Corlette J, Schmalz R. Comparison of the incidence, nature and cause of injuries sustained on grass and new generation artificial turf by male and female football players. Part 2: training injuries. *Br J Sports Med.* 2007;41(suppl 1):i27-i32.
10. Junge A, Dvorak J. Soccer injuries. *Sports Med.* 2004;34(13):929-38.
11. Hägglund M, Waldén M, Ekstrand J. UEFA injury study–an injury audit at European Championships 2006 to 2008. *Br J Sports Med.* 2009;43(7):483-9.
12. Östenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123 players during one season. *Scand J Med Sci Sports.* 2000;10(5):279-85.
13. Junge A, Dvorak J. Injuries in female football players in top-level international tournaments. *Br J Sports Med.* 2007;41(suppl 1):i3-i7.
14. Dick R, Putukian M, Agel J, Evans TA, Marshall SW. Descriptive epidemiology of collegiate women's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2002–2003. *J Athl Train.* 2007;42(2):278.
15. Murphy D, Connolly D, Beynnon B. Risk factors for lower extremity injury: a review of the literature. *Br J Sports Med*. 2003;37(1):13-29.
16. Myer GD, Ford KR, Paterno MV, Nick TG, Hewett TE. The effects of generalized joint laxity on risk of anterior cruciate ligament injury in young female athletes. *Am J Sports Med.* 2008;36(6):1073-80.
17. Söderman K, Alfredson H, Pietilä T, Werner S. Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surg Sports Traumatol Arthrosc*. 2001;9(5):313-21.
18. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J. Deficits in neuromuscular control of the trunk predict knee injury risk a prospective biomechanical-epidemiologic study. *Am J Sports Med*. 2007;35(7):1123-30.
19. Sutton KM, Bullock JM. Anterior cruciate ligament rupture: differences between males and females. *J Am Acad Orthop Surg*. 2013;21(1):41-50.
20. Hewett TE, Myer GD, Ford KR. Anterior cruciate ligament injuries in female athletes part 1, mechanisms and risk factors. *Am J Sports Med.* 2006;34(2):299-311.
21. Hewett TE, Myer GD, Ford KR, Heidt RS, Colosimo AJ, McLean SG, *et al.* Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes. A prospective study. *Am J Sports Med.* 2005;33(4):492-501.
22. Malinzak RA, Colby SM, Kirkendall DT, Yu B, Garrett WE. A comparison of knee joint motion patterns between men and women in selected athletic tasks. *Clin Biomech.* 2001;16(5):438-45.
23. Wallace BJ, Kernozek TW, Mikat RP, Wright GA, Simons SZ, Wallace KL. A comparison between back squat exercise and vertical jump kinematics: implications for determining anterior cruciate ligament injury risk. *J Strength Cond Res*. 2008;22(4):1249-58.
24. Fulcher ML, Hanna CM, Elley CR. Reliability of handheld dynamometry in assessment of hip strength in adult male football players. *J Sci Med Sport.* 2010;13(1):80-4.
25. Hislop H, Avers D, Brown M. *Daniels and Worthingham's muscle testing: Techniques of manual examination and performance testing.* 9 ed. St. Louis, MI: Elsevier; 2014. 223.
26. Norkin CC, White DJ. *Measurement of joint motion: a guide to goniometry.* 4 ed. Philadelphia, PA: FA Davis; 2009.
27. Chiaia TA, Maschi RA, Stuhr RM, Rogers JR, Sheridan MA, Callahan LR, *et al.* A musculoskeletal profile of elite female soccer players. *HSS J.* 2009;5(2):186-95.
28. Brophy R, Silvers HJ, Gonzales T, Mandelbaum BR. Gender influences: the role of leg dominance in ACL injury among soccer players. *Br J Sports Med*. 2010;44(10):694-7.
29. American Academy of Orthopaedic Surgeons. *Joint motion: method of measuring and recording.* Edinburgh: Churchill Livingstone; 2011. 87.