Departamento de Nutrición y Bromatología

Facultad de Farmacia

Universidad de Granada

Influencia de la Actividad Física y la Nutrición en Jóvenes

Influence of Physical Activity and Nutrition in Young People

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CONTENIDOS [Contents]

RESUMEN

La inactividad física y el establecimiento de hábitos alimentarios saludables son los principales factores modificables determinantes de enfermedad crónica. Un aumento de la capacidad aeróbica y el seguimiento de las pautas nutricionales relacionadas con la dieta mediterránea están inversamente relacionados con distintos parámetros de salud en jóvenes. Por este motivo, es importante el desarrollo de programas específicos que mejoren la capacidad aeróbica y la nutrición de los jóvenes, siendo la escuela el lugar de origen y núcleo de potenciales iniciativas encaminadas al impulso de hábitos saludables. De la misma forma, es importante involucrar a los padres en dichos programas, ya que ha sido demostrado que la influencia que estos ejercen sobre los hábitos de vida saludables de sus hijos es muy alta.

El objetivo general de la Tesis Doctoral es estudiar la relación entre la actividad física y la nutrición con los diversos parámetros relacionados con la salud en jóvenes, así como estudiar el efecto combinado de esta intervención en sujetos con síndrome metabólico.

Los resultados de la presente memoria de Tesis ponen de manifiesto la importancia y utilidad de las intervenciones combinadas de actividad física y nutrición como determinantes de salud. La metodología utilizada en estas intervenciones puede ser utilizada como estrategia educativa y sanitaria para la prevención de diversas enfermedades, así como para la reducción de las mismas.

SUMMARY

Physical inactivity and unhealthy eating habits are two mayor modifiable determinants of chronic diseases. Increases in aerobic capacity and development of nutritional patterns related with the traditional Mediterranean diet are related with positive improvements to specific health parameters in youth. For this reason, it is important to develop programs for young people which specifically target improvements aerobic capacity and nutrition. The school is a potential setting for such interventions making it well-placed to improve the health habits of its pupils. In addition, it is important to involve parents in healthy interventions, as parents have a strong influence on the health habits of their children.

Studies have begun to demonstrate improvements in some physiological risk factors using vigorous physical training programs with obese children and adolescents during after-school hours. In recognition, the American Heart Association (AHA) now recognizes the importance of prevention and treatment.

The overall objective of this thesis was to study the relationship between physical activity and nutrition on different parameters related with health in the young population. In addition the thesis examines the effects of combined interventions in subjects with metabolic syndrome.

The results of the present work highlight the importance and usefulness of interventions combining physical activity and nutrition with regards to health determinants. The methodology used in these interventions can be used as part of an education and health strategy for the reduction and/or prevention of illness and diseases.

ABREVIATURAS [Abbreviations]

ACSM	American College of Sport Medicine
AHA	American Heart Association
BMI	Body max index
BP	Blood pressure
C	Compliant
CA	Capacidad aeróbica [Aerobic capacity]
CG	Control group
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DM	Diabetes mellitus
ESO	Educación Secundaria Obligatoria [CGSE]
EVOO	Extra virgin olive oil
FC	Frecuencia cardiaca [Heart rate]
GC	Grupo control [Control group]
GL	Glycemia
G2S	Grupo intervención 2 sesiones [Intervention group with 2 sessions]
G3S	Grupo intervención 3 sesiones [Intervention group with 3 sessions]
HDLc	High density lipoprotein cholesterol
IG	Intervention group
IPAQ	International physical activity questionnaire

IR	Ingesta recomendada [Recommended intake]
ISAK	International Society for the Advancement of Kinanthropometry
LDLc	Low density lipoprotein cholesterol
MD	Mediterranean diet
MHR	Maximun heart rate
MI	Myocardial infarction
MS	Metabolic syndrome
NC	Non-compliant
RDA	Recommended Daily Allowances
SBP	Systolic blood pressure
TC	Total cholesterol
TG	Triglycerides
VE	Ventilación pulmonar [Pulmonary ventilation]
VCO_2	Volumen de dióxido de carbono [Carbon dioxide uptake]
VEPA	Vigorous extracurricular physical activity
VO_2	Volumen de oxígeno [Oxygen uptake]
VO_{2MAX}	Maximum oxygen uptake
VT1	Umbral ventilatorio 1 [Ventilation threshold 1]
VT2	Umbral ventilatorio 2 [Ventilation threshold 2]
WHO	World Health Organization
20mSRT	20 meter shuttle run test

INTRODUCCIÓN

En la actualidad, el elevado consumo de alimentos de alta densidad energética, ricos en grasas saturadas, azúcar y sal, la falta de actividad física y el incremento de actividades sedentarias, representan los estilos de vida de gran parte de la población infantil[1]. Esta es la causa principal que ha hecho que la obesidad en la infancia y la adolescencia se haya incrementado de manera alarmante en los últimos años[2,3]. La obesidad está relacionada con el aumento del riesgo de una serie de enfermedades como por ejemplo el desarrollo de diabetes mellitus, hipertensión, dislipemias, osteoporosis, enfermedades cardiovasculares y algunos tipos de cáncer[4]. Aunque recientes estudios demuestran que el componente genético es un importante factor a la hora de explicar y comprender la obesidad, parece no ser la principal causa del rápido aumento en el número de obesos, dentro de una población relativamente estable[5]. Resultados obtenidos en investigaciones internacionales muestran que la dieta, la actividad física y los comportamientos sedentarios son los factores más importantes de riesgo para los jóvenes con sobrepeso[6].

Actualmente la inactividad física es considerada por diversos autores como uno de los principales problemas de salud pública del siglo XXI[7]. La prevalencia de un patrón insuficiente de actividad física oscila entre el 37% y el 40% en la población escolar española, en función de su sexo (niños y niñas, respectivamente)[8]. Existen evidencias científicas abrumadoras que relacionan la actividad física y la salud física y mental. La actividad física se asocia negativamente con el sobrepeso y la obesidad[7], y positivamente con la salud cardiovascular en personas jóvenes[9,10]. Un aumento de la capacidad aeróbica está relacionado inversamente con distintos parámetros de salud en jóvenes, como el perfil lipídico[11,12], la resistencia a la insulina[13,14], la masa grasa[15,16] y parámetros relacionados con el síndrome metabólico[17,18] .

La nutrición ha sido catalogada como uno de los principales factores modificables determinantes de enfermedades crónicas[19]. El establecimiento de hábitos alimentarios saludables durante la infancia y la adolescencia es importante, ya que se ha demostrado que las preferencias alimenticias y los hábitos alimentarios se establecen durante la infancia temprana[20] y pueden perdurar hasta la edad adulta[21]. Se ha demostrado que una adecuada ingesta de frutas y verduras tienen efecto protector sobre la salud tanto a corto como largo plazo[22]. La dieta mediterránea es de interés para la salud pública ya que un elevado número de investigaciones han demostrado el efecto beneficioso de los componentes específicos de la dieta mediterránea sobre la pérdida de peso[23,24], obesidad abdominal[25], resistencia a la insulina[26,27], riesgo de sufrir diabetes mellitus[28,29] y enfermedades cardiovasculares[30,31]. Esta dieta se caracteriza por un alto consumo de cereales integrales, aceite de oliva, legumbres, verduras, frutas y cereales, de moderado a alto consumo de pescado y de moderado a bajo consumo de carne y productos cárnicos, leche y productos lácteos, además de un consumo moderado de alcohol en forma de vino en las comidas. Los posibles mecanismos por los que la dieta mediterránea puede influir en estas enfermedades son debidos al elevado contenido en fibra que puede influir en la sensación de saciedad, el alto contenido en antioxidantes en la β-disfunción de las células, efecto antiinflamatorio de vitaminas, minerales, antioxidantes y grasa insaturada (sobre todo aceite de oliva) presentes en altos niveles en la dieta mediterránea[32,33].

La American Heart Association (AHA) se ha pronunciado de forma oficial, basándose en evidencias científicas, y propone la escuela como el lugar de origen y núcleo de potenciales iniciativas encaminadas a la promoción y el impulso de comportamientos saludables[34]. De igual importancia es la involucración de los padres en intervenciones saludables, ya que la influencia que ejercen los padres sobre los hábitos alimenticios de los jóvenes y adolescentes es elevada[35].

INTRODUCTION

Nowadays, the lifestyle of the majority of child population is characterized by a high intake of food which is energy-dense, high in saturated fats, and high in sugar and salt. This is often compounded by low levels of physical activity and high levels of sedentary behavior[1]. This is the main contributor to the alarming rise in childhood and adolescent obesity in recent years[2,3]. Obesity is associated with an increased risk of a number of illnesses such as; the development of diabetes mellitus, hypertension, dyslipidemia, osteoporosis, cardiovascular disease and certain types of cancer[4]. Although recent studies show that genetic components are important factors in explaining and understanding obesity, it is unlikely to be the main cause of the rapid rise in the number of cases of obesity, within a relatively stable population[5]. Results gathered in international research show that diet, physical activity and sedentary behaviour are the most important risk factors for excessive weight in youth[6].

Physical inactivity is considered to be one of the main threats to public health in the 21st century[7]. Estimated prevalence`s of physical inactivity froma Spanish scholar population (boys and girls, respectively) range from 37% to 40%[8]. There is scientific evidence which links physical activity with both physical and mental health. Physical activity is negatively associated with overweight and obesity[7], and positively associated with cardiovascular health in young people[9,10]. Increases in aerobic capacity are related with improvements to specific health parameters in youth including: the lipid profile[11,12], insulin resistance[13,14], fat mass[15,16] and parameters associated with metabolic symdrome[17,18].

Nutrition has been labeled as one of the main modifiable determinants of chronic diseases[19]. Establishing healthy eating habits during childhood and adolescence is important, since it has been shown that food preferences and eating habits are established in early childhood[20] and can persist into adulthood[21]. Researchers have been shown that adequate intake of fruits and vegetables have a protective effect on both shirt and long-term health[22]. Research surrounding the Mediterranean diet is of interest for public health as a large number of studies have now demonstrated the beneficial effects of specific components of the Mediterranean diet on weight loss[23,24], abdominal obesity[25], insulin resistance[26,27], risk of diabetes mellitus[28,29] and cardiovascular diseases[30,31]. This dietary pattern is characterized by a high consumption of whole-grain cereals, olive oil and, plant foods (i.e. vegetables, fruits, and legumes), a moderate-to-high intake of fish, and a low-to-moderate intake of meat. There is also a moderate intake of alcohol in the form of wine consumed with meals. The possible mechanisms through which the Mediterranean diet may influence these diseases are via its high fibre content which can influence satiety, influence of high antioxidant content on β-cell dysfunction, and the inflammatory effects of the high levels of vitamins, minerals, antioxidants and unsaturated fats (especially olive oil)[32,33].

Previous studies which obese children and adolescents have demonstrated improvements in some physiological risk factors[15] using vigorous physical training programs during after-school hours. The American Heart Association (AHA) now recognizes the importance of prevention and treatment. In addition, it is important to involve parents in healthy interventions, as parents have a strong influence on the eating habits of young people and adolescents[16].

OBJETIVOS

General

El objetivo general de la Tesis Doctoral es estudiar la relación entre la actividad física y la nutrición con los diversos parámetros relacionados con la salud en jóvenes, así como estudiar el efecto combinado de esta intervención en sujetos con síndrome metabólico.

Específicos

I. Describir el grado de actividad física, estado nutricional y prevalencia de sobrepeso/obesidad en niños y jóvenes escolarizados en Granada.

II. Analizar la influencia de una intervención, de corta duración, combinada de actividad física y educación nutricional sobre parámetros relacionados con la salud en escolares.

III. Determinar el efecto de una intervención combinando actividad física, educación nutricional y consumo de aceite de oliva virgen extra, de manera combinada y aislada, sobre parámetros relacionados con la salud en escolares.

IV. Estudiar los efectos de un programa de actividad física moderada-vigorosa de seis meses de duración y del consumo diario de un aceite de oliva virgen extra rico en polifenoles sobre la actividad de la enzima catalasa en niños sanos.

V. Examinar el efecto de un programa de entrenamiento aeróbico de alta intensidad desarrollado durante las clases de educación física sobre la capacidad aeróbica de adolescentes.

VI. Identificar la relación existente entre realizar actividad física y una nutrición adecuada y la posibilidad de sufrir infarto de miocardio en sujetos con síndrome metabólico.

AIMS

General

The overall objective of this thesis was to study the relationship between physical activity and nutrition on the different parameters related with health in a young population. This thesis also examines the effects of combined interventions in subjects with metabolic syndrome.

Specific

I. To describe the physical activity habits, nutritional status, and prevalence of overweigh/obesity in school children and youth in Granada.

II. To analyze the effects of a short-term intervention combining, nutritional education with physical activity on the improvement of health-related parameters in children at primary school.

III. To determine the effects of nutritional education, vigorous extra-curricular physical activity and extra virgin olive oil, both individually and in combination on health related parameters in children in primary education.

IV. To study the effects of a 6 months intervention incorporating moderate-vigorous physical activity and daily extra virgin olive oil consumption rich in polyphenols on catalase activity in healthy children.

V. To examine the effect of high intensity aerobic training delivered during physical education classes on the aerobic capacity of adolescents.

VI. To identify the relationship between physical activity and proper nutrition on the probability of suffering from myocardial infarction in subjects with metabolic syndrome.

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MATERIAL, MÉTODOS, RESULTADOS Y DISCUSIÓN

El material, métodos, resultados y discusión se presentan a continuación en cada uno de los capítulos que componen la memoria de la presente Tesis Doctoral.

MATERIALS, METHODS, RESULTS AND DISCUSSION

Materials, methods, results and discussion are presented below for each chapter which constitutes the mayor research of the thesis.

ASSESSMENT OF NUTRITIONAL STATE IN CHILDREN AND ADOLESCENT STUDENTS OF GRANADA

I

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nutrición clínica y Dietética Hospitalaria

Artículo Original

Evaluación del estado nutricional en niños y jóvenes escolarizados en Granada

Assessment of the nutritional state in children and adolescent students of Granada

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Resumen

El objetivo de este estudio ha sido analizar el índice de masa corporal (IMC), el grado de actividad física y valorar el estado nutricional de niños y jóvenes escolarizados en Granada. Para ello se realizó un estudio nutricional en una muestra formada por 77 sujetos, 37 niños (16 varones y 21 mujeres) con una media de edad de 11.46 ± 0.55 años y 40 jóvenes (20 varones y 20 mujeres) con una media de edad de 15.8 ± 0.75 años, mediante un registro dietético de 3 días. Además se evaluó el IMC y el grado de actividad o sedentarismo realizando encuestas personales. Los resultados nos muestran como el aporte calórico de los macronutrientes fue desequilibrado: alto de lípidos (36.11%) y prótidos (16.78%) y bajo de hidratos de carbono (47.09%). Con respecto a los micronutrientes, las dietas evaluadas fueron, en general, adecuadas, excepto en el caso de la vitamina E, ácido fólico, potasio y calcio para todos los grupos; magnesio para todos los grupos a excepción del grupo de niños género femenino; y hierro para el grupo de jóvenes género femenino, donde se observan deficiencias. El IMC medio está dentro de los valores de normopeso, sin embargo un alto porcentaje de los sujetos estudiados tienen unos IMC superiores a los establecidos como normopeso. El número de sujetos activos va disminuyendo con la edad, independientemente del género. Analizando los resultados parece conveniente realizar algún tipo de intervención nutricional y de actividad física para prevenir posibles trastornos como es el caso de la obesidad.

Palabras clave

Estado nutricional, obesidad, IMC, actividad física, jóvenes.

Abstract

The objective of this study was to analyze the Body Mass Index (BMI), physical activity, and to assess the nutritional state of children and adolescent students of Granada. The nutritional assessment was developed in a sample of 77 subjects, 37 children (16 boys and 21 girls) aged 11.46 ± 0.55 years and 40 adolescents (20 boys and y 20 girls) aged 15.8 ± 0.75 years, by means

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of a 3 day dietetic recording. BMI has been also studied, as well as the grade of physical activity or sedentary pattern by means of personal interviews. The results show calorie support of macronutrients was misbalanced, high in lipids (36.11%) and proteins (16.78%), and low in carbohydrates (47.09%). In respect to micronutrients, evaluated diets were, in general, adequate, except in the case of E vitamin, Folic Acid, Potassium, and Calcium for all the groups; Magnesium for all the groups except children girls; and Iron for the adolescent girls. Mean BMI is within the values of normal weight, although a high percentage of the studied subjects sows higher values of BMI than the considered as normal. The number of subjects physically active is decreasing with age independently of gender. Should be important to carry out an intervention in nutritional pattern as well as in physical activity to prevent disorders as obesity.

Key words

Nutritional state, obesity, BMI, physical activity, young people.

Abreviaturas:

RDA: Recommended Daily Allowances.

IMC: Índice de Masa Corporal.

WHO: World Healt Organization.

ESO: Educación Secundaria Obligatoria.

IR: Ingesta Recomendada.

Introducción

En las últimas décadas se han acumulado evidencias sobre la importancia de una buena alimentación, especialmente en las etapas de desarrollo. Durante la niñez y la adolescencia, una adecuada nutrición es fundamental para alcanzar el máximo desarrollo tanto físico como intelectual. Es durante este periodo del desarrollo donde se establecen patrones de consumo que pueden contribuir, en la edad adulta, a la aparición de diversas enfermedades[1,2]. La valoración del estado nutricional como un indicador del estado de salud, es un aspecto importante en la localización de grupos de riesgo con deficiencias y excesos dietéticos que pueden ser factores de riesgo en muchas de las enfermedades crónicas más prevalentes en la actualidad[3]. Múltiples estudios epidemiológicos y clínicos demuestran que los cambios en la dieta producidos en los últimos años en los países más desarrollados han provocado un alarmante aumento del número de españoles con problemas de sobrepeso y obesidad, un incremento en las cifras de colesterol hasta concentraciones similares a las de los países del norte de Europa, así como un aumento en las cifras de presión arterial. Igualmente, el consumo de dietas con alta densidad energética y baja densidad de nutrientes, puede dar lugar a desnutriciones subclínicas que pueden afectar a nutrientes esenciales[4].

La obesidad en la infancia y la adolescencia se ha incrementado de manera alarmante en los últimos años[5,6]. Esta alta prevalencia de la obesidad en la edad infantil debe tener progresivas y amenazadoras consecuencias para la salud biopsicosocial, tanto durante la niñez y adolescencia como en la edad adulta[7]. En España, es muy evidente el aumento de la prevalencia del sobrepeso y la obesidad en niños, adolescentes y jóvenes adultos. Así en el estudio enKid (1998-2000) se demuestra que un 26,3% presentan sobrepeso y un 13,9% obesidad, utilizando como puntos de corte el percentil 85 y 97 del estudio de la Fundación Orbegozo (1988)[8]. Los resultados en estudios longitudinales nos indican que los niños obesos tienden a ser adultos obesos en el futuro[9]. Por todo ello, prevenir el exceso de peso y la obesidad en la edad pediátrica y muy especialmente en el periodo de la adolescencia, e identificar a niños que tienen factores de riesgo de obesidad, se convierte en una prioridad sanitaria, ya que es el método más eficaz para alcanzar una media de peso y de índice de masa corporal (IMC) óptima en la población, que coincide con la menor prevalencia de obesidad y la menor tasa de morbimortalidad[10].

El estilo de vida más sedentario de los jóvenes y adolescentes debido a las nuevas tecnologías y a los cambios sociales ha provocado que exista un alto porcentaje de españoles con un estilo de vida sedentario, y además con una tendencia al cambio ínfima[11]. Este estilo de vida constituye el principal determinante de la salud y ejerce un importante impacto en la morbimortalidad de las poblaciones[12]. La actividad física practicada de forma regular, mejora la salud y reduce el riesgo de mortalidad[13] y si se desarrolla de acuerdo a unos criterios de tipo, duración, intensidad, frecuencia y progresión[14], se adaptada a las posibilidades del individuo, mejorando la salud del mismo y ayuda al tratamiento de enfermedades, entre las que sobresalen por su importancia las coronariopatías, la hipertensión arterial, la diabetes mellitas, la osteoporosis, cáncer de colon y la depresión, sin olvidar cómo afecta al desarrollo del sobrepeso[15-17]. El análisis de los beneficios de la práctica regular de actividad física y los riesgos derivados de un estilo de vida sedentario nos muestran su importante contribución a la morbimortalidad. Como vienen reiterando numerosos estudios, una temprana intervención en estos aspectos y en edades tempranas no sólo reduciría estos riesgos sino que abarataría los costes derivados de estas patologías en un futuro. En EE.UU los gastos atribuibles a la obesidad son de 78.5 billones de dólares o 9,1% de todo el gasto médico en Estados Unidos para 1988[18].

El objetivo de este trabajo ha sido analizar el grado de actividad física, el IMC y valorar el estado nutricional de niños y jóvenes escolarizados en la provincia de Granada.

Material y Método

La muestra está formada por 77 sujetos, 37 niños (16 varones y 21 mujeres) con una media de edad de 11.46 ± 0.55 años y 40 jóvenes (20 varones y 20 mujeres) con una media de edad de 15.8 ± 0.75 años de centros públicos de la capital de Granada (Andalucía, España), durante el curso 2007-08. Se ha realizado un muestreo aleatorio simple, siendo la muestra representativa de los cursos de 6º de Primaria y 4º de ESO a un nivel de confianza del 90%. Antes de realizar las entrevistas con los alumnos y las determinaciones antropométricas, se ha contado con el consentimiento expreso por parte de los padres.

Para evaluar el estado nutricional se realizó un registro dietético de 3 días. Se valoró el aporte medio diario de micronutrientes y macronutrientes mediante el programa Dietsource en su versión 1.2. Los datos se analizaron en el paquete estadístico SPSS, en su versión 15.0. Tras comprobar la normalidad de las variables, a través de la prueba Shapiro-Wilk, se utilizó el test T de Student para comparar los valores medios de la ingesta estimada para los distintos micronutrientes y macronutrientes y las RDA (Recommended Daily Allowances). Se consideró como significativo un nivel de $P < 0,05$.

Para evaluar el IMC se midieron y pesaron a todos los sujetos, calculando su IMC posteriormente.

Para evaluar el grado de actividad o sedentarismo, hemos observado la duración e intensidad del ejercicio (ligera, moderada y vigorosa) según la clasificación establecida por la Organización mundial de la Salud (WHO) en 1985, encuestando a los sujetos sobre las siguientes preguntas:

¿Realizas actividad física fuera del horario escolar?

¿De qué tipo?

¿Durante cuántas horas a la semana?

Resultados

En la tabla 1 figuran los datos en cuanto a sobrepeso y obesidad de la muestra dividida por género y edad. Como puntos de corte se han seleccionado los establecidos por Cole et al., (2000)[19]. El IMC medio, tanto en hombres como en mujeres, e independientemente de la edad estaba dentro de los valores de normopeso establecidos por Cole et al. Sin embargo, un 43.75% de los niños de 6º de Primaria obtienen unos puntos de corte superiores a los establecidos como normopeso, en el caso del género femenino el 33.33% supera estos valores. En jóvenes de género masculino el 45% de los sujetos tienen valores superiores a los considerados como normopeso, mientras que en el caso del género femenino el 20% supera estos valores. (Tabla 1)

La tabla 2 muestra el grado de actividad de los sujetos, quedando divididos en sujetos activos (realizan dos o más horas de actividad física extraescolar de tipo moderada o vigorosa) y sedentarios (no realizan actividad fí-

Tabla 2. Comparación entre activos y sedentarios por curso y género

Curso	Género	% Activos	%Sedentarios
6º Primaria	Masc.	75	25
6º Primaria	Fem.	23.81	76.19
4º ESO	Masc.	60	40
4º ESO	Fem.	10	90

Tabla 1. Distribución de sobrepeso y obesidad según género y edad

N	Género	Edad ± DS	IMC± DS	%Sobrepeso	%Obesidad	%Sobrepeso/Obesidad
16	Masc.	11.44 ± 0.61	19.44 ± 3.5	37.5	6.25	43.75
21	Fem.	11.48 ± 0.5	20.29 ± 3.68	23.81	12.5	33.33
20	Masc.	15.9 ± 0.7	23.3 ± 4.41	35	10	45
20	Fem.	15.7 ± 0.78	20.85 ± 2.85	20	0	20

sica extraescolar; realizan actividad física extraescolar del tipo modera o vigorosa durante menos de dos horas a la semana o realizan actividad física extraescolar de tipo ligera). Podemos observar como el número de sujetos activos va disminuyendo con la edad, independientemente del género, manifestando ser activos un 45.95% en 6º de Primaria, frente a un 35% que manifiesta serlo en 4º de Educación Secundaria Obligatoria (ESO). Dividiendo la muestra por género observamos grandes diferencias entre sujetos activos, siendo un 66.67% los sujetos de género masculino que manifiestan ser activos, frente a un 17.07% del género femenino. (Tabla 2)

Los resultados globales muestran como el aporte de energía a través de proteínas y lípidos supera de manera estadísticamente significativa (P<0.05) las ingestas diarias recomendadas, mientras que el de carbohidratos presenta un valor estadísticamente significativo inferior al de las ingestas diarias recomendadas (P<0.05). En cuanto al tipo de lípidos ingeridos la ingesta es superior a la recomendada para ácidos grasos saturados, siendo estas diferencias estadísticamente significativas (P<0.05), y para colesterol, siendo los resultados próximos a la significatividad estadística. La ingesta de ácidos grasos monoinsaturados y poliinsaturados es inferior a las recomendaciones, siendo estas diferencias estadísticamente significativas (P<0.05). Comparando los resultados con las recomendaciones de la WHO (2002), podemos comprobar como la dieta de los jóvenes escolarizados estudiados tiene deficiencias en cuanto a carbohidratos, ya que tan sólo el 47% de la ingesta calórica diaria obtenida proviene de este macronutriente, mientras las recomendaciones nos indican que debería ser de entre un 50-60%. En cuanto a las proteínas, el porcentaje de ingesta calórica diaria es excesivo, ya que está situado en un 17%, mientras las recomendaciones lo sitúan entre un 10-15%. En cuanto a los lípidos también existe exceso de ingesta calórica diaria, ya que el porcentaje estudiado se sitúa en el 36%, mientras que las recomendaciones están entre el 30-35%. La tabla 3 compara la ingesta de macronutrientes entre géneros y divididos por curso. (Tabla 3)

En cuanto a la ingesta de micronutrientes observamos que existen deficiencias en vitamina E, ácido fólico, potasio y calcio para todos los grupos estudiados, siendo estas diferencias estadísticamente significativas para todos los casos (P<0.05). El grupo de niños (género masculino y femenino) y el de jóvenes de género masculino presenta deficiencias en vitamina D, no siendo estas diferencias estadísticamente significativas para ninguno de los casos. Todos los grupos presentan deficiencia de magnesio, con diferencias estadísticamente significativas para todos los casos, a excepción del grupo niños de género femenino. El hierro presenta deficiencias en el grupo de jóvenes de género femenino, siendo estas diferencias estadísticamente significativas. La tabla 4 muestra la comparativa por género entre la ingesta de micronutrientes y las RDA para los sujetos de 6º de Primaria, la tabla 5 muestra la comparativa por género entre la ingesta de micronutrientes y las RDA para los sujetos de 4º de ESO. (Tabla 4) (Tabla 5)

Discusión

El porcentaje de niños y jóvenes con sobrepeso y obesidad (según los puntos de corte establecidos por Cole et al., 2000) fue alto, tanto para alumnos de 6º de Primaria (43.75% en varones y 36.31% en mujeres) como para alumnos de 4º de ESO (45% en varones y 20% en mujeres). Estos resultados, aunque algo superiores, coinciden con los descritos en otros estudios, como los del estudio enKid, realizado en una muestra representativa de la población española de entre 2 y 24 años con una muestra de 3850 sujetos, donde pode-

Tabla 3. Consumo de macronutrientes por persona y día

	6º H	6º M	P valor	4º H	4ºM	P valor
Proteínas (g)	66.32±14.55	70.65±14.5	.145	66.96±17.89	74.36±15.45	.352
H.C (g)	190.36±50.38	191.76±57.09	.463	199.49±48.55	198.55±52.12	.471
Lípidos (g)	138.99±17.04	165.85±27.06	.02*	151.14±22.02	142.34±26.26	.256
AGS (g)	43.57±6.11	52.14±10.77	.044*	48.15±8.68	46.46±9.6	.369
AGM (g)	52.44±6.44	57.1±9.4	.156	53.91±8.59	51.03±10.21	.291
AGP (g)	13.72±1.9	14.86±3.24	.224	16.14±3.38	13.98±2.54	.098
Colesterol (mg)	367.47±109.88	399.7±101.98	.191	368.43±158.65	347.06±147.83	.335

P<0,05*, P<0,01**, P<0,001***

Tabla 4. Comparativa por género entre ingesta de macronutrientes y RDA alumnos 6º Primaria

	Masculino	RDA	P Valor	Femenino	RDA	P Valor
Vit. A (µg/d)	1060.4±365.76	600	.000***	1093.2±541.88	600	.000***
Vit. B2 (mg/d)	1.7±0.44	0.9	.000***	1.8±0.47	0.9	.000***
Vit. B6 (mg/d)	1.7±0.36	1	.000***	1.7±0.58	1	.000***
Vit C (mg/d)	90.7±55.85	45	.003**	102.3±34.28	45	.000***
Vit D (µg/g)	3.2±4.81	5	.089	3.8±5.66	5	.187
Vit. E (mg/d)	7.2±2.55	11	.000***	7.2±4.14	11	.000***
Eq.Niacina(mg/d)	19.3±4.17	12	.000***	19.9±5.08	12	.000***
Ác.Folico (µ/d)	145.3±39.23	300	.000***	136.4±40.18	300	.000***
Sodio (g/d)	2.4±0.7	1.5	.000***	2.5±0.61	1.5	.000***
Potasio (g/d)	2.2±0.36	4.5	.000***	2.3±0.6	4.5	.000***
Calcio (mg/d)	898.9±263.59	1300	.000***	1085.6±282.32	1300	.001**
Fósforo (mg/d)	1220.2±239.51	1250	.319	1305.1±325.77	1250	.229
Magnesio (mg/d)	215.4±38.63	240	.013*	229±55.32	240	.193

P<0,05*, P<0,01**, P<0,001***

Tabla 5. Comparativa por género entre ingesta de macronutrientes y RDA alumnos 4º ESO

	Masculino	RDA	P Valor	Femenino	RDA	P Valor
Vit. A (µg/d)	1385.3±712.28	900	.004**	1453.9±991.33	700	.002**
Vit. B2 (mg/d)	1.4±0.43	1.3	.299	1.5±0.36	1	.000***
Vit. B6 (mg/d)	1.5±0.49	1.3	.017*	1.5±0.41	1.2	.001**
Vit C (mg/d)	104.7±49.29	75	.008**	135.2±54.57	65	.000***
Vit D (µg/g)	4±4.19	5	.155	5.8±3.93	5	.204
Vit. E (mg/d)	6.1±3.38	15	.000***	6.2±2.68	15	.000***
Eq.Niacina(mg/d)	17.6±4.5	16	.089	19.2±4.51	14	.000***
Ác.Folico (µ/d)	154.5±44.63	400	.000***	171.7±43.71	400	.000***
Sodio (g/d)	2.2±0.64	1.5	.000***	2.6±0.88	1.5	.000***
Potasio (g/d)	2.2±0.51	4.7	.000***	2±0.5	4.7	.000***
Calcio (mg/d)	953.6±332.89	1300	.000***	1018.2±277.41	1300	.000***
Fósforo (mg/d)	1168.8±253.84	1250	.09	1192.9±342.35	1250	.238
Magnesio (mg/d)	212.6±37.07	410	.000***	216.8±38.25	360	.000***
Hierro (mg/g)	11.2±2.39	11	.383	11.77±2.37	15	.000***

P<0,05*, P<0,01**, P<0,001***

mos observar una prevalencia de sobrepeso/obesidad en varones de 10-13 años del 41.9%, en el caso de las mujeres es del 20%. Para varones de 14-17 años la prevalencia se sitúa en un 26.2%, en el caso femenino es del 17.1%[20]. Otros estudios realizados en escolares de la Unión Europea hacen hincapié en el dramático incremento de la obesidad y el sobrepeso en la infancia y la adolescencia sobre todo en los últimos 10 años. Estos estudios sitúan la prevalencia de sobrepeso/obesidad de los escolares europeos en un 18%, situándose el incremento anual de casos entre el 0.55% y 1.65%, lo que supone un incremento de 400.000 nuevos casos cada año[21,22]. Resultados similares se han encontrado en el estudio AVENA realizado en adolescentes españoles con un 16% de las mujeres con sobrepeso y un 2% con obesidad y un 19% de los varones con sobrepeso y un 6% con obesidad[23].

El alto grado de sedentarismo de los niños y jóvenes estudiados (59.74%), coincide con los resultados descritos por otros investigadores. Un estudio realizado en 24 países europeos muestra que los escolares españoles (11-17 años) son los más sedentarios de Europa[24]. Otro estudio sociológico muestra que el 43% de la población comprendida entre 15 y 24 años no practica deporte ninguno[25]. En cuanto a la distinción por género nuestro estudio muestra una mayor prevalencia de sedentarismo en el género femenino (82.93%) frente al género masculino (33.33%), estos resultados muestran relación con los de un estudio trasversal llevado a cabo sobre una muestra representativa de la población de Pamplona de 18 a 65 años, que muestra como un 76,6% de las mujeres tienen un estilo de vida sedentario, mientras que en los varones este porcentaje se reduce hasta un 56,7%. El sedentarismo se incrementa con la edad, existiendo hasta un 80,3% de varones sedentarios en el grupo de mayor edad, y un 86,3% entre las mujeres, respectivamente[26].

El perfil calórico de las dietas analizadas se aleja de las recomendaciones, existiendo un aporte excesivo a través de proteína (16.78%) y lípidos (36.11%) y una carencia en el aporte a través de carbohidratos (47.09%) siendo las recomendaciones del 10-15% para proteínas, 30-35% para lípidos y 50-60% para carbohidratos, coincidiendo esto con otros estudios[27,28]. En cuanto al tipo de lípidos existe exceso de ácidos grasos saturados, frente a una carencia en ácidos grasos monoinsaturados y poliinsaturados. Otros estudios, como el llevado a cabo en Reus entre 1983 y 1993, sobre una muestra representativa de 941 sujetos de entre 10 y 69 años pone de manifiesto como el tanto por ciento de energía a partir de los lípidos y las grasas saturadas aumenta significativamente durante la década de seguimiento, estando por encima de las recomendaciones[29]. Los valores de colesterol superan las recomendaciones para todos los grupos de seguimiento (>300 mg/día). Estos resultados coinciden con otros estudios realizados en España como el realizado en León por Capita y Alonso-Calleja en 1.000 personas entre 20 y 40 años, en el que el consumo diario de colesterol fue 440,8 mg (hombres) y 359,1 mg (mujeres)[30]. Más próximos a nuestros resultados son los encontrados en otro estudio realizado en Granada con una muestra de 288 sujetos de entre 6 y 18 años que muestras que el 48.8% de la población estudiada ingiere ≤300 mg/d frente a un 35.5% que supera los 400 mg/d[31].

Las deficiencias que percibimos en la muestra en cuanto a micronutrientes coincide con las deficiencias encontradas en otros estudios, como el realizado en Canarias por Serra et al[32] en el que se cuantificó la ingesta de energía y nutrientes sobre una muestra de 1.747 participantes entre 6 y 75 años. Un elevado porcentaje de la población estudiada presentó ingestas por debajo de 2/3 de las ingestas recomendadas (IR) para vitaminas D (92,5%), E(87,4%) y A (74%), ácido fólico (44,7%), hierro (30,1%), magnesio (14,9%) y vitamina C (5,4%). El estudio eVe sobre las vitaminas en la alimentación de los españoles encontró una ingesta media de folatos de 267 µg/día en hombres y 252 µg/día en mujeres, ambos por debajo de las ingestas recomendadas; el aporte medio de vitamina A representó el 67% de las IR en varones y el 83% en mujeres; vitamina E: 76% en hombres y 69% de las IR en mujeres. Tampoco quedaron cubiertas las de vitamina D: 57,9% y 48% de las IR en hombres y mujeres respectivamente[33]. El estudio llevado a cabo por Arias-Rodríguez[34] en los comedores de colegios públicos de Tenerife sobre una muestra de 8411 sujetos con edades comprendidas entre 4 y 12 años encuentra deficiencias en el aporte de vitaminas B2, D, E y en los minerales yodo, hierro y zinc, sobre todo para los niños de mayor edad.

Conclusiones y recomendaciones

En función de los resultados obtenidos parece conveniente realizar algún tipo de intervención nutricional que sirva como mejora de hábitos alimenticios en los niños y jóvenes escolarizados en Granada. Esta mejora de hábitos ayudaría a paliar enfermedades derivadas de estos desequilibrios nutricionales como es el caso de la obesidad. Se debería fomentar el incremento de la actividad física de tipo moderado o vigoroso entre esta población de forma que lo adoptaran como un hábito y pudiese compensar algunos desequilibrios dietéticos observados, además de por sus beneficios directos sobre enfermedades como esta.

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II

RESULTS OF A 7 –WEEK SCHOOL- BASED PHYSICAL ACTIVITY AND NUTRITION PILOT PROGRAM ON HEALTH-RELATED PARAMETERS IN PRIMARY SCHOOL CHILDREN IN SOUTHERN SPAIN

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ABSTRACT

The goal of this study was to determine the effect of nutrition education combined with sessions of vigorous extracurricular physical activity (VEPA) on the improvement of health related parameters in children in primary education. The sample group consisted of 54 children in the fifth year of primary education divided into two groups: an intervention group (IG) of 25 students and a control group (CG) of 29 students. The intervention lasted 7 weeks and consisted of 13 sessions of VEPA combined with sessions of nutritional education that were attended by the students in the IG as well as their parents. During the intervention the IG showed a decrease in the body fat percentage, total cholesterol, cholesterol linked to low-density lipoproteins and blood pressure, together with an increase in cholesterol linked to high-density lipoproteins, and an improvement in the maximum oxygen uptake and dietary intake profile compared to the CG, which showed an increase in the percentage of fats and no significant changes ($P<0.05$) in other parameters. The results of this study provide evidence that a 7-week program of nutritional education and vigorous short-duration physical activity can improve health related parameters in children.

KEY WORDS: Nutrition, physical activity, health, children.

INTRODUCTION

Physical inactivity is considered to be one of the main problems of public health in the 21st century (5). Engaging in regular physical activity is widely accepted as an effective preventative measure for a variety of obesity related chronic diseases including diabetes, metabolic syndrome and cardiovascular diseases. An increase in aerobic capacity is inversely related with certain health parameters in youth, such as the lipid profile, insulin resistance, arterial resistance and fat mass (21). Studies report that the greatest decreases in physical activity occur during early to late adolescence, a critical period of child growth and development. This decrease is correlated with a rapid increase in the prevalence of children who are overweight or obese.

In Spain, the association between saturated fatty acids and plasma cholesterol levels in children has been found to be similar to that observed in adults. The consumption of saturated fatty acids induces an increase in plasma LDL cholesterol levels and is associated with higher cardiovascular risk (29). Diets with less saturated fat are associated with better food intake, nutritional profile and plasma lipid profiles. Through research into the prevention and treatment of adult diseases, it has become clear that many originate in childhood (16) and as illustrated in this review such antecedents are largely a function of the nutrition, physical activity, and other habits of developing children.

Results gathered in international research show that diet, physical activity and sedentary behavior are "universal" factors contributing to the risk of excessive mass among the young (10). Mainly because of technological advances and social change (4), there is a high percentage of Spanish youth today that has a sedentary lifestyle and is resistant to change (34). These behavioral alterations include changes in eating habits, with an increase in consumption of foods with high calorie content and rich in saturated fats, and a lower consumption of unrefined carbohydrates. Maintaining a balanced diet adapted to the different stages of life is important for the healthy physical and psychological growth of the individual, in order to prevent illness and obtain an optimum level of health (6).

The typical paradigm used to view pediatric obesity is based on common knowledge derived from the adult experience. This suggests that reducing energy intake and introducing physical activity into the lifestyle will create an energy deficit resulting in mass loss. The results of a recent study (15) illustrate the need for the problem of pediatric obesity prevention to be viewed in a different light. It is noteworthy that this study found lower levels of percentage body fat to be associated with higher amounts of vigorous physical activity, but not with moderate physical activity. Other studies have also found that relatively active young people tend to consume more energy and accumulate less fat than inactive youths (22).

The American Heart Association (AHA) has identified the importance of prevention and treatment, based on studies of vigorous physical training in obese children and adolescents during after-school hours that have demonstrated improvements in some physiological risk factors (25). The American Academy of Pediatrics (2) recommends increasing the amount of daily physical activity engaged in by students in US schools. Exercise has been shown to reduce systolic and diastolic blood pressure over 8 months in children with hypertension.

The aim of our study was to determine the effect of nutritional education given to children and their parents combined with sessions of vigorous extra-curricular physical activity (VEPA) on the improvement of health-related parameters in primary education students. Our hypothesis was that the intervention program would improve the fat profile, aerobic capacity, blood pressure, and blood cholesterol, while nutritional habits would also improve.

MATERIAL AND METHODS

Participants

We chose two schools in a similar rural environment and with the same socio-economic status. Students were aged between 10 and 11 years (M = 10.6±0.4). Within each school there were two fifth-year classes made up of 25 pupils (classes A and B). The program consisted of one control group (CG) and one intervention group (IG). The CG was made up of class A from each school and the IG group was made up of class B from each school, giving 50 pupils in each group. Class A and B were homogenous but entirely independent within each school. The chance to participate was offered to the parents of all the children regardless of BMI. Out of a total of 100 pupils, 64 decided to participate (64%), these were divided into a CG and an IG containing 32 pupils each. In the CG, three pupils failed to complete some or all of the post-test exercises and were eliminated from the study, while in the IG seven pupils failed to complete the process. This left 25 children (15 boys and 10 girls) in the IG and 29 children (10 boys and 19 girls) in the CG. A total of 27.59% and 36% presented as overweight or obese in the CG and IG respectively. Overweight or obesity was defined according to international criteria (7).

The Tanner and Whitehouse stage of sexual maturity was established by a trained researcher of the same sex as the young person via brief observation of the mammary development in females and genital development in males. All the participants in the study were found to be in stages 1 or 2 with no significant differences between the sexes for any of the studied parameters, thus this aspect was not taken into account when forming the IG and CG.

All children were healthy and were not undergoing any medical treatment. All the participants took part voluntarily in accordance with the Declaration of Helsinki regarding ethical research. The ethical committee of the University of Granada for human research approved the study. Informed consent was also obtained from all of the children's parents.

Intervention

This is a pilot study for a wider research project in which we shall examine the health benefits of physical exercise and nutritional intervention both separately and in combination. The intervention will be carried out over an extensive period in order to see whether changes occurring to the parameters increase or remain steady over time.

The intervention consisted of thirteen 60-minutes sessions of physical activity held twice a week. In addition nutritional education sessions lasting approximately 2 hours each were provided to both students and their parents with parents completing 4 and the student completing 2. The study was carried out for 7 weeks between April and June 2010. The intervention consisted of thirteen 60-minute sessions of VEPA [80% of the maximum heart rate (MHR) for 35-40 minutes, 60-70% of the MHR for 10-15 minutes, and 50-60% for 5-10 minutes] twice a week (scheduled between 4:30 and 5:30 p.m.). Physical activity was controlled by means of heart rate monitoring (Polar RS800cx pulsometer). The aim of the training sessions was to improve aerobic capacity, using physical activity such as motor skills, games and sports, specifically targeted for health gains. Play was used in all the activities to motivate the students and achieve the desired level of physical activity. All games and tasks were designed and developed by a group of experts in education and sports science and were directed by the same supervisor. The methodology has been put into practice in previous studies and was adapted to the age of the participants for this study. Only students who attended more than 75% of sessions were included in the intervention group; those not completing the sessions were excluded from the study. Out of a total of 32 pupils, 26 completed over 75% of the sessions (81.25%).

The nutritional education sessions informed participants about the benefits of healthy diets and lifestyle. Nutritional education involved both parents and students. For parents, there were four classes of nutritional education, each lasting approximately 2 hours (16:00 to 18:00). There was one session per week for the first 4 weeks of physical intervention. Either one or both parents could attend the sessions. For children, there were two nutritional education sessions during school hours (tutorial hours), each lasting about 1 hour. One session was held per week for the first 2 weeks of physical intervention. It was compulsory for pupils to attend both nutrition sessions held during school time. All of the 32 initial participants attended these sessions (100%). Pupils were considered fit to participate as participants for the IG if they participated in over 75% of the school physical activity sessions, attended the two sessions on nutritional education, and had at least one parent attend over 75% of the parental educational sessions. Out of a total of 32 pupils, 25 fulfilled these conditions (78.1%).

During the intervention period, the CG continued doing the same activities as they were doing before the intervention (they did not receive intervention). They participated in pre and post-test measures only to provide a comparison to the IG and identify any changes in parameters.

Measures

The following variables were measured in the pre-test as well as in the post-test:

Aerobic Capacity. The maximal oxygen uptake (VO_2max) was estimated with 20 meter Shuttle Run Test. This test is a 20 m incremental-maximum shuttle field test, employing the equation proposed by Ruiz et al. (31) to estimate the VO_2max. The "Shuttle Run Test" or "Course Navette Test" involves running to and fro between two lines 20 m apart. Participants start at an initial velocity of 8.5 kph, and increase their speed by 0.5 kph for every 20 m covered as indicated by an audio recording played on a validated CD-ROM. The test concludes when the subject is unable to reach the line on two consecutive occasions at the speed demanded by the audio recording.

Anthropometric Data. Following all the considerations of the International Society for the Advancement of Kinanthropometry (ISAK) (20), all anthropometric measurements were carried out at the same place by an ISAK-certified level II anthropometrics researcher. The following instruments were used: GPM Stadiometer (±1 mm accuracy); Tefal scale (± 50 g accuracy); Holtain skinfold compass (± 1 mm accuracy); Holtain caliper (±1 mm accuracy); Holtain flexible metallic metric belt (±1 mm accuracy). The following measurements were taken: height, weight, skinfolds (triceps, biceps, subscapular, suprailiac, supraspinal, abdominal, thigh, and calf), perimeters (waist, hip, relaxed biceps, flexed and contracted biceps, thigh and calf), and diameters (bicondylar humerus, bistiloid and bicondylar femur). The Body Mass Index (BMI) was calculated from height and weight. Using the Slaughter equation, we compared the results gathered from the sum of the 6 skinfolds (triceps, subscapular, supraspinal, abdominal, thigh, and calf), 8 skinfolds (triceps, biceps, subscapular, suprailiac, supraspinal, abdominal, thigh, and calf) and fat percentage.

Blood Biochemistry. We used venous blood analysis to determine the health-related biochemical components. The analysis was performed in the morning after a 12 hour fast. Ten millilitres of whole blood samples were taken from each subject by venipuncture using vacutainers and stored in containers with ice packs to maintain the temperature between 3 and 4ºC. Blood was centrifuged at 3,000 rpm for 15 minutes for plasma separation using a bench centrifuge and 1.5 ml aliquots pipetted into plastic Eppendorf tubes. The aliquots were then stored at -80ºC until further analysis. The following parameters were measured: total cholesterol (TC) (mg/dl), HDL cholesterol (cHDL) (mg/dl), LDL cholesterol (cLDL) and triglycerides (TG) (mg/dl). TC, cHDL and TG were determined using commercially available enzymatic colorimetric assays (Sigma Diagnostics, St. Louis, MO) on an automated ACE analyzer. cLDL was calculated by the Friedewald equation. (13).

Blood Pressure. Both systolic and diastolic blood pressure measurements were taken using an OMROM M7® monitor (Omrom Health Care, Ukyo-ku, Kyoto, Japan) and a cuff on the right arm, according to the recommendations of the European Hypertension Society (24), and with the greatest care, following the method stipulated by international guidelines (19). Resting blood pressure was determined *in situ* on the morning (casual blood pressure) of the pre and post tests with measurements taken at the same time of day on each occasion. Participants were instructed to sit quietly for 5 min with their right arm rested at heart level and their feet flat on the floor. Three blood pressure readings were taken at 5, 7, and 9 min, and the cuff was then removed. An average blood pressure measure was calculated.

Dietary Changes. All the pupils completed two dietary intake diaries, one before the intervention and another after. Diaries were for 3 consecutive days and included at least one weekend day. All children and their parents were instructed to fill out the forms using weights and home measurements, noting all the food they consumed both at home and outside.

Healthy Habits Survey. Together with the dietary intake diaries, the pupils also completed a questionnaire (Krece Plus) (32) on their dietary habits and lifestyle, with consideration of adequacy of intake to the Mediterranean diet. The surveys were administered by trained personnel, with the aim of evaluating the physical, psychological, and nutritional status of the participants. The sum of answers 7 and 8 gave an evaluation of physical activity on a scale of 0-10, while the sum of questions 9 to 23 gave an evaluation of dietary habits on a similar scale. According to the scores obtained, the children's feeding was classified as having a very low nutritional level (≤ 3), medium nutritional level (4-7), or high nutritional level (≥ 8). This test also classifies the lifestyle based on the average time in hours the children spend watching television or playing videogames, and the hours spent weekly in sporting activities outside school, with scores classified as being bad (0-3), average (4-6), or good (≥ 7).

Data Analysis

For all measures the investigators were blinded to the grouping. Normality of the data was analyzed using the Shapiro-Wilk test. A series of 2 (gender) x 2 (group: intervention vs. control) ANOVAs assessed gender differences in the outcome variables at pre and post time points. There was no significant main effect of gender on any of the tested outcome variables at pre- ($p>.05$) or at post-intervention ($p>.05$). The interactions between group and gender were also not significant ($p>.05$). Based on these results further analyses were not stratified by gender. We carried out the T test or Wilcoxon test for two related samples comparing the variables of aerobic capacity, blood composition, blood pressure, and dietary changes. We used the Chi-Squared parameter or the McNemar test to evaluate the changes produced in the results of the Krece Plus test and to compare two categorical variables. DietSource 3.0 was used to evaluate macronutrients. All analyses were made using the SPSS 19.0 statistics package. The level of significance was established at 0.05. The statistical power test was performed for all variables, and type II error probability associated with this test of null hypothesis was 0.05.

RESULTS

Maximal Oxygen Uptake

We found no significant differences between the IG and CG in the pre-test (43.45 ± 2.56 ml/kg/min VS. 42.95 ± 2.99 ml/kg/min). For CG there were no significant differences between pre-test and post-test (42.95 ± 2.99 ml/kg/min VS. 43.25 ± 3.29 ml/kg/min), however the IG showed significant ($p<0.01$) improvement after treatment (43.45 ± 2.56 ml/kg/min VS. 45.95 ± 4.26 ml/kg/min). At post-test values were significantly higher in the IG relative to the CG (45.95 ± 4.26 ml/kg/min VS. 43.25 ± 3.29 ml/kg/min).

Anthropometric Parameters

The results show a statistically significant increase in weight between the pre-test and post-test values of both groups. However, BMI increased significantly only in the CG, remaining stable in the IG (Table 1). The CG shows a statistically significant increase for the sum of the 6 skinfolds, sum of the 8 skinfolds and fat percentage. Conversely, we observed a slight decrease in the sum of the skinfolds and fat percentage in the IG. Comparison of post-test values between the CG and the IG also show the IG to exhibit significantly lower fat percentage.

Blood Pressure and Blood Composition

As shown in table 1, students in the IG showed significant reductions in both systolic blood pressure (SBP) and diastolic blood pressure (DBP) ($p<0.05$). In contrast the CG showed no such changes. The IG achieved statistically significant reductions in TC and cLDL ($p<0.01$) between pre and post test. In addition DBP, CT ($p<0.05$) and cLDL ($p<0.01$) measured at post-test were significantly lower in the IG relative to the CG.

Dietary intake in 72-Hour Regimen

The calorie profile of the diets analyzed before intervention showed an excess of proteins (15.4% CG and 15.2% IG) and fats (40.2% CG and 36.3% IG), and a lack of carbohydrates (44.4% for CG and 48.5% for IG). This is inadequate to recommendations for the Spanish population of; 10-15% proteins, 30-35% fats, and 50-60% carbohydrates (Table 3). Cholesterol levels were higher than recommended (<300 mg/day) for both groups (CG: 439.9 mg/day, IG: 466.6 mg/day). Throughout the intervention, the IG experienced changes in calorie profile, adjusting to the Spanish recommended levels (Table 2). At post-test the IG showed significant reductions in cholesterol, however levels remained higher than values stated by the recommendations (Table 2).

Krece Plus Test

At post-test the IG showed increased levels of physical activity relative to pre-test (Table 3). In addition post-test values regarding the dietary variable were significantly better in the IG relative to the CG. Following the intervention the IG showed a tendency towards improvement for all items on the questionnaire. This reached significance for the following items ($p<0.05$): hours of daily physical exercise, hours of television per day, cereal breakfasts and pasta or rice consumption less than three times per week (Table 3).

DISCUSSION

The rising prevalence of childhood obesity represents a major public health crisis, because it is associated with considerable risks to the child's present and future health (12). Our study demonstrates that a program combining physical activity and nutritional education and conducted within the school environment can produce significant improvements in various health-related variables. In this study, while the CG experienced significant deterioration in most measured variables, the IG showed significant and consistent improvements.

Vigorous physical activity can reduce overall body fat while simultaneously increasing bone and muscle mass. A child can therefore improve their body composition with no significant reduction in weight or BMI (9). This may have occurred during the present study which detected no significant change in BMI despite increases in weight. We therefore suggest that other body composition indices may be more appropriate for use in future studies.

There are many papers describing intervention programs targeting obesity within pre-pubertal children and adolescents. Such interventions are based on physical activity, sometimes in combination with controlled diets or nutritional education for families. However, it is noteworthy that most of the studies are performed with an overweight or obese population whereas we focused on prevention with a sample including normal weight children.

A recent study (8) successfully improved the plasma glucose, insulin, cLDL and triglycerides of overweight pre-pubertal children by introducing a physical-activity program, a parental dietary-modification program, or a combination of the two. There were no changes in DBP, cHDL or TC. Similar results had been found in another study using obese pre-pubertal children (12). This showed reductions in whole body and abdominal fat, TG, TC and cLDL and increases in fat-free mass. Resaland et al. (26) found similar changes after a school-based physical activity intervention.

Importantly, early reports have suggested that regular exercise may have beneficial effects on cardiovascular risk factors particularly in obese children. In our study we observed changes in health-related parameters in a school population of healthy pre-pubertal children. Hypertension is considered to be an important cardiovascular disease risk factor, contributing to around 50% of coronary heart disease. Multiple epidemiological studies have described an inverse relation between level of habitual physical activity and blood pressure (33). The decrease in SBP for the IG observed in our study corresponds with other studies using obese children (12, 8). To our knowledge, just one recent paper (26) describes improvements in systolic and diastolic blood pressure in 9-year old children after a physical activity intervention at school.

In our study, the levels of serum lipids obtained are similar to those obtained by Ruiz et al. (30) in a representative sample of Spanish adolescents. Ben Ounis et al. (3) also combined physical activity and dietary restriction over two months and similarly reduced the TC and cLDL of a group of 24 obese adolescents between the ages of 12 and 14 years. In addition significant improvements to cHDL and TG were observed.

Collins et al. (8) found important changes in biochemical parameters after a 6-month intervention. Beneficial developments in blood pressure and the lipid profile have also been found after a 2-year intervention (26). Most studies propose a daily physical activity program at school (2, 11, 26) even for pre-school children (18). The program structures are usually very different, however the majority last between 10 to 12 weeks and consist of three 30-60 min sessions a week (11). The present study observed changes in health related parameters with an exercise program of just 7 weeks. The physical activity program was performed twice a week, with sessions lasting 60 minutes.

In our study, a vigorous physical activity program was achieved. Other authors found that interventions with obese children are more effective when the emphasis on vigorous physical activity is increased (15). Previous studies have shown that aerobic fitness was inversely associated with metabolic risk. However, aerobic fitness level is still not well recognized as a screening tool in pediatric populations (1). As schools provide an opportunity to promote lifestyle change and health-related fitness, school-based programs which assess aerobic fitness could play a pivotal role in identifying high-risk children and supporting them to engage in physical activity.

It is notable that successful interventions often involve the whole family (14), as parents can be important role models, particularly for younger children. This was apparent in our study, as both the participating children and their parents committed to making lifestyle changes. Other authors such as Collins et al., (8) have encouraged parental involvement, suggesting that future treatment programs may need to target parents, especially when interventions include a dietary program.

In addition to increasing vigorous physical activity other methods exist which can reduce negative habits. These methods relate to time spent sitting in front of a computer, consumption of sugary beverages and excessive snacks, dietary composition and eating habits. Reviews of interventions targeting childhood obesity indicate that a combination of a reduction in sedentary behavior, exercise, and nutritional programs could drastically improve body fat loss (27). In the present research, the students in the IG showed significant improvements in the hours spent watching TV per day, physical exercise, and the number of points earned for their nutrition habits, all of which may have resulted in significant fat loss.

The dietary profile developed from the diets analyzed at pre-test is clearly unbalanced with a high percentage of calories obtained from proteins and fats, and a low percentage of calories obtained from carbohydrates. This situation is typical in Spain and other countries whose dietary habits could be classified as Mediterranean (23). Some authors to have analyzed the diet of school-aged children from Spain found significant differences for lipid levels depending on saturated fat intake (28). In our study, the high ingestion of proteins coincides with other studies carried out in Spain and agrees with the general tendency in the Spanish population to consume high amounts of meat and meat products (17). Regarding carbohydrates, the daily intake was lower than recommended which is similar to that found in other studies (27).

CONCLUSIONS

The results of this study provide evidence that a 7 week program incorporating vigorous short-duration physical activity and a nutritional education component carried out at school can improve health-related parameters in children.

LIMITATIONS AND FUTURE RECOMMENDATIONS

The results obtained in this study must be understood in the context of several limitations. Firstly, we recognize that the sample size is small and therefore it is not representative of the population of 10-11 years-old in southern Spain. However, this enabled us to have greater control over delivery of the intervention so implementation could be consistent for all participants e.g. all participants received the same instructor for all components thus receiving identical information.

Secondly, the heart rate monitors were used exclusively to control the intensity of physical activity sessions. Future study could use accelerometry or heart rate monitoring continuously throughout the day to provide more detailed information on total physical activity and enable closer control of physical activity programs.

Thirdly, groups were made up of pupils from within the same school and the occurrence of contamination is not known. However, this method was chosen to make groups more homogenous and reduce influences on the physical activity levels of children resulting from having different physical education teachers. The classes were also independent making contamination less likely. Finally, the results obtained do not show the cause and effect of health-related parameters. The intervention consisted of numerous components; exercise, nutritional education and lifestyle education. Independent effects of each component cannot therefore be determined.

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Table 1: Changes produced in the body and blood profile after a short-term nutritional and physical intervention.

	CG		IG		
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Power**
SBP (mmHg) ± SD	98.7±17.0	96.8±13.2	100.8±8.2	97.0±7.1*	.869
DBP (mmHg) ± SD	60.8±10.0	58.9±7.9	59.0±6.5	54.3±4.3*, +	.942
TC (mg/dl) ± SD	161.8±19.1	155.9±19.4	156.1±23.4	140.5±15.8**, +	.997
cHDL (mg/dl) ± SD	51.9±14.8	52.6±12.0	49.2±9.4	54.3±7.9	.815
cLDL (mg/dl) ± SD	93.9±23.4	93.3±11.6	93.5±21.0	73.3±13.4**, ++	.897
TG (mg/dl) ± SD	67.3±21.7	64.1±25.2	68.9±28.7	71.5±26.0	.857
Weight (kg) ± SD	39.1±10.3	41.9±11.7**	45.2±11.7	46.0±11.8***	.976
BMI (kg/m^2) ± SD	19.17±4.14	19.34±4.06**	21.20±3.88	21.22±3.86	.821
Fat % (Slaughter) ± SD	17.3 ± 6.3	18.1 ± 6.4*	15.0 ± 5.7	14.7 ± 5.4+	.806
6 Fold Sum± SD	103.6 ± 46.9	109.2 ± 49.8*	98.4 ± 39.7	95.8 ± 37.2	.915
8 Fold Sum± SD	133.3 ± 60.9	140.9 ± 63.9**	126.4 ± 51.4	124.6 ± 49.1	.822

*, **,***: significant differences between Pre-test-Post-Test in both groups at the level of $p \leq .05$, $p \leq .01$, $p \leq .001$ respectively
+, ++: significant differences between Pre-test vs. Pre-test and Post-Test vs. Post-test at the level of $p \leq .05$, $p \leq .01$ respectively
CG: Control Group IG: Intervention Group; SBP: Systolic Blood Pressure; DBP Diastolic Blood Pressure; TC: Total Cholesterol; cHDL: cholesterol linked to High Density Lipoproteins; cLDL: cholesterol linked to Low Density Lipoproteins; TG: Triglycerides

Table 2. Comparison of macronutrient ingestion and cholesterol for the CG and IG

	CG		IG		
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Power**
Energy (Kcal) ± SD	2371±608	2370±546	2309±554	2218±498	.957
Proteins (g) ± SD	91.4±18.6	90.5±17.7[+]	87.9±21.0	77.0±12.4	.853
(%)	(15.4%)	(15.3%)	(15.2%)	(13.9%)	
Carbs (g) ± SD	263.0±79.8	262.8±80.0	280.0±80.1	299.1±68.2	.836
(%)	(44.4%)	(46.3%)	(48.5%)	(53.9%)	
Fats (g) ± SD	105.9±28.7	106.3±28.5[+]	93.0±19.6	79.3±18.3[*]	.965
(%)	(40.2%)	(40.4%)	(36.3%)	(32.2%)	
Cholesterol (mg) ± SD	463.9±169.6	457.9±172.0[+]	466.8±182.2	322.6±90.0[**]	.999

*, **: significant differences between Pre-test-Post-Test in both groups at the level of $p \leq .05$, $p \leq .01$ respectively
+, ++: significant differences between Pre-test vs. Pre-test and Post-Test vs. Post-test at the level of $p \leq .05$, $p \leq .01$ respectively
CG: Control Group IG: Intervention Group

Table 3. Results obtained from the Krece Plus Test.

	Group	Pre-test	Post-test	p value
Physical	CG	4.78 ± 1.85	4.87 ± 1.49	.619
Activity ± SD (points)	IG	5.56 ± 1.29	6.95 ± 1.03	$.004^{b}$
p value		.442	$.002^{b}$	
Dietary	CG	5.61 ± 1.57	5.91 ± 1.62	.564
Habits ± SD (points)	IG	6.32 ± 1.53	7.53 ± 1.39	.261
p value		.432	$.032^{a}$	
Hours of	CG	1.55 ± 1.27	1.30 ± .97	.961
Phys. Exercise ± SD (hours/day)	IG	1.84 ± 1.17	2.84 ± .69	$.003^{b}$
p value		.692	$.000^{c}$	
Hours of	CG	1.71 ± 1.05	1.39 ± .89	.351
Television± SD (hours/day)	IG	1.32 ± .89	.95 ± .97	$.003^{b}$
p value		.316	.269	
Cereal/similar	CG	.72 ± .46	.64 ± .49	.581
Breakfast. ± SD (% consumption per day)	IG	.53 ± .51	.95 ± .23	$.008^{b}$
p value		.137	$.016^{a}$	
Pasta or Rice	CG	.43 ± .50	.61 ± .50	.549
+3 times/wk ± SD (% consumption)	IG	.47 ± .51	.84 ± .38	$.016^{a}$
p value		.497	.092	

$p \leq .05^{a}$, $p \leq .01^{b}$, $p \leq .001^{c}$ CG: Control Group IG: Intervention Group

III

EFFECT OF PHYSICAL ACTIVITY, NUTRITIONAL EDUCATION, AND CONSUMPTION OF EVOO ON LIPID, PHYSIOLOGICAL, AND ANTHROPOMETRIC PROFILES IN A PEDIATRIC POPULATION.

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Effect of physical activity, nutritional education, and consumption of EVOO on lipid, physiological, and anthropometric profiles in a pediatric population.

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ABSTRACT

Objective: To determine the effects of nutritional education and vigorous extracurricular physical activity both individually and combination on healthy related parameters in children in primary education

Material and Methods: The sample group consisted of 134 children (9-11 years) divided between five groups: 41 students in the control group (G0), 28 students in the physical activity intervention group (G1), 21 students in nutritional education group (G2), 25 students in a combined intervention group (G3), and 19 also in a combined intervention group but with additional substitution of normally used oil for EVOO.

Results: Students in the groups receiving physical activity reduced their fat percentage and increased muscle post intervention, whereas group G2 and G0 increased their fat percentage. At post-test the lipid profile improved in all intervention groups, whereas total cholesterol significantly increased in the G0 group. The proportion of macronutrients and dietary cholesterol improved in the groups receiving nutritional education, with no significant changes observed in other groups.

Conclusions: Interventions providing nutritional education and vigorous extracurricular physical activity and conducted within the school can improve healthy related parameters in children.

Key-words: Nutrition, physical activity, health, children

INTRODUCTION

Physical inactivity is considered to be one of the main threats to public health in the 21st century[1]. Physical activity is negatively associated with overweight and obesity[1], and positively associated with cardiovascular health in young people[2]. Increases in aerobic capacity are inversely related improvements to specific health parameters in youth, including the lipid profile[3], insulin resistance[4], fat mass[5] and parameters associated with metabolic symdrome[6].

Nutrition has been labeled as one of the main modifiable determinants of chronic diseases[7]. Establishing healthy eating habits during childhood and adolescence is important, since it has been shown that food preferences and eating habits are established in early childhood and can persist into adulthood[8]. Research suggests that many children consume sugar, salt and saturated fats in excess of recommended amounts and at the same time fail to consume the recommended amounts of fresh fruit and vegetables. The abandonment of the Mediterranean lifestyle in the Western world[9] has highlighted the need to promote the traditional Mediterranean Diet (DM) among pupils in schools with a view to improving dietary habits. A large number of studies have demonstrated the beneficial effects of specific components of the DM on weight loss[10], abdominal obesity[11], insulin resistance[12], risk of diabetes mellitus[13] and cardiovascular diseases[14].

Following on from studies which have demonstrated improvements in some physiological risk factors[15] using vigorous physical training programs with obese children and adolescents during after-school hours, the American Heart Association (AHA) has recognized the importance of prevention and treatment. In addition, it is important to involve parents in healthy interventions, as parents have a strong influence on the eating habits of young people and adolescents[16].

The aim of our study was to determine the effects of nutritional education and vigorous extracurricular physical activity both individually and in combination on health related parameters on children in primary education.

MATERIAL AND METHODS

Participants

We chose five schools in a similar rural environment and with the same socio-economic status. Students were aged between 10 and 11 years (M = 10.7±0.5). The opportunity to participate was offered to the parents of all the children regardless of body mass index (BMI). The sample was randomized at school-level into 5 groups; each school belonged to a different group and received a different intervention. The program consisted of one group which did not receive any intervention (G0; n =41, 20 boys and 21 girls). A group which received physical activity intervention (G1; n = 28, 13 boys and 15 girls). A Group in which parents and pupils received nutritional education sessions (G2; 21, 10 boys and 11 girls. A group which received both of the above interventions (G3; n= 25, 14 males and 11 girls). The final group did the same as G3 and also replaced the oil that they normally consumed with extra virgin olive oil (EVOO) during the final month of the intervention (G4; n = 19, 11 boys and 9 girls). Out of a total of 242 pupils, 162 decided to participate (66.9 %), and 134 completed the intervention (55.3 %). A total of 50.2%, 39.2%, 20.1%, 32% and 42.1% presented as overweight or obese in G0, G1, G2, G3 and G4 respectively. Overweight or obesity was defined according to international criteria[17].

The Tanner and Whitehouse[18] stage of sexual maturity was established by a trained researcher of the same gender as the young person via brief observation of the mammary development in females and genital development in males. All participants were found to be in stages 1 or 2 with no significant differences between the sexes for any of the studied parameters. This aspect was therefore not taken into account when forming the IG and CG.

All children were healthy and were not receiving any medical treatment. All the participants took part voluntarily in accordance with the Declaration of Helsinki regarding ethical research. The ethical committee of the University of Granada for human research approved the study. Informed consent was also obtained from all of the children's parents.

Intervention

This study examined the health benefits of physical exercise and nutritional intervention both separately and in combination and the effects of EVOO consumption.
The intervention consisted of thirteen 60 minute sessions of physical activity held twice a week. In addition nutritional education sessions lasting approximately 2 hours each were provided to both students and their parents with parents completing 6 and the student completing 2. The study was carried out over 6 months between January and June 2012. The intervention consisted of thirteen 60 minute sessions of vigorous extracurricular physical activity (VEPA) [80% of maximum heart rate (MHR) for 35-40 minutes, 60-70% of the MHR for 10-15 minutes, and 50-60% for 5-10 minutes] twice a week. Physical activity was controlled by means of heart rate monitoring (Polar RS800cx pulsometer). The aim of the training sessions was to improve aerobic capacity using physical activities specifically targeted for health gains such as, motor skills, games and sports. Play was used in all the activities to motivate the students and achieve the desired level of physical activity. All games and tasks were designed and developed by a group of experts in education and sports science and were directed by the same supervisor. The present methodology has been put into practice in previous studies and

was adapted to the age of the participants for this study. Only students who attended more than 75% of sessions (more than 36 sessions) were included in the intervention group; those not completing the sessions were excluded from the study. Out of a total of 72 pupils, 61 completed over 75% of the sessions (84.7%).

The nutritional education sessions informed participants about the benefits of a MD (high fruit, vegetable, legumes, fish, cereals, unsaturated to saturated fat ratio, and low meat & meat products and dairy products) and lifestyle. Nutritional education involved both parents and students. For parents, there were six classes of nutritional education, each lasting approximately 2 hours. One session was provided each week for the first 6 weeks of intervention. Either one or both parents could attend the sessions. For children, there were two nutritional education sessions during school hours (tutorial hours), each lasting about 1 hour. One session was held each week for the first 2 weeks of intervention. It was compulsory for pupils to attend both nutrition sessions held during school time. Seventy three of the 75 initial participants attended these sessions (97.3%). Pupils were considered fit to participate as participants in nutritional groups if they participated in over 75% of the school physical activity sessions, attended the two sessions on nutritional education, and had at least one parent attend over 75% of the parental educational sessions. Out of a total of 75 pupils, 58 fulfilled these conditions (77.3%).

G4 each pupil´s parent received 2 liters of EVOO per week in the last month of intervention. The parents formally agreed to substitute their normal oil consumption with this oil every time they cooked.

During the intervention period, G0 continued with their usual activities. They participated in pre and post-test measures only to provide a comparison for the other groups and enable identification of changes in any parameters.

Measures

The following variables were measured during pre-test and the post-test:

Aerobic Capacity. Maximal oxygen uptake (VO_2max) was estimated using a 20 m incremental-maximum shuttle run field test, employing the equation proposed by Ruiz et al[19]. The shuttle run test involves running to and fro between two lines placed 20 m apart. Participants start at an initial velocity of 8.5 kph, and increase their speed by 0.5 kph for every 20 m covered as indicated by an audio recording played on a validated CD-ROM. The test concludes when the subject is unable to reach the line on two consecutive occasions at the speed demanded by the audio recording.

Anthropometric Data. Following all the considerations of the International Society for the Advancement of Kinanthropometry (ISAK)[20], all anthropometric measurements were carried out at the same place by an ISAK-certified level II anthropometrics researcher. The following instruments were used: GPM Stadiometer (±1 mm accuracy); Tefal scale (± 50 g accuracy); Holtain skinfold compass (± 1 mm accuracy); Holtain caliper (±1 mm accuracy); Holtain flexible metallic metric belt (±1 mm accuracy). The following measurements were taken: height, weight, skinfolds (triceps, biceps, subscapular, suprailiac, supraspinal, abdominal, thigh, and calf), perimeters (waist, hip, relaxed biceps, flexed and contracted biceps, thigh and calf), and diameters (bicondylar humerus, bistiloid and bicondylar femur). The body mass index (BMI) was calculated from height and weight. We compared the results gathered from the sum of the 8 skinfolds (triceps, biceps, subscapular, suprailiac, supraspinal, abdominal, thigh, and calf), fat percentage using the Slaughter equation[21] and mass percentage using the Poortman equation[22].

Blood Biochemistry. We used venous blood analysis to determine the health-related biochemical components. The analysis was performed in the morning after a 12 hour fast. Ten milliliters sample of whole blood were taken from each subject by venipuncture using vacutainers and stored in containers with ice packs to maintain the temperature between 3 and 4ºC. Blood was centrifuged at 3,000 rpm for 15 minutes for plasma separation using a bench centrifuge and 1.5 ml aliquots pipetted into plastic Eppendorf tubes. The aliquots were then stored at -80ºC until further analysis. The following parameters were measured: glycemia (GL) (mg/dl), total cholesterol (TC) (mg/dl), HDL cholesterol (cHDL) (mg/dl), LDL cholesterol (cLDL) and triglycerides (TG) (mg/dl). TC, cHDL and TG were determined using commercially available enzymatic colorimetric assays (Sigma Diagnostics, St. Louis, MO) on an automated ACE analyzer. cLDL was calculated by the Friedewald equation[23].

Blood Pressure. Both systolic and diastolic blood pressure measurements were taken using an OMROM M7® monitor (Omrom Health Care, Ukyo-ku, Kyoto, Japan). The cuff was placed carefully on the right arm, following the recommendations of the European Hypertension Society, and the method stipulated by international guidelines[24]. Resting blood pressure was determined *in situ* on the morning (casual blood pressure) of the pre- and post-tests with measurements taken at the same time of day on each occasion. Participants were instructed to sit quietly for 5 min with their right arm rested at heart level and their feet flat on the floor. Three blood pressure readings were taken at 5, 7, and 9 min, and the cuff was then removed. An average blood pressure measure was calculated.

Dietary Changes. All the pupils completed two dietary intake diaries, one before the intervention and another after. Diaries covered 3 consecutive days and included at least one weekend day. All pupils and their parents were instructed to fill out the forms using weights and home measurements, noting all the food they consumed both inside and outside the home.

Data Analysis

For all measures the investigators were blinded to the grouping. Normality of the data was analyzed using the Shapiro-Wilk test. A series of 2 (gender) x 5 (group) ANOVAs assessed gender differences in the outcome variables at pre and post time points. There was no significant main effect of gender on any of the tested outcome variables at pre- ($p>.05$) or post-test ($p>.05$). Interactions between group and gender were also not significant ($p>.05$). Based on these results further analyses were not stratified by gender. We performed T tests and Wilcoxon tests for two related samples to compare aerobic capacity, blood composition, blood pressure, and dietary changes. DietSource 3.0 was used to evaluate macronutrients. All analyses were conducted using the SPSS 19.0 statistics package. The level of significance was established at 0.05.

RESULTS

Maximal Oxygen Uptake

We found no significant differences between groups at pre-test. Neither G0 nor G2 demonstrated any significant differences between their pre- and post-test results, however all groups which incorporated physical activity (G1, G3 and G4) showed significant ($p<0.01$) improvements after intervention (table 1).

Anthropometric Parameters

All groups experienced an increase in weight between the pre- and post-test which G0 experiencing the greatest increase ($p<0.001$). BMI significantly increased in group G0 only ($p<0.01$). G0 showed a significant increase in the sum of the 8 skinfolds and in fat percentage at post-test. Conversely, we observed a significant decrease in the sum of the skinfolds and fat percentage in G1, G3 and G4. At the same time these groups significantly increased their muscle percentage ($p<0.01$). G1 and G4 were the only groups with a significantly decreased waist circumference and waist-hip ratio (WHR). (Table 1).

Blood Pressure and Blood Composition

Table 2 showed the changes in blood pressure and blood composition between pre- and post-test values. Systolic blood pressure (SBP) increased in G0 and decreased in the rest of groups, though significant reductions occurred only in G1 and G4 ($p<0.01$). Diastolic blood pressure (DBP) increased in G0, was unchanged in G2 and decreased in the other three groups, with significant reductions in G1 and G3 ($p<0.05$). G1, G3 and G4 achieved significant reductions in GL ($p<0.05$) and TC ($p<0.05$), with no significant changes in the other groups. G4 was the only group showing significant changes in HDL ($p<0.05$). The LDL level increased in G0 and decreased in all other groups with significant reduction in G1, G3 and G4 ($p<0.01$). TG showed a significant reduction in G1, G2 and G4 ($p<0.05$) while the other groups showed significant changes.

Dietary intake in 72-Hour Regimen

The calorie profile of the diets analyzed before intervention showed an excess of proteins and fats, and a lack of carbohydrates. This is inadequate to meet the recommendations; 10-15% proteins, 30-35% fats, and 50-60% carbohydrates, for the Spanish population. Cholesterol levels were higher than recommended (<300 mg/day) for all groups. Throughout the intervention, G2, G3 and G4 experienced changes in calorie profile, making it more congruent with the Spanish recommended levels. At post-test G2, G3 and G4 showed significant reductions in cholesterol ($p<0.01$), bringing values loser to these stated by the recommendations (Table 3).

DISCUSSION

The main findings of the present study suggest that a combination of physical activity and nutritional education conducted over 6 months within the school environment and, involving both parents and pupils, can have an influence on health by promoting positive lifestyle changes.

The school environment is recognized as an important setting for childhood health promotion interventions. Reviews have found that well-designed and well-implemented school-based interventions can have positive effects on children's nutrition and physical activity behaviours[25]. Another important factor in childhood health promotion, especially for younger children, is the use of parents as prominent role model. The present study encouraged parental involvement. Other authors such as Ventura et al[26] have found evidence of strong relationships between parenting practices and their children's eating, physical activity, and weight status. The promotion of effective parenting therefore appears critical for prevention.

Many papers have described intervention programs targeting obesity within children. Such interventions tend to focus on physical activity, sometimes in combination with controlled diets or nutritional education. However, it is noteworthy that most of the studies are performed with an overweight or obese population. In contrast, the present study focuses on prevention with a sample which includes normal weight, overweight and obese children.

Vigorous physical activity can reduce overall body fat while simultaneously increasing muscle mass. A child can therefore improve their body composition with no significant reduction in weight or BMI[27]. This may have occurred during the present study as no significant changes in BMI were detected yet weight increased. We therefore suggest that other body composition indices may be more appropriate for use in future studies.

Previous studies have shown that a decreased level of aerobic fitness in children is inversely associated with body fatness, impairment of several cardiovascular disease risk factors and hypertension[28]. Our research shows that the pupils who increased their vigorous physical activity also experienced reductions in body fatness, SBP and DBP, and parameters related with cardiovascular risk e.g. CT, c-LDL and TG. Interestingly, aerobic fitness level is still not well recognized as a screening tool in pediatric populations[29].

The decrease in SBP and DBP which occurred only in the groups that received physical activity and nutritional education observed in our study corresponds with other studies using similar children[30]. To our knowledge, just one recent paper[31] describes improvements in systolic and diastolic blood pressure in 9-year old children after a physical activity intervention at school.

Levels of serum lipids obtained after intervention in the present study are similar to those obtained by Ben Ounis et al[32]. This study also combined physical activity and dietary restriction with a group of 24 obese adolescents between the ages of 12 and 14 years and found reductions in TC and cLDL over a two month period. In addition, significant improvements to cHDL and TG were observed. Another recent study[33] found improvements in plasma glucose, insulin, cLDL and triglycerides of overweight pre-pubertal children by introducing a physical-activity program, a parental dietary-modification program, or a combination of the two. Present findings suggest that physical activity may overcome the deleterious effects of unhealthy dietary habits. Similar conclusions were made by Cuenca et al[34] using an adolescents sample.

The dietary profiles developed using diets analyzed at pre-test were clearly unbalanced and contained a high percentage of calories obtained from proteins and fats, and a low percentage of calories obtained from carbohydrates. This situation is typical in Spain and other countries whose dietary habits could be classified as Mediterranean[35]. In our study, the high ingestion of fats, proteins and cholesterol, and low ingestion of carbohydrates and fiber replicates findings from other studies conducted in Spain[36]. This is also consistent with the general tendency in the Spanish population to consume high amounts of meat and meat products.

There is accumulating evidence to suggest that c-HDL and its main apolipoprotein A1, may be increased by increasing olive oil in human diets[37]. In the present study the group which replaced the oil that they normally consumed with EVOO showed improved c-HDL levels.

The results of this study provide evidence that a school-based program incorporating vigorous physical activity, nutritional education for children and parents, and replacement of normally used oils with EVOO, can improve health-related parameters in children relative to children receiving just one or none of these components.

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Table 1: Changes produced in the body profile and VO_2max in different groups after intervention.

	G0		G1		G2		G3		G4	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
Weight (kg) ± SD	44.1±10.2	45.2±10.2***	43.3±12.4	43.7±12.0*	35.8±5.6	36.1±5.9	38.3±8.6	39.0±9.1**	40.9±8.8	41.0±8.4
BMI (kg/m^2) ± SD	20.9±4.1	21.1±4.0**	19.7±3.4	19.7±3.3	17.8±2.3	17.8±2.6	18.7±3.4	18.8±3.5	19.7±3.5	19.5±3.1
Fat % (Slaughter) ± SD	32.2±11.0	33.4±11.2*	29.7±8.4	28.7±7.7*	23.4±8.5	23.4±8.2	27.9±8.8	26.9±8.2*	29.0±7.5	26.7±6.2**
Mass % (Poortmans) ± SD	40.4±3.5	40.8±3.8	41.7±2.6	42.3±2.8*	41.7±4.0	42.1±4.6	41.5±4.4	42.7±4.4**	41.5±4.1	42.4±3.7*
Waist (cm) ± SD	70.1±10.9	69.6±10.0	68.4±11.6	65.8±9.6**	62.0±5.6	62.2±5.6	64.5±8.2	63.8±8.6	69.4±7.9	65.5±7.3***
WHR ± SD	.825±.066	.815±.053	.812±.066	.787±.050**	.814±.033	.817±.038	.803±.053	.798±.049	.851±.037	.799±.035***
Σ 8 Fold (mm) ± SD	128.2±57.3	133.7±60.4**	114.2±49.2	107.1±41.9**	84.0±47.2	82.7±47.1	95.9±48.2	91.0±52.8*	105.8±42.5	97.1±34.9**
VO_2max (ml/kg/min) ± SD	43.2±3.2	43.2±3.8	41.8±2.1	43.8±3.1***	43.4±3.4	43.6±4.5	43.7±2.6	45.7±4.2**	42.9±3.0	45.7±3.3***

*, **,***: significant differences between Pre-test-Post-Test in different groups at the level of $p \leq .05$, $p \leq .01$, $p \leq .001$ respectively

BMI: Body Mass Index; WHR: Waist-Hip Ratio.

Table2: Changes produced in the blood profile in different groups after intervention.

	G0		G1		G2		G3		G4	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
SBP (mmHg) ± DE	101.2±16.4	104.2±15.7	104.5±19.8	98.2±14.1**	98.3±9.1	96.7±10.8	98.0±11.7	96.1±7.9	102.6±11.0	96.6±9.8**
DBP (mmHg) ± DE	56.7±8.9	59.6±7.9	62.2±7.8	57.9±8.4*	58.3±4.8	58.6±7.0	59.4±7.2	53.7±4.7*	54.7±7.7	52.7±4.7
Glycemia (mg/dl) ± DE	90.2±6.8	93.3±8.5	93.3±8.5	80.4±17.7**	91.08±10.8	91.8±8.1	93.9±9.8	84.3±12.5*	88.5±9.6	75.8±20.3*
CT (mg/dl) ± DE	155.3±23.5	168.3±28.3*	159.9±23.3	148.3±29.3***	157.2±31.9	148.7±32.3	154.9±22.5	139±17.5***	158.4±16.8	145.3±31.6***
cHDL (mg/dl) ± DE	62.1±14.9	62.4±14.9	52.6±12.3	57.6±11.2	56.1±13.1	58.2±11.0	50.9±10.9	55.9±8.0	54.6±11.3	63.8±14.6*
cLDL (mg/dl) ± DE	81.06±17.3	87.06±21.4	91.3±17.6	78.3±19.8***	84.1±20.9	76.9±23.9	90.1±19.2	70.3±13.7***	87.7±13.4	72.9±25.5**
TG (mg/dl) ± DE	89.7±20.7	86.4±19.1	80.4±27.4	70.0±28.3*	80.0±28.8	67.5±25.4*	67.1±23.5	68.6±20.3	78.9±34.3	69.1±26*

*, **,***: significant differences between Pre-test-Post-Test in both groups at the level of $p \leq .05$, $p \leq .01$, $p \leq .001$ respectively

SBP: Systolic Blood Pressure; DBP Diastolic Blood Pressure; TC: Total Cholesterol; cHDL: cholesterol linked to High Density Lipoproteins; cLDL: cholesterol linked to Low Density Lipoproteins; TG: Triglycerides

Table 3. Comparison of macronutrient ingestion, cholesterol and fiber in different groups after intervention.

	G0		G1		G2		G3		G4	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
E (kcal) ± DE	1863±401	1893±393	1988±316	1848±277	2037±324	1932±294	2037±423	1831±189**	1966±341	1982±279
Car (%) ± DE	47.1±5.7	45.0±5.3	47.3±4.7	46.6±4.4	44.8±4.6	50.0±2.4**	47.0±4.3	48.9±2.6	47.9±6.3	50.9±3.6**
Fats (%) ± DE	37.8±4.7	39.4±5.2	36.9±4.7	37.3±3.7	38.9±5.22	33.4±3.9**	37.3±3.8	35.5±2.1*	37.1±5.9	34.6±3.9**
Prot (%) ± DE	15.3±2.6	15.8±2.3	15.9±2.1	16.4±2.3	16.3±2.3	16.4±2.2	16.0±2.7	15.3±1.8	15.0±2.2	14.5±2.6
Fiber (g) ± DE	11.1±3.6	10.3±3.2	11.0±2.5	9.5±3.2	13.2±4.2	14.1±3.2	12.8±4.0	13.2±2.7	11.2±2.9	12.7±3.0
Cho (mg) ± DE	322.3±113.5	350.6±71.6	390.2±128.5	408.3±125.1	350.5±108.8	262.9±87.8***	390.6±95.8	293.7±85.8**	350.7±132.7	278.1±103.3***

*, **,***: significant differences between Pre-test-Post-Test in both groups at the level of $p \leq .05$, $p \leq .01$, $p \leq .001$ respectively

E: Energy; Car: Carbs; Prot: Proteins; Cho: Cholesterol.

IV

ANTIOXIDANT ACTIVITY OF CATALASE IN ERYTHROCYTES FROM HEALTHY CHILDREN: INFLUENCE OF MODERATE-VIGOROUS PHYSICAL ACTIVITY AND EXTRA VIRGIN OLIVE OIL INTAKE

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In Process

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Antioxidant activity of catalase in erythrocytes from healthy children: Influence of moderate-vigorous physical activity and extra virgin olive oil intake

Muros Molina J.J., Oliveras López M.J., Martín F., López García de la Serrana H.

Introduction

Nutrition trends about health promotion and prevention of chronic diseases appear to reduce oxidative stress. Regular physical activity together with a Mediterranean diet has been widely accepted as the best strategies to prevent obesity and reduce risk factors of chronic diseases. There is evidence that the prevention and treatment of adult diseases must be initiated at childhood (Halfon et al, 2012; Muros et al, 2013). The principal defense system against free radicals is formed by the antioxidant enzymes, superoxide dismutase, glutathione peroxidasa, gluthatione reductase and in particular catalase, which is one of the first systems of antioxidant defense (Fang et al, 2002). Numerous recent studies have shown that intense levels of physical activity may increase oxidative stress (Aguilo et al, 2005; Cases et al, 2006; Revan et al, 2010). On the other hand, the potent antioxidant activity of phenolic compounds from extra-virgin olive oil has been widely confirmed (Oliveras-López et al., 2008; Paiva-Martins et al, 2009; Konstantinidou et al, 2010).

The aim of this research was to study the effects of 6 months moderate-vigorous physical activity and daily extra virgin olive oil (EVOO) consumption on catalase activity of healthy children from the South of Spain.

Methods

Subjects of the study

The study consisted of an intervention period of 6 months and involved 44 volunteers with 11-12 years old, divided in three groups: (i) Control group (CTL) who maintained their dietary and physical activity habits throughout the study (n=15); (ii) Physical activity group (PA) who maintained their dietary habits and practiced 60-min moderate-vigorous physical activity 2 days a week for 6 months (n=15); Olive oil group (OO), who maintained their dietary habits and physical activity habits throughout the study but consumed a selected EVOO instead of usual fats during the last 4 weeks of the intervention period (n=14).

Samples collection and antioxidant enzyme activity measurements

Blood samples were collected at baseline and at the end of the 6-month intervention period. After centrifugation, the erythrocyte layer was separated, aliquoted in cryovials and stored at -80º C until enzyme activity analysis. Activities of erythrocyte catalase (CAT) were measured by spectrophotometric assays using commercial kits (Cayman Chemicals). The activities were given in µmol/min/mL and all determinations were run in triplicate.

Statistical analysis

All data were analyzed using the SPSS 17.0 statistical package (SPSS, Inc.). The normalcy of variables was checked. Comparisons between the 6 groups were assessed by one-way ANOVA followed by Bonferroni post-hoc test. Values are expressed as mean with standard errors (X ± SEM). Differences were considered significant for $p < 0.05$.

Results

The results from our study reveal that moderate-vigorous physical activity and EVOO consumption improved erythrocyte catalase activity. The activity of catalase antioxidant enzyme changed significantly ($p < 0.001$) in OO children after the 4-week consumption of EVOO (figure 1). In addition, OO levels after intervention period were significantly higher than CTL and PA levels at baseline ($p < 0.001$). Our results show an increase from baseline of CAT activity in the PA group after the 6-month intervention period, with no significant differences. However, this increase was significant when comparing PA after intervention with CTL and OO at baseline ($p < 0.05$). After the interventions CAT resulted to be significantly higher in OO than in PA

($p < 0.05$). We did not find any significant differences between men and women in any of the groups.

In conclusion, our results support an association between a 6 months moderate-vigorous physical activity and the consumption of extra virgin olive oil with an improvement of the catalase antioxidant system in healthy children. To our knowledge, this is the first time that these two interventions have been performed in healthy children regarding antioxidant status.

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Figure

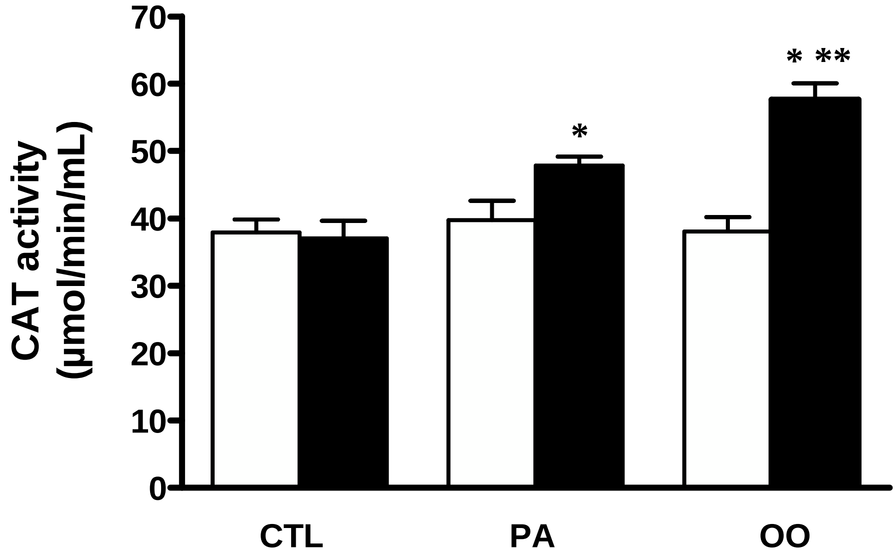

Figure 1. Catalase activity in erythrocytes from CTL, PA and OO children at baseline (white) and after the intervention period (black). *p< 0.05, ***p< 0.001.

EFFECT OF AN 8-WEEK AEROBIC TRAINING PROGRAM DURING PHYSICAL EDUCATION LESSON ON AEROBIC FITNESS IN ADOLESCENTS

V

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Original

Efecto de un programa de entrenamiento aeróbico de 8 semanas durante las clases de educación física en adolescentes

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Resumen

Objetivo: **Determinar el efecto de un programa de entrenamiento aeróbico de alta intensidad de 8 semanas, desarrollado durante las clases de Educación Física, sobre la capacidad aeróbica de adolescentes de 15 a 18 años.**

Método: **Un total de 84 adolescentes (51 chicos y 33 chicas) participaron en el presente estudio. La capacidad aeróbica (VO_2max) se midió directamente con un analizador de gases portátil (K4*b*², Cosmed) durante la realización del 20 Meter Shuttle Run Test (20mSRT). La muestra fue dividida en 2 grupos experimentales (G2S y G3S) y 1 grupo control. El programa de entrenamiento consistió en la práctica de actividad física aeróbica con una intensidad equivalente al 75-80% del VO_2max. El G2S realizó 2 sesiones semanales mientras que el G3S realizó 3 sesiones.**

Resultados: **El G2S incrementó el VO_2max (de 55,7 a 56,6 ml/kg/min los chicos; de 37,8 a 38,7 ml/kg/min las chicas, p < 0,001) y el n.º stages en el 20mSRT (9,0% los chicos, p < 0,001; 20,0% las chicas, p < 0,001). El G3S también aumentó el VO_2max (de 54,9 a 56,0 ml/kg/min los chicos; de 36,0 a 38,7 ml/kg/min las chicas) y el n.º stages en el 20mSRT (10,4% los chicos, p < 0,001; 32,3% las chicas, p <0,001). En G2S y G3S, las chicas mostraron una mayor mejora que los chicos.**

Conclusiones: **Un programa de entrenamiento aeróbico de alta intensidad de 8 semanas, 2 días por semanas, mejora la capacidad aeróbica de los alumnos. Una sesión extra de ejercicio intenso por semana supone una mayor mejora en las chicas, no produciendo tales efectos en los chicos.**

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Palabras clave: *Capacidad aeróbica. VO_2max. Adolescentes. Educación Física.*

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EFFECT OF AN 8-WEEK AEROBIC TRAINING PROGRAM DURING PHYSICAL EDUCATION LESSONS ON AEROBIC FITNESS IN ADOLESCENTS

Abstract

Objective: **To determine the effect of a high intensity aerobic training program of 8 weeks, developed during physical education classes, on the aerobic capacity of adolescents aged 15 to 18 years.**

Methods: A total of 84 adolescents (51 boys and 33 girls) participated in this study. The aerobic capacity (VO_2max) was measured directly with a portable gas analyzer (K4*b*², Cosmed) during the performance of the 20 Meters Shuttle Run Test (20mSRT). The sample was divided into 2 experimental groups (G2S and G3S) and 1 control group. The training program was composed of aerobic physical activity (75-80% VO_2max.). The G2S developed 2 sessions per week while the G3S made 3.

Results: The G2S increased VO_2max (boys: from 55.7 to 56.6 ml/kg/min; girls: from 37.8 to 38.7 ml/kg/min; p < 0.001) and the number of stages in the 20mSRT (9.0% boys, p < 0.001; 20.0% girls, p < 0.001). The G3S also increased VO_2max (boys: from 54.9 to 56.0 ml/kg/min; girls: from 36.0 to 38.7 ml/kg/min) and the number stages in the 20mSRT (10.4% boys, p < 0.001; 32.3% girls, p < 0.001). In G2S and G3s, girls showed greater improvement than boys.

Conclusions: **A high intensity aerobic training program developed during 8 weeks, 2 sessions per week, improves aerobic capacity of the students. An extra session of intense exercise for week is a greater improvement in girls, but do not produce such effects in boys.**

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Key words: *Aerobic capacity. VO_2max. Adolescents. Physical education.*

Abreviaturas

CA: Capacidad Aeróbica.
VO_2max: Consumo Máximo de Oxígeno.
ACSM: American College of Sport Medicine.
FC: Frecuencia Cardíaca.
EF: Educación Física.
GC: Grupo Control.
G2S: Grupo Intervención 2 sesiones.
G3S: Grupo Intervención 3 sesiones.
20mSRT: 20 Meter Shuttle Run Test.
VT1: Umbrales Ventilatorio 1.
VT2: Umbral Ventilatorio 2.
VE: Ventilación Pulmonar.
VO_2: Volumen de Oxígeno.
VCO_2: Volumen de Dióxido de Carbono.
IPAQ: International Physical Activity Questionnaire.

Introducción

La condición física relacionada con la salud incluye: la capacidad aeróbica (CA) o cardiorrespiratoria, la fuerza y resistencia muscular, la flexibilidad y la composición corporal[1], siendo considerado el componente cardiorrespiratorio como el más importante[2,3] y principal exponente del estado de forma del sujeto[4].

El consumo máximo de oxígeno (VO_2max) es el mejor indicador fisiológico de la CA y del estado cardiovascular[5]. Estudios recientes han demostrado que el VO_2max es el predictor más potente de riesgo de muerte por todas las causas y especialmente por enfermedad cardiovascular, tanto en hombres[6], como en mujeres[7] de diferentes edades[8] y estados de salud[9]. Además, un reciente estudio de revisión ha comprobado que altos niveles de CA durante la adolescencia se asocian con una mayor salud cardiovascular durante la edad adulta[10].

Debido a la importancia que tiene la CA sobre la salud, el American College of Sport Medicine[11] recomienda, para desarrollar y mantener la CA, una actividad física aeróbica continua o intermitente de 3 a 5 días a la semana, de 20-60 minutos de duración con una intensidad equivalente al 55-90% de la frecuencia cardíaca (FC) máxima o el 45-85% de la FC de reserva o del consumo de oxígeno de reserva. Las recomendaciones del Helena Group Study para adolescentes europeos son similares[12]. Sin embargo, en España, las clases de Educación Física (EF) en Primaria y Secundaria tienen una frecuencia de 2 días a la semana y una duración de 60 minutos. Por este motivo, diversos investigadores han estudiado los efectos que tienen las clases de EF sobre la condición física del alumnado. La mayoría de ellos han concluido que aunque la duración de la actividad durante las clases de EF es adecuada[13], la intensidad de trabajo durante las mismas no es suficiente para provocar mejoras a nivel cardiovascular[14]. Expresándose como causa que la intensidad del ejercicio es raramente individualizada en función de la capacidad de cada estudiante[15].

Los objetivos de este estudio fueron determinar los efectos de un programa de entrenamiento aeróbico de alta intensidad de 8 semanas, desarrollado durante las clases de EF, sobre la capacidad aeróbica de adolescentes de 15 a 18 años, y conocer los beneficios que supondría una tercera clase de EF más a la semana sobre la capacidad aeróbica de los alumnos.

Material y método

Sujetos

Se diseñó un estudio experimental en el que participaron 84 sujetos (51 chicos y 33 chicas; 15-18 años). La muestra fue seleccionada de manera aleatoria, siendo todos los sujetos seleccionados estudiantes de Educación Secundaria Obligatoria de la ciudad de Granada (España) y con el mismo nivel socio-económico. Los sujetos participaron de manera voluntaria después de recibir una explicación detallada acerca del objetivo e implicaciones de la investigación. Se obtuvo el consentimiento informado por escrito de los padres y de los participantes. El estudio fue aprobado por el Comité de Ética de Investigación Humana de la Universidad de Granada.

La CA (VO_2max) de los sujetos fue medida previamente, y en base a ella, la muestra se distribuyó de forma aleatoria en 3 grupos de 28 personas (17 chicos y 11 chicas), comprobando que eran homogéneos en relación a su VO_2max. Un grupo realizó las clases regulares de EF (GC), un segundo grupo desarrolló un programa de entrenamiento aeróbico de alta intensidad 2 días en semana (G2S), y el tercer grupo ejecutó el mismo programa de entrenamiento aeróbico de alta intensidad 3 días en semana (G3S). El G2S desarrolló el programa durante las clases de EF, y el G3S desarrolló 2 sesiones durante las clases de EF y 1 durante la hora de tutoría cedida para este fin. Al finalizar el programa de entrenamiento, la CA de todos los sujetos (experimentales y control) se volvió a evaluar utilizando los mismos procedimientos que en la evaluación inicial.

Medidas

Capacidad Aeróbica (VO^2max). El VO_2max se midió de forma directa mediante la utilización de un analizador de gases portátil (K4b^2, Cosmed, Roma, Italia), mientras los sujetos realizaban una prueba máxima. La prueba que se utilizó fue el 20 Meter Shuttle Run Test (20mSRT)[16]. El 20mSRT permite evaluar la CA máxima de adolescentes, siendo su objetividad, fiabilidad y validez demostrada en personas jóvenes[17]. El test es de carácter incremental máximo y consiste en correr entre dos líneas separadas 20 m siguiendo el ritmo que marca el protocolo del 20mSRT. La velocidad inicial es de 8,5 km/h y se incrementa 0,5 km/h cada minuto. El peso del equipo K4b^2 Cosmed es de 1,5 kg incluyendo la batería y el arnés. Ha sido demostrado que portar el analizador de gases durante la realización del 20mSRT no altera significativamente las demandas energéticas de los sujetos[18].

Los participantes recibieron instrucciones comprensivas de cómo realizar el test y realizaron sesiones de familiarización una semana antes de la evaluación. Todos los sujetos realizaron el test individualmente monitorizados con el analizador de gases portátil (K4b^2, Cosmed, Roma, Italia) en un gimnasio cubierto con condiciones estandarizadas. La frecuencia cardíaca se registró de forma continua mediante pulsómetro (Polar S810). Todos los test fueron realizados, en un gimnasio cubierto, por los mismos investigadores y a la misma hora (entre 10:00 y 13:00 h). Los adolescentes fueron instruidos para abstenerse de realizar ejercicio extenuante 48 horas antes de la realización del test.

Umbrales ventilatorios. A través del análisis de gases, el instrumental utilizado (K4b^2, Cosmed, Roma, Italia) nos permitió determinar los umbrales VT1 (indica el comienzo de la producción de lactato) y VT2 (indica un máximo estable de lactato en sangre). El criterio utilizado para determinar el VT1 durante el test incremental fue el incremento del VE/VO_2 (ventilación pulmonar entre volumen de oxígeno) sin que aumente del VE/VCO_2 (ventilación pulmonar entre volumen de dióxido de carbono). Y el criterio para determinar el VT2 fue el incremento del VE/VCO_2, una vez que se incrementó con anterioridad el VE/VO_2.

Actividad Física. Con objeto de controlar la actividad física que el alumnado pudiera hacer en horario extraescolar, la cual podría contaminar los efectos del tratamiento, se utilizó el International Physical Activity Questionnaire (IPAQ) en su versión corta autoadministrada para adolescentes, por ser, un instrumento válido y fiable en las edades estudiadas[19] y aplicado en diversos países[20].

Procedimiento

El programa de entrenamiento consistió en la práctica de actividad física aeróbica continua durante 30 minutos por sesión con una intensidad equivalente al 75-80% del VO_2max. Cada una de las sesiones de tratamiento consistió en realizar carrera continua a la intensidad prescrita individualmente alrededor de un circuito establecido durante 30 min. El G2S realizó 2 sesiones semanales mientras que el G3S realizó 3 sesiones. La duración del programa de entrenamiento fue de 8 semanas. La prescripción del ejercicio se realizó en base al VO_2max alcanzado en la evaluación inicial. La FC equivalente al 75-80% del VO_2max de cada estudiante fue determinada. Cada sujeto llevó un pulsómetro (Polar S810), con el fin de controlar la intensidad del ejercicio y poder comprobar que los sujetos mantenían la intensidad prescrita.

Análisis estadístico

Los valores de las diferentes variables son mostrados como media ± desviación estándar. Para comparar las variables con respecto al género se utilizó el test Welch, después de verificar la normalidad de las variables estudiadas. Para realizar la comparación entre grupos se utilizó ANOVA (para variables con distribución normal) y el test de Kruskal-Wallis (para variables que no verifican los supuestos del ANOVA). En los casos con diferencias significativas se realizaron comparaciones múltiples post-hoc controlando la propagación del error por el método de Bonferroni. Todos los datos fueron analizados usando el programa estadístico SPSS 15.0 para Windows XP. La cota máxima para el nivel de significación fue del 5% para todos los análisis.

Resultados

La tabla I muestra las características de los sujetos en función del género. Se observaron diferencias significativas ($p < 0,05$) por género para todas las variables relacionadas con la CA (VO_2max, n.º stages y tiempo en el 20mSRT, VO_2 en VT1 y VT2, tiempo en alcanzar VT1 y VT2) siendo estos valores mayores en el grupo de los chicos.

Tabla I
Características (media ± desviación estándar) de los sujetos estudiados en la evaluación inicial, en función del género

	Chicos (n = 51)	*Chicas (n = 33)*
Edad (años)	16,8 ± 1,2	16,6 ± 0,8
Altura (cm)	173,8 ± 6,5	159,7 ± 6,4[b]
Peso (kg)	68,6 ± 13,5	57,9 ± 9,2[b]
VO_2max (ml/kg/min)	54,6 ± 6,2	36,9 ± 5,4[b]
Stages 20mSRT (n.º)	8,0 ± 1,6	3,8 ± 1,0[b]
Tiempo 20mRT (seg)	493,4 ± 102,5	248,4 ± 61,9[b]
VO_2 en VT1 (ml/kg/min)	33,5 ± 4,9	25,7 ± 3,2[b]
Tiempo en VT1 (seg)	53,3 ± 23,0	46,6 ± 11,6[a]
VO_2 en VT2 (ml/kg/min)	43,4 ± 5,4	31,9 ± 4,0[b]
Tiempo en VT2 (seg)	213,6 ± 89,6	128,9 ± 46,6[b]
FCmax (lpm)	200 ± 7,1	195 ± 8,2[a]

VO_2: Consumo de oxígeno; VO_2max: Consumo máximo de oxígeno; 20mSRT: 20 meter Shuttle Run Test; VT1: Umbral ventilatorio 1; VT2: Umbral ventilatorio 2. [a]$p \leq 0,05$; [b]$p \leq 0,001$.

Tabla II

Variables de capacidad aeróbica (media ± desviación estándar) de los sujetos estudiados en función del grupo de tratamiento y el género, en el Pre-Test y Post-Test

	Chicos (n = 51)				*Chicas (n = 33)*			
	G3S (n = 27)	*G2S (n = 27)*	*GC (n = 27)*	*p*	*G3S (n = 11)*	*G2S (n = 11)*	*GC (n = 11)*	*p*
Pre-Test								
VO_2max(ml/kg/min)	54,9 ± 6,8	55,7 ± 4,5	53,1 ± 7,0	0,489	36,0 ± 5,5	37,8 ± 7,4	36,9 ± 4,0	0,774
Stages 20mSRT (n.º)	8,0 ± 1,8	8,3 ± 1,2	7,6 ± 1,9	0,436	3,6 ± 1,2	3,7 ± 1,6	4,1 ± 0,8	0,494
Tiempo 20mRT (seg)	495,3 ± 109,2	512,7 ± 77,7	472,3 ± 98,4	0,524	235,2 ± 73,4	241,2 ± 70,3	262,2 ± 78,2	0,555
VO_2 en VT1 (ml/kg/min)	34,2 ± 4,4	32,9 ± 3,7	33,24 ± 6,6	0,717	25,9 ± 3,6	26,4 ± 4,0	25,2 ± 2,3	0,700
Tiempo en VT1 (seg)	67,0 ± 30,5	54,7 ± 12,9	59,7 ± 19,5	0,119	45,0 ± 12,2	46,6 ± 15,8	43,9 ± 7,1	0,623
VO_2 en VT2 (ml/kg/min)	42,0 ± 6,2	44,9 ± 4,0	43,3 ± 5,7	0,305	31,9 ± 5,0	33,0 ± 4,7	31,6 ± 2,9	0,634
Tiempo en VT2 (seg)	207,3 ± 84,0	230,2 ± 83,3	202,5 ± 85,0	0,641	131,6 ± 61,7	135,0 ± 41,0	136,2 ± 41,6	0,831
Post-Test								
VO_2max(ml/kg/min)	56,0 ± 6,2	56,6 ± 3,7	52,9 ± 6,9	0,128	38,7 ± 5,8	38,7 ± 5,9	36,8 ± 3,4	0,642
Stages 20mSRT (n.º)	8,7 ± 1,4	9,0 ± 1,1	7,4 ± 1,6	0,005[b]	4,5 ± 1,1	4,3 ± 1,1	4,0 ± 0,8	0,590
Tiempo 20mRT (seg)	536,7 ± 87,	557,8 ± 71,4	459,8 ± 98,3	0,005[b]	283,7 ± 77,5	277,8 ± 66,7	259,3 ± 50,6	0,652
VO_2 en VT1 (ml/kg/min)	34,0 ± 4,0	33,4 ± 4,0	31,6 ± 4,3	0,742	26,7 ± 3,7	26,1 ± 4,4	26,0 ± 2,9	0,918
Tiempo en VT1 (seg)	74,1 ± 35,3	62,6 ± 17,7	57,0 ± 12,5	0,211	51,6 ± 8,0	48,0 ± 13,7	43,6 ± 8,0	0,628
VO_2 en VT2 (ml/kg/min)	42,2 ± 4,9	46,7 ± 4,9	42,5 ± 3,8	0,724	32,8 ± 5,6	32,8 ± 5,8	32,1 ± 3,1	0,174
Tiempo en VT2 (seg)	241,7 ± 90,1	270,6 ± 83,4	190,0 ± 55,7	0,209	155,6 ± 74,3	156,0 ± 58,8	139,0 ± 46,0	0,763

G3S: Grupo 3 ses/sem; G2S: Grupo 2 ses/sem; GC: Grupo control; VO_2: Consumo de oxígeno; VO_2max: Consumo máximo de oxígeno; 20mSRT: 20 meter Shuttle Run Test; VT1: Umbral ventilatorio 1; VT2: Umbral ventilatorio 2.
p ≤ 0,01[b].

La tabla II muestra los valores de las variables de CA en el pre-test y post-test, en función del grupo y el género. Se observó una homogeneidad entre grupos antes del tratamiento. Tras la intervención, se encontraron diferencias significativas (p < 0,05) entre grupos en las variables de nº de stages y tiempo en el 20mSRT para el género masculino. En estos casos, las comparaciones múltiples (tabla III) mostraron diferencias significativas (p < 0,05) entre el GC y los dos grupos experimentales (G3S y G2S). Sin embargo, no existen diferencias entre G3S y G2S en ninguna variable. En el género femenino no se detectan diferencias significativas entre grupos.

La tabla IV muestra las intensidades de ejercicio prescritas y registradas durante el programa de entrenamiento en los grupos experimentales (G2S y G3S), así

Tabla III

Comparaciones múltiples (método de Bonferroni) entre los grupos de género masculino en el Post-Test

Variable	*(A) grupo*	*(B) grupo*	*Diferencia de medias (A-B)*	*Error típico*	*Sig.*	*Intervalo de confianza al 95%* *Límite inferior*	*Límite superior*
Stages 20mSRT (n.º)	G3S	G2S	-0,34	0,50	1,00	-1,58	0,90
		GC	1,27[a]	0,50	0,042	0,032	2,52
	G2S	GC	1,61[a]	0,49	0,006	0,39	2,84
Tiempo 20mSRT (seg)	G3S	G2S	-21,07	30,10	1,000	-95,81	53,67
		GC	76,92[a]	30,10	0,042	2,18	151,67
	G2S	GC	98,00[a]	29,64	0,005	24,39	171,60

G3S: Grupo 3 ses/sem; G2S: Grupo 2 ses/sem; GC: Grupo control; VO_2: Consumo de oxígeno; VO_2max: Consumo máximo de oxígeno; 20mSRT: 20 meter Shuttle Run Test; VT1: Umbral ventilatorio 1; VT2: Umbral ventilatorio 2.
[a]p ≤ 0,05.

Tabla IV
Intensidad del ejercicio prescrita y registrada[1] durante el programa de entrenamiento según grupo y género

	Chicos (n = 51)			*Chicas (n = 33)*		
	G3S (n = 27)	*G2S (n = 27)*	*GC (n = 27)*	*G3S (n = 11)*	*G2S (n = 11)*	*GC (n = 11)*
VO_2 prescrito (% max)	75-80	75-80		75-80	75-80	
FC prescrita (lpm)	176 (155-190)	175 (160-185)		175 (160-190)	175 (162-191)	
FC registrada (lpm)	175 (157-191)	176 (162-188)	139 (111-162)[b]	176 (162-193)	176 (160-191)	123 (107-155)[b]

[1]Media y rango entre paréntesis.
[b]p ≤ 0,001 GC *vs* G2S y G3S.
G3S: Grupo 3 ses/sem; G2S: Grupo 2 ses/sem; GC: Grupo control; VO_2: Consumo de oxígeno; % max: % en función del consumo máximo de oxígeno; FC: Frecuencia cardíaca; lpm: Latidos por minuto.

como la intensidad registrada en el GC durante las clases regulares de EF. Los valores indican que no existen diferencias en la intensidad registrada entre ambos grupos experimentales, sin embargo se aprecia una menor intensidad entre el GC y los grupos experimentales, para ambos sexos.

La tabla V muestra la comparación de los valores del pre-test y el post-test de cada variable de la CA, para cada grupo y género. En el caso del género masculino, se observaron diferencias significativas tanto en el G3S (p < 0,05) como en el G2S (p < 0,001) en las variables de nº stages y tiempo en el 20mSRT. Sin embargo, en el GC no se detectan diferencias significativas en ninguna variable. Por otra parte, en el género femenino, también existen diferencias significativas en el G3S (p < 0,001) y el G2S (p < 0,001) en las variables de nº stages y tiempo en el 20mSRT, y en el G3S además en la variable VO_2max (p < 0,001). No se detectaron diferencias significativas en el GC.

Por último, la tabla VI muestra el cambio relativo (%) de las variables en las que se han detectado diferencias significativas en algún grupo o género. Podemos observar que los chicos de ambos grupos de tratamiento (G3S y G2S) han incrementado su rendimiento en el 20mSRT (nº de stages y tiempo) aproximadamente un 10%, después de realizar el programa de entrenamiento. Aunque las mejoras en el VO_2max no alcanzan el 2% en ambos grupos. Respecto a las chicas,

Tabla V
Cambios en la capacidad aeróbica (media ± desviación estándar) en respuesta a 8 semanas de programa, según grupo y género

	G3S (n = 27)			*G2S (n = 27)*			*GC (n = 27)*		
	pre	*post*	*p*	*pre*	*post*	*p*	*pre*	*post*	*p*
Género masculino									
VO_2max(ml/kg/min)	54,9 ± 6,8	56,0 ± 6,2	0,311	55,7 ± 4,5	56,6 ± 3,7	0,314	53,1 ± 7,0	52,9 ± 6,9	0,616
Stages 20mSRT (n.º)	8,0 ± 1,8	8,7 ± 1,4	0,015[a]	8,3 ± 1,2	9,0 ± 1,1	0,000[c]	7,6 ± 1,9	7,4 ± 1,6	0,492
Tiempo 20mRT (seg)	495,3 ± 109,2	536,7 ± 87,4	0,016[a]	512,7 ± 77,7	557,8 ± 71,4	0,000[c]	472,3 ± 98,4	459,8 ± 98,3	0,329
VO_2 en VT1 (ml/kg/min)	34,2 ± 4,4	34,0 ± 4,0	0,706	32,9 ± 3,7	33,4 ± 4,0	0,627	33,24 ± 6,6	31,6 ± 4,3	0,702
Tiempo en VT1 (seg)	67,0 ± 30,5	74,1 ± 35,3	0,216	54,7 ± 12,9	62,6 ± 17,7	0,095	59,7 ± 19,5	57,0 ± 12,5	0,828
VO_2 en VT2 (ml/kg/min)	42,0 ± 6,2	42,2 ± 4,9	0,898	44,9 ± 4,0	46,7 ± 4,9	0,113	43,3 ± 5,7	42,5 ± 3,8	0,724
Tiempo en VT2 (seg)	207,3 ± 84,0	241,7 ± 90,1	0,130	230,2 ± 83,3	270,6 ± 83,4	0,130	202,5 ± 85,0	190,0 ± 55,7	0,119
Género femenino									
VO^2max(ml/kg/min)	36,0 ± 5,5	38,7 ± 5,8	0,000[c]	37,8 ± 7,4	38,7 ± 5,9	0,348	36,9 ± 4,0	36,8 ± 3,4	0,893
Stages 20mSRT (n.º)	3,6 ± 1,2	4,5 ± 1,1	0,000[c]	3,7 ± 1,6	4,3 ± 1,1	0,001[b]	4,1 ± 0,8	4,0 ± 0,8	0,794
Tiempo 20mRT (seg)	235,2 ± 73,4	283,7 ± 77,5	0,000[c]	241,2 ± 70,3	277,8 ± 66,7	0,001[b]	262,2 ± 78,2	259,3 ± 50,6	0,936
VO_2 en VT1 (ml/kg/min)	25,9 ± 3,6	26,7 ± 3,7	0,405	26,4 ± 4,0	26,1 ± 4,4	0,743	25,2 ± 2,3	26,0 ± 2,9	0,491
Tiempo en VT1 (seg)	45,0 ± 12,2	51,6 ± 8,0	0,351	46,6 ± 15,8	48,0 ± 13,7	0,594	43,9 ± 7,1	43,6 ± 8,0	0,998
VO_2 en VT2 (ml/kg/min)	31,9 ± 5,0	32,8 ± 5,6	0,179	33,0 ± 4,7	32,8 ± 5,8	0,613	31,6 ± 2,9	32,1 ± 3,1	0,395
Tiempo en VT2 (seg)	131,6 ± 61,7	155,6 ± 74,3	0,142	135,0 ± 41,0	156,0 ± 58,8	0,128	136,2 ± 41,6	139,0 ± 46,0	0,226

G3S: Grupo 3 ses/sem; G2S: Grupo 2 ses/sem; GC: Grupo control; VO_2: Consumo de oxígeno; VO_2max: Consumo máximo de oxígeno; 20mSRT: 20 meter Shuttle Run Test; VT1: Umbral ventilatorio 1; VT2: Umbral ventilatorio 2. Pre: Antes del programa de entrenamiento. Post: Después del programa del programa de entrenamiento. p ≤ 0,05[a]; p ≤ 0,01[b]; p ≤ 0,001[c].

Tabla VI
Cambio relativo (%) de las variables de capacidad aeróbica según grupo y género

	Chicos (n = 51)			*Chicas (n = 33)*		
	G3S (n = 27)	*G2S (n = 27)*	*GC (n = 27)*	*G3S (n = 11)*	*G2S (n = 11)*	*GC (n = 11)*
VO_2max(ml/kg/min)	1,9%	1,7%	-0,1%	7,8%	4,8%	0,9%
Stages 20mSRT (n.º)	10,4%	9,0%	-0,6%	32,3%	20,0%	-0,5%
Tiempo 20mRT (seg)	9,3%	9,4%	-1,4%	24,3%	17,1%	-0,1%

G3S: Grupo 3 ses/sem; G2S: Grupo 2 ses/sem; GC: Grupo control; VO_2max: Consumo máximo de oxígeno; 20mSRT: 20 meter Shuttle Run Test.

el G3S muestra un mayor incremento que el G2S en las variables VO_2max (7,8% *vs* 4,8%), n.º de stages (32,3% *vs* 20%) y tiempo en 20mSRT (24,3% *vs* 17,1%). Por otra parte, las chicas de los grupos de tratamiento muestran un mayor incremento en los valores de las variables VO_2max, nº de stages y tiempo en el 20mSRT, respecto a los chicos que también han recibido el tratamiento. Los cambios en el GC no llegan al 1% en ambos géneros.

Discusión

Los incrementos en el VO_2max de los sujetos experimentales (G3S y G2S) no son elevados debido a la corta duración del programa. Otros estudios similares[21] tampoco encontraron mejoras significativas en el VO2max de jóvenes con 8 semanas de entrenamiento aeróbico, 3 sesiones por semana, a una intensidad del 80-85% de la FCmax.

El incremento en el rendimiento en el test incremental de los G3S y G2S (de ambos géneros) se ha podido deber, además de la mejora del VO_2max, al desplazamiento hacia la derecha de los umbrales ventilatorios[22]. Otros estudios indican que el entrenamiento de resistencia aeróbica produce adaptaciones (aumento de la densidad capilar, tamaño y número de las mitocondrias, actividad de la enzimas oxidativas) que ayudan a aumentar la intensidad del ejercicio antes de comenzar a acumular lactato en sangre[23]. Por otra parte, en el GC no se detectan diferencias en los umbrales VT1 y VT2 después de las 8 semanas. Resultados similares se observan en otros estudios[24].

Las diferencias encontradas en la CA coinciden con las observadas por otros autores[25,26]. Los investigadores sugieren que esta diferencia entre sexos está relacionada con que las chicas tienen mayor grasa corporal y menores niveles de hemoglobina[27], y son menos activas físicamente[28,29] debido a factores socioculturales[30]. Además, estas diferencias entre sexos en la CA incrementan durante la adolescencia[31].

En los grupos experimentales, las chicas consiguen una mejora relativa mayor que los chicos después del programa de entrenamiento. Esto es debido a que cuanto más alto es el estado inicial de acondicionamiento, menor es la mejora relativa para el mismo programa de entrenamiento. Si comparamos el nivel inicial de CA (nº de stages en el 20mSRT) de nuestros sujetos con una muestra representativa de adolescentes españoles de la misma edad[32], observamos que los valores medios del 20mSRT de las chicas se corresponden con el percentil 50 y los valores medios de los chicos con el percentil 70 respecto a los adolescentes españoles. Estudios similares, encuentran que, después de un programa de entrenamiento de 6 meses, las chicas que siguen el tratamiento mejoran un 8,5% el 20mSRT más que las chicas del grupo control, sin embargo los chicos mejoran un 3,8% el 20mSRT respecto a los chicos del grupo control[33].

Nuestros resultados sugieren que la eficacia del programa se debe a la alta intensidad de las sesiones, y no tanto, a la frecuencia semanal de las mismas. Por tanto, corroboramos los hallazgos encontrados por otros autores[14], quienes indican que la intensidad de las sesiones regulares de EF no es suficiente para provocar mejoras en la CA. Los resultados del presente estudio están en concordancia con los encontrados por otros investigadores[34], quienes en un estudio realizado con adolescentes, comprobaron que el entrenamiento de alta intensidad (75-80% del VO_2max) provoca mayores incrementos en la CA que el de intensidad moderada (55-60% del VO_2max). Otros estudios[35] muestran que con 3 horas a la semana de EF, el grupo que realiza 1 sesión de las 3 con una intensidad alta (programa entrenamiento aeróbico) mejora el rendimiento en el 20mSRT (3,8%) después de 10 semanas de programa, sin embargo el grupo control que realiza 3 sesiones de EF a la semana no mejora su rendimiento. Una revisión reciente[36], muestra como el entrenamiento aeróbico produce una mejora media del 5-6% en el VO_2max de niños y adolescentes, y cuando el efecto del entrenamiento es significativo, la mejora media en el VO_2max alcanza el 8-10%. Nuestros resultados, en el caso de las chicas, están en concordancia con estos hallazgos.

En concordancia con otros estudios[15], nuestros resultados sugieren que es posible mejorar la CA durante las clases de EF aunque para ello es necesario aumentar la intensidad de las mismas, individualizar la intensidad del ejercicio en función de la capacidad de cada estudiante y controlar la intensidad prescrita durante las clases de EF. Los estudios realizados con adolescentes sugieren que son necesarias intensidades mayores que el 80% de la FCmax para producir mejoras significativas en el VO_2max[36,37].

Conclusiones

En base a nuestros resultados y en el contexto de nuestro estudio, concluimos que las clases de EF requieren de una intensidad mayor a la habitualmente desarrollada para producir mejoras en la capacidad aeróbica de los adolescentes. Además, una sesión extra de ejercicio intenso por semana puede suponer una mejora añadida en las chicas, aunque no produciría mejoras significativas añadidas en la capacidad aeróbica de los chicos.

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INFLUENCE OF PHYSICAL ACTIVITY AND DIETARY HABITS ON LIPID PROFILE, BLOOD PRESSURE AND BMI IN SUBJECTS WITH METABOLIC SYNDROME

VI

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Original

Influence of physical activity and dietary habits on lipid profile, blood pressure and BMI in subjects with metabolic syndrome

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Abstract

Background: **The present study was determined the influence of physical activity and dietary habits on lipid profile, blood pressure (BP) and body mass index (BMI) in subjects with metabolic syndrome (MS).**

Aims: **Identify the relationship between physical activity and proper nutrition and the probability of suffering from myocardial infarction (MI).**

Methods: **Hundred chronically ill with MS who were active and followed a healthy diet were classified as compliant, while the remaining subjects were classified as non-compliant.**

Results: **The compliant subjects show lower BMI values (30.8 ± 4.9 *vs* 32.5 ± 4.6), as well as lower levels of triacylglycerol (130.4 ± 48.2 *vs* 242.1 ± 90.1), total cholesterol (193.5 ± 39 *vs* 220.2 ± 52.3) and low-density lipoprotein cholesterol (105.2 ± 38.3 *vs* 139.2 ± 45). They show higher values in terms of high-density lipoprotein cholesterol levels (62.2 ± 20.1 *vs* 36.6 ± 15.3), with statistically significant differences. In terms of both systolic and diastolic pressure, no differences were revealed between the groups; however, those who maintain proper dietary habits show lower systolic blood pressure levels than the inactive subjects. The probability of suffering from MI greatly increases among the group of non-compliant subjects.**

Conclusions: **Our results demonstrate how performing aerobic physical activity and following an individualized, Mediterranean diet significantly reduces MS indicators and the chances of suffering from MI.**

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Key words: *Physical activity. Dietary habits. Health. Metabolic syndrome.*

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INFLUENCIA DE LA ACTIVIDAD FÍSICA Y LOS HÁBITOS NUTRICIONALES SOBRE EL PERFIL LIPÍDICO, PRESIÓN ARTERIAL E IMC EN SUJETOS CON SÍNDROME METABÓLICO

Resumen

Introducción: **En el presente estudio se determinó la influencia de la actividad física y los hábitos nutricionales sobre el perfil lipídico, presión arterial (PA) e índice de masa corporal (IMC) en sujetos con SM.**

Objetivos: **Comprobar la relación entre realizar actividad física y una nutrición adecuada, y la posibilidad de sufrir infarto de miocardio (IM).**

Método: **Se evaluaron 100 sujetos con SM. Los sujetos que manifestaban ser activos y llevaban una alimentación saludable fueron clasificados como cumplidores, mientras que al resto se les clasificó como no cumplidores.**

Resultados: **Los sujetos cumplidores presentan valores menores en cuanto a su IMC (30,8 ± 4,9 *vs* 32,5 ± 4,6) y sus niveles de triglicéridos (130,4 ± 48,2 *vs* 242,1 ± 90,1), colesterol total (193,5 ± 39 *vs*220,2 ± 52,3) y colesterol unido a lipoproteínas de baja densidad (105,2 ± 38,3 *vs* 139,2 ± 45); y valores mayores en los niveles de colesterol unido a lipoproteínas de alta densidad (62,2 ± 20,1 *vs* 36,6 ± 15,3) siendo las diferencias estadísticamente significativas. La PA, tanto sistólica como diastólica, no muestra diferencias entre ambos grupos; en cambio el grupo que manifiesta realizar una alimentación adecuada obtiene unos niveles de presión arterial sistólica menores que el grupo que no la realiza. La posibilidad de padecer IM aumenta significativamente en el grupo de sujetos no cumplidores.**

Conclusiones: **Nuestros resultados muestran como la realización de actividad física de tipo aeróbica y llevar a cabo una alimentación individualizada de tipo mediterráneo reduce significativamente los parámetros relacionados con el SM y las posibilidades de sufrir IM.**

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Palabras clave: *Actividad física. Hábitos dietéticos. Salud. Síndrome metabólico.*

Introduction

Metabolic syndrome (MS) refers to heterogeneous clustering of risk factors associated with increased probability of suffering from a cardiovascular disease (CVD) or diabetes mellitus (DM).[1,2] Such factors include abdominal obesity, hydrocarbon metabolism alterations or dysglycaemia, arterial hypertension and atherogenic dyslipidemia, with insulin-resistance as a common physiopathological base.[3]

At present, various authors consider physical inactivity to be one of the main problems affecting public health in the XXI century.[4] An increase in aerobic physical activity leads to an increase in aerobic capacity, which is inversely related to different health indicators, such as lipid profile, insulin-resistance, fat mass, MS indicators and arterial resistance.[5-9] Epidemiological studies demonstrate that performing moderate to vigorous physical activity daily prevents the incidence of chronic illnesses and premature death,[10] and when carried out according to certain criteria concerning the type, duration, intensity, frequency and progression of the activity,[11] it adapts to the individual's potential. In this way, the exercise helps to improve his or her health and assists the treatment of illnesses, especially coronary artery disease, arterial hypertension, DM, osteoporosis, colon cancer and depression, not to mention the way in which physical activity affects the development of obesity and CVD.[12-14]

In addition to a decrease in the performance of physical activity, social and technological changes imply transformations in dietary behaviours, such as an increased consumption of high-calorie foods rich in saturated fats, and a low consumption of unrefined carbohydrates. Some authors have emphasized that dietary treatment should vary, depending on the presence of different components of MS, and that treatment should be individualized according to the specific metabolic disorders affecting each patient.[15,16] It has been demonstrated that following a healthy diet, such as the Mediterranean diet, yields a negative relationship between the highest scores of adherence to such a diet and central obesity, fasting glycaemia and plasma triacylglycerols, and a positive relationship with HDL-C levels.[17]

The objective of this paper was to determine the influence of physical activity and dietary habits on lipid profile, blood pressure (BP) and body mass index (BMI) in subjects with MS. Likewise, the authors evaluated the influence of physical activity and proper nutrition on the probability of suffering from myocardial infarction (MI).

Methods

Sample

The sample group is representative of people chronically ill with MS. Selected participants are from a town in the province of Malaga (Spain) and receive treatment at a primary care nursing service which pays special attention to care for chronic patients. 100 subjects participated in the study, including 64 females and 36 males, with an average age of 68.4 ± 10.9. The MS diagnosis is made when an individual meets three of the five following diagnostic criteria (modified ATP-III): BMI > 28·8; BP ≥ 130/85 mmHg; high density lipoprotein cholesterol (HDL-C) < 40 mg/dl in males or < 50 mg/dl in females; triacylglycerols (TAG) ≥ 150 mg/dl; basal fasting glycaemia ≥ 110 mg/dl or receiving hypoglycaemia treatment, or the presence of previously diagnosed DM. Abdominal obesity was evaluated on the basis of a BMI ≥ 28.8 instead of abdominal circumference, a modification which has been validated previously in large cohorts.[18] All participants acted voluntarily, and the Declaration of Helsinki about ethics in research was respected. The University of Granada human research ethics committee approved this study.

Measurements

Body Composition: The anthropometric measurements were taken in the same place, by the same researcher, following all of the standards set by the International Society for the Advancement of Kinanthropometry (ISAK).[19] Height was measured with a stadiometer (GPM, Seritex, Inc., Carlstadt, New Jersey) with an exactness of 0.1 cm, and weight was determined on a portable scale (model 707, Seca Corporation, Columbia, Maryland) with an exactness of 0.1 kg. BMI was calculated as weight/height^2, with weight expressed in kilograms (kg) and height in meters (m).

Lipid Profile: All subjects were fasting since 12 hours before the experience started. The biochemical components were determined through blood analysis. Measured indicators included: total cholesterol (TC) (mg/dl), HDL-C (mg/dl), LDL-cholesterol (LDL-C) and TAG (mg/dl). In the laboratory, the blood serum and plasma were then separated to calculate the different fractions of the sample. Enzymatic methods were used.

Blood pressure: Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured weekly with mercury phygmomanometers, taken with the utmost care and following the method approved by international guidelines.[20] The BP levels were also determined *in situ* on the day of the consultation (casual BP).

Procedure

A clinical and nutritional interview was given to each subject, using a worksheet with multiple indicators, assessing life habits, cardiovascular risk factors, microand macro-vascular complications and dietary and/or pharmacological treatments. Also, BMI, BP and analytical determinations were calculated. The subject's level of physical activity was evaluated as sedentary or active, with sedentary patients performing fewer than 30 minutes of moderately intense aerobic exercise (between 55 and 60% of theoretical maximum cardiac frequency) per day. The level of physical activity was determined through recording cardiac frequency, using Polar RS800cx pulsometers. Through analyzing the written list of food provided by the patient or person responsible for his or her nutrition, as part of the sample is illiterate, the subjects were classified according to their adherence to proper nutrition, according to the nutritional recommendations set by the WHO and guidelines of the Mediterranean diet. Dietary treatment was performed in an individualized manner, depending on the specific metabolic disorders affecting each patient.[21] Subjects who met these two criteria (active and proper nutrition) were classified as compliant (C), while the remaining subjects were classified as non-compliant (NC).

Statistical analysis

Values were expressed as mean values with their standard errors. The obtained data was analyzed through the statistical package, SPSS 17.0. (SPSS, Inc.). After checking the normalcy of the variables and verifying the inexistence of significant gender-based differences, the t-test and non-parametric tests were performed, as applicable, in order to evaluate the statistical differences between the subjects characteristics in terms of various parameters. The χ^2 test was used to compare proportions.

Results

Figure 1 shows the prevalence of MS components among the sample groups. BMI, high basal glucose levels and high BP are the most common of these components among men, while women more commonly experience high glucose levels and BMI, and low levels of HDL-C. In all of the subjects, three of more of these components were altered.

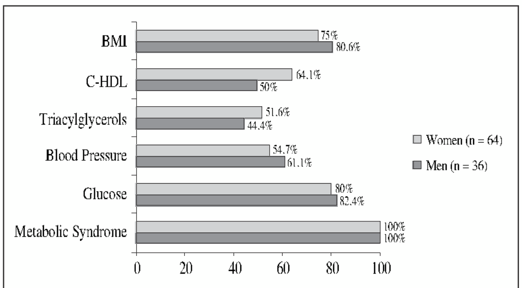

Fig. 1.—

Table I
Differences in MS-related parameters in accordance with level of physical activity

	Sedentary	*Active*	*P Value*
TAG	241.5 ± 95.9	150.9 ± 83.8	0.007^{b}
HDL-C	35.9 ± 14.9	58.9 ± 21	0.000^{c}
LDL-C	139.3 ± 45.2	111 ± 41.2	0.002^{b}
TC	219 ± 52.7	200 ± 43.1	0.061
Glycaemia	154 ± 32.5	126.4 ± 28.3	0.001^{b}
SBP	134.3 ± 17.5	133.9 ± 12.3	0.907
DBP	71.2 ± 9.3	72.5 ± 8.2	0.481
BMI	32.9 ± 4.5	30.5 ± 4.7	0.004^{b}

$p < 0.05^{a}$, $p < 0.01^{b}$, $p < 0.001^{c}$ TAG: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; TC: Total Cholesterol; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index.

Table I demonstrates how physically active subjects show lower BMI values, as well as lower TAG and LDL-C levels, with statistically significant differences. TC values were also lower, but the differences were not statistically significant. Active subjects have higher HDL-C levels, with statistically significant differences when compared with sedentary subjects. Systolic and diastolic blood pressure (SBP and DBP, respectively) revealed no differences between the two groups.

Table II displays the type of dietary habits adopted by the subjects. The results show how subjects who follow the WHO's nutritional recommendations have lower BMI values and TAG, LDL-c and TC levels, with statistically significant differences. Compared with those who do not follow these recommendations, compliant nutritional recommendations subjects have higher HDL-C levels, with statistically significant differences. Compared with non-compliant nutritional recommendations subjects, SBP revealed reductions in subjects who followed the dietary recommendations, with statistically significant differences, when comparing DBP did not reveal differences between the two groups after the dietary treatment.

Table II
Differences in MS-related parameters according to diet type

	Healthy diet	*Unhealthy diet*	*P Value*
TAG	143.2 ± 71.2	275.2 ± 110.5	0.000^{c}
HDL-C	55.7 ± 21.1	33.1 ± 12.4	0.000^{c}
LDL-C	115.8 ± 39.9	141.7 ± 48.2	0.005^{b}
TC	198.7 ± 38.4	225.7 ± 57.1	0.006^{b}
Glycaemia	166.1 ± 27.1	122.7 ± 24.4	0.000^{c}
SBP	130.8 ± 14.9	137.9 ± 15.6	0.022^{a}
DBP	71.1 ±8.8	72.5 ± 9	0.449
BMI	31.1 ± 4.7	32.8 ± 4.6	0.026^{a}

$p < 0.05^{a}$, $p < 0.01^{b}$, $p < 0.001^{c}$ TAG: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; TC: Total Cholesterol; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index.

Table III
Differences in MS-related parameters according to degree of compliance

	C	NC	P Value
TAG	130.4 ± 48.2	242.1 ± 90.1	0.001[b]
HDL-C	62.2 ± 20.1	36.6 ± 15.3	0.000[c]
LDL-C	105.2 ± 38.3	139.2 ± 45	0.000[c]
TC	193.5 ± 39	220.2 ± 52.3	0.011[a]
Glycaemia	121.7 ± 25.5	154.8 ± 31.9	0.000[c]
SBP	133.9 ± 13	134.2 ±16.8	0.943
DBP	72 ±8.5	71.6 ± 9.1	0.851
BMI	30.8 ± 4.9	32.5 ± 4.6	0.026[a]

$p < 0.05^a$, $p < 0.01^b$, $p < 0.001^c$ TAG: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; TC: Total Cholesterol; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; BMI: Body Mass Index.

Table III demonstrates how C subjects show lower BMI values, as well as TAG, LDL-C and TC levels, with statistically significant differences. C subjects have higher HDL-C levels, with statistically significant differences in comparison with NC subjects. The two groups did not present differences in systolic and diastolic blood pressure.

Table IV shows how the probability of suffering from MI increases in a statistically significant way among the group of non-compliant subjects, compared with the group of compliant subjects.

Discussion

This study suggests that performing moderate physical activity on a regular basis significantly reduces various MS-related parameters. Subjects who perform this type of physical activity show lower values in terms of TC, LDL-C, TAG, glycaemia and BMI, and higher levels of HDL-C. These findings concur with previous studies which show that regular physical activity is an important protective factor against metabolic illnesses, as it prevents and reduces established atherosclerotic risk factors, including high TAG and low HDL cholesterol.[22-24] Studies such as that of Ekelund et al., performed on a sample of 3,193 young Europeans, demonstrate how performing a minor physical activity reveals a positive relationship with a lesser prevalence of MS after making adjustments for age and sex.[25]

Table IV
Incidence of myocardial infarction according to degree of compliance

	MI		P Value
	No	Yes	
C	50.7%	49.3%	0.004[b]
NC	18.2%	81.8%	

$p < 0.01^b$.

Our study shows how subjects who do not adopt proper dietary habits show greater MS-related parameters. A diet with excessive calorie intake is considered a risk factor for suffering from MS.[26] Various bibliographic references confirm that the ideal diet for preventing MS should be personalized and include healthy eating habits, which are beneficial not only for effective weight loss, but also for body weight maintenance and the reduction of CVD and MS-related parameters.[27]

In recent years, there has been increasing interest in implementing Mediterranean diets, as the effect of this type of diet on CVD- and MS-inducing parameters has been demonstrated.[28] Intervention studies such as ours show that following a Mediterranean diet reduces TC, LDL-C,[17] TAG[29] and BP levels due to the mono and polyunsaturated fats in olive oil,[30] and increases HDL-C values.[31]

MI control is essentially based on the management of risk factors, such as diabetes, dyslipidemia, hypertension, abdominal obesity and smoking. In recent times, and with more and more relevance, this control is based on lifestyle, with the pillars of diet and physical exercise.[32] Our study shows how compliant subjects have a lesser probability of suffering from MI. These results coincide with previous findings which demonstrate a relationship between physical inactivity, coronary artery disease and cardiovascular mortality,[33] and between following a healthy diet and the production of benefits in terms of morbidity among patients with acute myocardial infarction. The findings are in accordance with previous cohort studies which show that subjects who adhere to healthy lifestyles have less than one-tenth of the probability of suffering from MI that subjects who do not lead a healthy lifestyle have.[34-35]

Conclusions

Our results show how performing physical activity and adhering to an individualized, Mediterranean diet significantly reduces MS-related parameters. The results demonstrate the need to obtain more specific recommendations concerning the quantity and intensity of physical activity needed in order to prevent MS, as well as dietary studies which indicate the most effective diet for reducing MS-related parameters. Preventive efforts should focus on motivating people to improve their lifestyles. Governments and educational and health centres should joing forces to implement programs which incorporate physical activity and the promotion of a Mediterranean diet, and which assist with the prevention of MS.

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CONCLUSIÓN

Conclusión General

Los resultados de la presente memoria de Tesis ponen de manifiesto la importancia y utilidad de las intervenciones combinadas de actividad física y nutrición como determinantes de salud. La metodología utilizada en estas intervenciones puede ser utilizada como estrategia educativa y sanitaria para la prevención de diversas enfermedades, así como para la reducción de las mismas.

Esta conclusión general se sustenta en las siguientes conclusiones específicas, derivadas de cada capítulo presentado:

I. El perfil calórico de la dieta de los niños y jóvenes granadinos está desequilibrado existiendo un alto porcentaje energético proveniente de la ingesta de lípidos y proteínas y bajo porcentaje proveniente de los carbohidratos. Existe un alto porcentaje de niños y jóvenes con IMC superiores a los establecidos como normopeso. El porcentaje de niños que manifiestan ser activos es bajo y se va reduciendo con la edad.

II. Intervenciones de corta duración que incorporan realización de actividad física vigorosa y educación nutricional tanto a padres como a niños y de manera combinada, muestran mejoras en parámetros relacionados con la salud.

III. El efecto combinado de la actividad física vigorosa, la educación nutricional y la sustitución del aceite habitual por aceite de oliva virgen extra ha mostrado ser la intervención que más beneficios produce sobre los parámetros saludables en niños, en comparación con intervenciones aisladas.

IV. Una intervención basada en una actividad física moderada-vigorosa durante un periodo de seis meses y una ingesta crónica de aceite de oliva virgen extra durante el último mes de intervención, ha producido una mejora en la actividad de la enzima antioxidante catalasa en niños sanos.

V. Con un programa de entrenamiento aeróbico de alta intensidad (75-80% VO_2max) de 8 semanas, 2 días por semana, es posible mejorar la capacidad aeróbica de los alumnos durante las clases de Educación Física. La adición de una tercera sesión extra de ejercicio intenso semanal supone un incremento de la mejora en las chicas pero no en el caso de los chicos.

VI. La realización de actividad física de tipo aeróbico y la adhesión a la dieta mediterránea reducen significativamente el riesgo de sufrir infarto de miocardio en sujetos con síndrome metabólico.

CONCLUSION

Overall conclusion

The results of the present work highlight the importance and usefulness of combined physical activity and nutrition interventions in improving health determinants. The methodology used for these interventions can be used like an education and health strategy for the reduction and/or prevention of illness and disease.

This overall conclusion is supported by the conclusions derived in the following chapters:

I. The calorie profile of the diet of children and young people from Granada is imbalanced. There is a high intake of lipids and proteins and a low intake of carbohydrates. A high percentage of the studied subjects had higher values for BMI that which is considered to be normal. The percentage of subjects who are physically active is low and is decreasing further with age.

II. Short-duration physical activity and nutritional education involving both parents and children appear to improve health-related parameters.

III. A program incorporating vigorous physical activity, nutritional education and the replacement of normally used oils with extra virgin olive oil, can improve health-related parameters in children relative to children receiving just one of these components.

IV. Six months of moderate-vigorous physical activity and consumption of extra virgin olive oil in the last month of intervention improved the catalase antioxidant system of healthy children.

V. Two sessions per week of high intensity aerobic training (75-80% VO_2max) delivered over 8 weeks improves the aerobic capacity of students during physical education classes. An extra session of intense exercise per week results in a greater improvement in girls which is not seen in boys.

VI. Engaging in aerobic physical activity and following an individualized Mediterranean diet reduces the risk of suffering myocardial infarction for subjects with metabolic syndrome.

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- Diplomado en Magisterio, especialidad Educación Física. Universidad de Granada, Facultad de Ciencias de la Eduación (Junio 2001)
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