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Sumario / Summary

La fuerza, la olvidada en la prescripción del ejercicio físico para la salud

The force, the forgotten one in the prescription of the physical exercise for health

José Antonio de Paz Fernández

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La condición de ser nuevo para rechazar o aceptar un paradigma, es el anverso y el reverso de una misma moneda falsa.

Han pasado unos 9 años desde que la OMS publicara las recomendaciones que en materia de actividad física suponían los mínimos aconsejables para la población, con la principal novedad de incluir la recomendación de ejercicio de fuerza (fortalecimiento osteomuscular) de los principales grupos musculares, al menos dos o tres días a la semana, independientemente de la edad (de hecho desde los 5 años)[1]. Aún así, con demasiada frecuencia no se incluyen estas recomendaciones en las indicaciones generales que en materia de ejercicio se realizan en las consultas médicas.

Y lo que es más aberrante, aún se mantienen y transmiten antiguas creencias que hoy se saben falsas, sobre "lo malo que es el entrenamiento de fuerza para niños" por afectar al cartílago de crecimiento, por producir hipertrofia miocárdica…o "lo malo que es el ejercicio de fuerza para hipertensos o cardiópatas"… Son numerosos los trabajos publicacados demostrando la seguridad y los beneficios que este tipo de ejercicio supone para los niños sanos[2-4], personas obesas[5], o con enfermedades cardiovasculares[6], pero a pesar de tanta evidencia científica y profesional, no se terminan de disipar esas falsas creencias.

Por fortuna para la salud de la población, actualmente el ejercicio físico se aconseja a los pacientes afectados por cualquiera de la mayoría de padecimientos crónicos y crónico-degenerativos. Sin embargo, desde las consultas médicas el aspecto del ejercicio de fuerza, sigue sin ser aconsejado de forma clara, e incluso desaconsejado de forma expresa. Es ilustrativo una encuesta realizada a 272.887 norteamericanos no hipertensos y 179.789 hipertensos, a los que se les preguntaba si en las consultas médicas se les había recomendado ejercicio y de ser así, si se había aconsejado ejercicio aeróbico solo, de fuerza únicamente o ejercicio combinado aeróbico y de fuerza[7]. Al 36,9% de los sanos no se les había aconsejado ejercicio y al 45,7% de los hipertensos tampoco. A los que sí se les había recomendado se aconsejó ejercicio combinado al 23,1% y 15%, de fuerza sólo al 9,5% y 7,3% de sanos e hipertensos respectivamente. Y esto a pesar de los consensos que en materia de ejercicio se publican por parte de diferentes sociedades de especialidades médicas o de pacientes. Aun así, desafortunadamente no es infrecuente desaconsejar ejercicio de fuerza en pacientes que padecen una enfermedad crónica o con secuelas, a pesar de las publicaciones científicas mostrando lo contrario, lo importante y seguro de su realización de forma única o combinada con el clásico aeróbico. Tal es el caso de pacientes afectados de cardiopatía isquémica[8,9], hipertensión[10], diabetes[11], artrosis[12], osteoporosis[13], esclerosis múltiple[14], supervivientes al cáncer en general[15] o al de mama en particular[16,17], enfermedad pulmonar obstructiva crónica[18,19], enfermedad renal crónica[20]… y una larga lista que se podría detallar.

Existe una discrepancia entre lo que se sabe a la luz de la ciencia y lo que aconseja desde la práctica médica que está sustrayendo posibilidades de mejora funcional y de calidad de vida a la población sana y a la población enferma. Es conveniente, que desde la medicina del deporte se redoblen los esfuerzos pedagógicos hacia la medicina general y especializada en materia de prescripción de ejercicio de fuerza. Existen consensos, posicionamientos y recomendaciones científicamente aceptados, suficientes como para poder realizar una buena prescripción de entrenamiento de fuerza en el contexto de la salud para población general[21,22], para niños[23], para cardiópatas[24].

Si es cierto que los beneficios del ejercicio para la salud están relacionados con la duración, intensidad y frecuencia con que se realizan, no es menos cierto que existe una relación entre la dosis del ejercicio de

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fuerza y sus beneficios para la salud. No todo ejercicio en el que se vence sucesivamente una resistencia puede ser considerado entrenamiento adecuado de fuerza, ni ejercicio beneficioso para la mejora de la fuerza.

El ejercicio o el entrenamiento de fuerza no están contraindicados, lo que está contraindicado es el mal entrenamiento, (mala determinación de la carga, mala progresión de la carga, mala ejecución técnica, medios inadecuados e inseguros…).

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Índice

Relationships among motor coordination, body mass index and physical activity in adolescents with different weight status

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Summary

Purpose: To analyze the influence of physical activity level on associations between motor coordination and body mass index (BMI) in normal weight, overweight and obese adolescents.
Method: Thirty nine adolescents (13 normal weight, 13 overweight and 13 obese) aged 12-14 years old, participated in this study. The Physical Activity Questionnaire for Older Children (PAQ-C) and Körperkoordinationtest für kinder (KTK) tools were used in order to assess the levels of physical activity and motor coordination, respectively. Bivariate and partial correlations were used to analyze the interrelationships among motor coordination, BMI and physical activity. The analysis of covariance test was used in order to compare the levels of motor coordination among normal weight, overweight and obese adolescents, considering the physical activity level as a covariate.
Results: Moderate negative correlations ($p<0.05$) were found between motor coordination and BMI in the sample as a whole, normal weight and obese groups. However, when controlled for physical activity levels, it was not observed a significant correlation in the normal weight group. Motor coordination and BMI were not significantly correlated in overweight adolescents with and without controlling for physical activity levels. Furthermore, motor coordination level demonstrated a trend to be lower in overweight and obese adolescents.
Conclusion: Physical activity level influenced the association between motor coordination and BMI in normal weight adolescents, but not in overweight and obese. The negative effect of excess body mass on motor coordination level may overlap the possible influence that physical activity level exerts on the association between motor coordination and BMI in overweight and obese adolescents.

Key words:
Motor coordination. Obesity. Overweight. Adolescents. Biomechanics.

Relaciones entre la coordinación motora, índice de masa corporal y la actividad física en adolescentes con diferentes estados de peso corporal

Resumen

Objetivo: Analizar la influencia del nivel de actividad física en las asociaciones entre la coordinación motora y el índice de masa corporal (IMC) en adolescentes de peso normal, con sobrepeso y obesos.
Método: Treinta y nueve adolescentes (13 con peso normal, 13 con sobrepeso y 13 obesos) con edades comprendidas entre 12 y 14 años participaron en este estudio. Las herramientas Physical Activity Questionnaire for Older Children (PAQ-C) y Körperkoordinationtest für kinder (KTK) se usaron para evaluar los niveles de actividad física y coordinación motriz, respectivamente. Se usaron correlaciones bivariadas y parciales para analizar las interrelaciones entre la coordinación motora, el IMC y la actividad física. El análisis de covarianza se utilizó para comparar los niveles de coordinación motora entre los adolescentes de peso normal, con sobrepeso y obesos, considerando el nivel de actividad física como una covariable.
Resultados: se encontraron correlaciones negativas y moderadas ($p <0.05$) entre la coordinación motora y el IMC en la muestra como un todo, en los adolescentes con peso normal y obesos. Sin embargo, cuando se controlan los niveles de actividad física, no se observó una correlación significativa en el grupo de peso normal. La coordinación motora y el IMC no se correlacionaron significativamente en adolescentes con sobrepeso con y sin control de los niveles de actividad física. Además, el nivel de coordinación motora demostró una tendencia a ser menor en adolescentes con sobrepeso y obesos.
Conclusión: El nivel de actividad física influyó en la asociación entre la coordinación motora y el IMC en adolescentes de peso normal, pero no en adolescentes con sobrepeso y obesos. El efecto negativo del exceso de masa corporal en el nivel de coordinación motora puede superponerse a la posible influencia que ejerce el nivel de actividad física en la asociación entre la coordinación motora y el IMC en los adolescentes con sobrepeso y obesos.

Palabras clave:
Coordinación motora. Obesidad. Sobrepeso. Adolescentes. Biomecánica.

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Introduction

Pediatric obesity has become a global epidemic[1], being recognized as one of the most serious public health concerns in the 21st century[2]. In Brazil, more than 8 million children and adolescents are estimated to be obese[3]. This high prevalence is a concern due its associated health risks such as hypertension, hyperinsulinemia, glucose intolerance, type II diabetes and dyslipidemia[2].

Obesity seems also to be associated with poor motor coordination in children and adolescents[4-6]. Although few studies[7,8] have not found significant associations between motor coordination level and body mass index (BMI), most evidence suggests these variables are negatively associated[9-14]. Overall, these previous studies suggest obese children tend to have lower motor coordination level than their normal weight peers.

A plausible explanation for a negative association between BMI and motor coordination level in children and adolescents is based on biomechanical issues. That is, the higher the amount of body mass, the higher the mechanical work required to performing motor tasks, especially those which demand body weight-bearing. Evidence[10,15,16] has confirmed, at least partially, this weight-bearing hypothesis. However, the reported negative relationship between motor coordination level and BMI can be mediated by several alternative mechanisms[17].

One of mechanisms that can mediate, or influence, the relationship between motor coordination level and BMI in pediatric population is the physical activity level[4,18]. This assumption is based on evidence that physical activity level is positively associated with motor coordination level[19,20]. Also, it is important to recognize that not all obese children and adolescents have poor motor coordination or are physically inactive[21]. Therefore, the hypothesis that physical activity level may influence the association between motor coordination level and BMI in children and adolescents seems to be plausible.

Chagas and Batista[22] found physical activity level influences the association between motor coordination level and BMI in normal weight, but not in their overweight/obese peers. However, the comparisons realized in that study involved overweight and obese adolescents in the same group. Therefore, it remains unknown if physical activity level can influence the associations between motor coordination level and BMI in obese adolescents.

The purpose of this study was to analyze the influence of physical activity level on associations between motor coordination and BMI in normal weight, overweight and obese adolescents.

Material and method

One hundred and fifty five adolescents (69 boys and 86 girls) between seventh and ninth grade of elementary school (age ranged between 12 and 15 years old) from a Brazilian public school were initially recruited to participate in the study. Inclusion criteria required students to be under 15 years old with no history of injury or disease that could affect motor performance. Exclusion criteria consisted of subject's weight status classified as underweight. Ethical approval for this study was obtained from the University's Ethics Committee and parental consent and child assent were obtained prior to participation.

After initial recruitment (N=155), eight subjects were excluded from the study due to their being underweight. Further, thirteen obese adolescents were detected (n=13). Thus, among the 134 remaining subjects (28 overweight and 106 normal weight), 13 overweight and 13 normal weight adolescents were randomly selected to compose the final sample of 39 participants (17 boys and 22 girls). There was not missing data.

Body mass was measured to the nearest 0.1 kg using an electronic scale, with participants wearing their school uniform. Standing height was measured while unshod with a stadiometer wall to the nearest 0.1 cm. BMI (kg/m^2) was then calculated. World Health Organization[23] age-specific cut-off points for BMI were used in order to determine the weight status of participants (underweight, normal weight, overweight and obesity) according to gender.

The Physical Activity Questionnaire for Older Children (PAQ-C), a valid[24] self-applied 7-day recall instrument, was used to assess general levels of physical activity of participants. The PAQ-C is appropriate for elementary school-aged children approximately between 8–14 years old who are currently in the school system and have recess as a regular part of their school week. The summary score from the PAQ-C is the average of the sum of the nine item questions, each scored on a 5-point scale, with 1 being the lower level of physical activity and 5 the higher level.

Motor coordination level was assessed using the Körperkoordinationstest für Kinder (KTK). The KTK is appropriated to assess motor coordination level of participants because it is a reliable and valid instrument, with a teste-retest reliability coefficient of 0.97[25]. KTK is one of most used tools for assessing children's motor coordination[26] and it consists of four test items. The first is walking backwards along balance beams (3m length) of decreasing width (6, 4.5 and 3 cm). Each beam was crossed three times where a maximum of eight steps per trial were allowed (72 steps overall); the sum of steps in all trials determined score 1. The second involved one-legged hopping over an obstacle, formed by an increasing pile of pillows (pillow size 60 cm × 20 cm × 5 cm; the maximum was 12 pillows or a height of 60 cm). Only three trials were allowed for each obstacle and three, two, or one point(s) were/was awarded for successful performance on the first, second, or third try, respectively. Therefore, a maximum of 39 points (including a ground level trial) could be scored for each leg; the points were summed to determine score 2. The third task was two-legged sideways jumping across a wooden slat (60 cm × 4 cm × 2 cm) for 15 s as quickly as possible. The number of jumps performed correctly was summed over two trials to determine score 3. The final task involved moving sideways on wooden boards (25 cm × 25 cm × 5.7 cm) as many times as possible in 20 s. One point was awarded for each time the plate was transferred and one more for stepping on it. The number of relocations was counted and summed over two trials to determine score 4. KTK takes into account motor coordination level is gender and age-related. Thus, the four scores acquired in each item test were gender and age-adjusted in according to KTK normative database. Finally, the motor coordination level for each participant was derived from the sum of the four adjusted scores obtained in the tests.

Descriptive statistics were determined for all variables. The Kolmogorov–Smirnov test confirmed acceptable normality of the data distribution. Pearson's correlation coefficients were used to examine the bivariate relationships between levels of motor coordination, BMI and physical activity. Partial correlations were used to analyse the relationship between motor coordination level and BMI, controlling for physical activity levels. Analysis of covariance (ANCOVA) was used to compare the motor coordination levels between normal weight, overweight and obese adolescents, considering the physical activity level as a covariate. A significance level of 5% ($\alpha = 0.05$) was adopted in all statistical tests. Data analysis was executed using Statistical Package for Social Sciences software (SPSS ver. 22.0, IBM, USA).

Results

The total sample (N=39) presented the following values for age, body weight, height, BMI, motor coordination and physical activity levels, respectively: 13.7y (±0.6), 63.2kg (±17.5), 1.61m (±0.8), 24.1kg/m^2 (±5.9), 78.6 (±22.0) and 2.7 (±0.9). Descriptive statistics of group 1 (normal weight), group 2 (overweight) and group 3 (obese) are provided in Table 1.

As shown in Figure 1, motor coordination levels decline as weight status worsens, that is, as higher BMI, the lower motor coordination levels. However, results of ANCOVA test confirmed significant differences in motor coordination levels only between normal weight and obese groups (F=4.123, p=0.025).

Pearson and partial correlations coefficients are displayed in Table 2. Moderate negative correlations were found between BMI and motor coordination levels in the group as a whole, as well as in the normal weight and obese groups. However, when statistically controlled for physical activity levels, significant correlations were only observed in the group as a whole and obese group.

Table 1. Descriptive statistics (mean ± standard deviation) of age, body weight, height, BMI, motor coordination levels (MC) and physical activity levels (PA) of normal weight (group 1), overweight (group 2) and obese (group 3) adolescents.

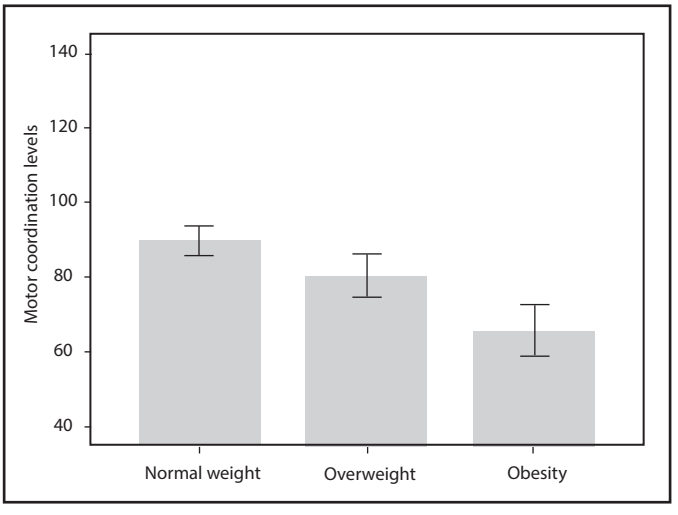
	Group 1 (n=13)	Group 2 (n=13)	Group 3 (n=13)
Age (years)	13.7 (±0.7)	13.6 (±0.6)	13.9 (±0.6)
Body Weight (kg)	45.0 (±8.2)	63.8 (±6.6)	80.8 (±13.1)
Height (m)	1.58 (±0.1)	1.64 (±0.1)	1.62 (±0.1)
BMI (kg/m^2)	18.0 (±1.9)	23.6 (±1.4)	30.8 (±4.1)
MC	89.9 (±13.5)	80.3 (±21.7)	65.6 (±23.5)
PA	2.9 (±0.9)	2.7 (±0.9)	2.5 (±0.8)

Table 2. Pearson and partial correlation coefficients between BMI and motor coordination levels (two-tailed test).

	Bivariate correlations	Partial correlations‡
Total sample	- 0.640**	- 0.622**
Group 1	- 0.569*	- 0.565†
Group 2	- 0.464†	- 0.465†
Group 3	- 0.691**	- 0.643*

‡Controlled for physical activity levels.
*Correlation significant at the 0.05 level.
**Correlation significant at the 0.01 level.
†Correlation non-significant (p>0.05).

Figure 1. Mean and standard error of motor coordination levels across three groups.



Discussion

The main aim of this study was to analyze the influence of physical activity level on associations between motor coordination and BMI in adolescents with different weight status. Our findings suggested motor coordination level and BMI are negatively associated in normal weight and obese adolescents. However, the association between these variables was not significant when controlled for physical activity level in normal weight adolescents. On the other hand, motor coordination level and BMI were significantly negatively correlated in obese adolescents regardless of physical activity level. These results suggest physical activity level can influence the association between motor coordination and BMI in normal weight adolescents. Furthermore, motor coordination level demonstrated a trend to be decline as weight status worsens.

Moderate negative correlations between motor coordination level and BMI were observed in the group as a whole, normal weight and obese adolescents. These findings are in line with previous studies[9-14]. Considering BMI as an indicator of body fat, it seems plausible to expect that individuals with higher BMI, i.e. higher adiposity, have higher difficulty to perform some motor tasks due to increased biomechanical

demands. That is, the higher BMI, higher physical difficulties experienced by individuals, such as increased moments of inertia and mechanical work, especially in weight-bearing tasks.

Nevertheless, our findings showed that motor coordination and BMI were not significantly correlated in overweight adolescents. Few previous studies[7,8] have also not found significant associations between motor coordination level and BMI. These findings can be explained by the fact that individuals with the same weight status, or even with the same BMI, may have considerable differences in body composition. That is, overweight individuals with relatively high levels of lean mass and low levels of body fat may have no increased difficulty to perform motor tasks due their BMI status.

Negative correlations between motor coordination levels and BMI remained weak to moderate when controlled for physical activity level in all groups. However, motor coordination level and BMI were not significantly correlated in normal weight adolescents when controlled for physical activity level. This evidence suggests physical activity level can influence the association between motor coordination and BMI in normal weight adolescents, but not in overweight and obese. These findings are in line with a previous study[22], corroborating the assumption that, in obese adolescents, motor coordination level and BMI are negatively associated regardless of physical activity levels. These results can be explained by negative effect of excess body mass on motor coordination level; it may overlap the possible influence that physical activity level exerts on the association between motor coordination and BMI in overweight and obese adolescents.

In line with previous findings[5,10,17], our results showed motor coordination level tend to decline as weight status worsens. These results add to the body of evidence suggesting obese adolescents tend to have poorer motor coordination level than their normal weight peers. These findings were expected due to increased biomechanical demands in some motor tasks experienced by individuals with higher BMI. However, significant differences in motor coordination level were observed only between normal weight and obese groups. That is, there were no significant differences in motor coordination level when overweight adolescents were compared with normal weight and obese peers. These findings can also be explained by possible differences in body composition, especially with regard to body fat, among participants whose weight status was classified as overweight.

In this study was hypothesized that the physical activity level, as a mediator mechanism, could influence the associations between motor coordination and BMI in adolescents with different weight status. Our findings corroborated only partially this hypothesis, because physical activity level influenced only the associations among normal weight adolescents. Besides the increased negative effect of body fat in overweight and obese, other complementary mechanisms, as perceived motor competence and physical fitness, can have influenced the approached relationship.

Another way to explain our findings concerns the role of physical activity level in this interrelationship. Indeed, it is expected the higher physical activity level among adolescents, higher their opportunities for practice. Considering that opportunities for practice is essential for motor development[27], it is expected that physical activity level is associated with motor coordination. However, the levels of physical activity showed for adolescents may not necessarily to be linked with diversified and increased opportunities for practice. Thus, the influence of physical activity on relationship between motor coordination and BMI can be low or inexistent. In this sense, the role of physical activity as a mediator mechanism, such as proposed in the conceptual framework proposed by Stodden *et al*.[28], may vary in according to opportunities for practice experienced by individuals.

This study had some limitations. First, motor coordination and physical activity were assessed using a test composed by gross motor skills and a self-reported questionnaire, respectively. Thus, the inference of our results is limited to these specific measures in adolescents. Second, both instruments used for assessing physical activity and motor coordination were not adapted to Brazilian population. Also, the small sample size was relatively small. Future investigations using different measurement tools should be conducted in order to corroborate or refuse our results.

Conclusions

Physical activity level influenced the association between motor coordination and BMI in normal weight adolescents, but not in overweight and obese. The increased negative effects of excess body mass, as well as the variability of opportunities for practice according to physical activity level, seem to explain these findings. Also, complementary analyses assessing the potential mediating effects of physical activity on the relationship between motor coordination and BMI should be considered in future studies. As practical application, physical educators and physicians must encourage not only a health weight status, but also the development of motor coordination among adolescents. Moreover, elevated levels of physical activity associated with diversified and increased opportunities for practice should also be promoted by health care professionals, as physical educators and physicians.

Conflict of interest

The authors do not declare a conflict of interest.

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Time limit at peak speed without prior warm-up: Effects on test duration, heart rate and rating of perceived exertion

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Summary

Background: Time limit (t_{lim}) at peak speed (V_{peak}), that is maximal time that an individual can keep running at maximal intensity, is used to prescribe interval durations during interval training. The aim of this study was to compare two protocols (without or with 15 minutes of warm-up) for the t_{lim} determination at 100% of V_{peak} in untrained men.
Material and method: Twelve untrained young men performed three running tests on a treadmill: one maximal incremental test to determine V_{peak} and two rectangular tests, performed in randomized order, without a warm-up (t_{lim0}) or with a 15-minute warm-up duration (t_{lim15}) at 60% of V_{peak} to determine the t_{lim} at 100% of V_{peak}, after the warm-up the tests were performed at the speed of the individual V_{peak} until volitional exhaustion. During the tests, heart rate (HR) and rating of perceived exertion (RPE) were monitored and blood lactate sampling was collected prior to session (LA_{pre}); immediately post-exercise ($LA_{0\text{-}min}$); 3 min ($LA_{3\text{-}min}$), 5 min ($LA_{5\text{-}min}$) and 7 min ($LA_{7\text{-}min}$) post-exercise to determine lactate concentrations. The Shapiro-Wilk test was used and confirmed the normality of the data distribution, with maximal and submaximal values compared using Student´s *t* test for dependent samples.
Results: Test duration at t_{lim0} was significant higher than that at t_{lim15} ($P = 0.02$). Additionally, different t_{lim} protocols influenced HR and RPE submaximal responses and did not modify lactate concentrations or maximal variables (HR_{max} and RPE_{max}).
Conclusions: These findings suggest that the determination of t_{lim} at 100% of V_{peak} without a prior warm-up led to a higher test duration in untrained men.

Key words:
Running. Exercise test. Physical endurance.

Tiempo límite en la velocidad máxima sin calentamiento previo: efectos sobre la duración de la prueba, frecuencia cardíaca y grado de esfuerzo percibido

Resumen

Objetivos: Tiempo límite (t_{lim}) en la velocidad máxima (V_{pico}), que es el tiempo máximo que un individuo puede permanecer corriendo en la intensidade máxima, se utiliza para prescribir la duración de los intervalos durante el entrenamiento interválico. El objetivo de este estudio fue comparar dos protocolos (sin o con 15 minutos de calentamiento) para la determinación de t_{lim} al 100% de la V_{pico} en hombres no entrenados.
Material y método: Doce jóvenes no entrenados realizaron tres pruebas de carrera en la cinta rodante: una prueba incremental máxima para determinar V_{pico} y dos pruebas rectangulares, realizadas en orden aleatorio, sin calentamiento (t_{lim0}) o con una duración de calentamiento de 15 minutos (t_{lim15}) al 60% de la V_{pico} para determinar el t_{lim} al 100% de la V_{pico}; después del calentamiento las pruebas fueron realizaradas en la velocidad de la V_{pico} individual hasta el agotamiento voluntario. Durante las pruebas, la frecuencia cardíaca (FC) y el grado de esfuerzo percibido (RPE) fueron monitorizadas y se tomaron muestras de sangre antes de la sesión (LA_{pre}); inmediatamente después del ejercicio ($LA_{0\text{-}min}$); 3 min ($LA_{3\text{-}min}$), 5 min ($LA_{5\text{-}min}$) y 7 min ($L_{A7\text{-}min}$) después del ejercicio para determinar las concentraciones de lactato. Se utilizó la prueba de Shapiro Wilk y se confirmó la normalidad de la distribuición de los datos, con los valores máximos y submáximos comparados utilizando la prueba t de Student para muestras dependientes.
Resultados: La duración de la prueba en el t_{lim0} fue significativamente mayor que aquella en el t_{lim15} ($P = 0.02$). Además, los diferentes protocolos de t_{lim} influenciaron las respuestas submáximas de FC y RPE y no modificaron las concentraciones de lactato o las variables máximas (FC_{max} y RPE_{max}).
Conclusiones: Estos resultados sugieren que la determinación del t_{lim} en la 100% de la V_{pico} sin calentamiento prévio lleva a una mayor duración de la prueba em hombres no entrenados.

Palabras clave:
Carrera. Prueba de ejercicio. Resistencia física.

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Introduction

Endurance racing has been gaining popularity recently; thus, the training prescriptions linked to running performance improvements have received great attention[1,2]. Such prescriptions should be planned for each individual according to the physiological (*e.g.*, heart rate [HR]), psychological (*e.g.*, rating of perceived exertion [RPE]), and performance variables (peak speed [V_{peak}], time limit [t_{lim}]) that control and monitor effort intensity[3].

The t_{lim} is the maximal time that an individual can maintain a given exercise intensity[4], such as V_{peak} occurrence velocity. The original protocol for the t_{lim} determination included a prior 15-minute warm-up at an intensity equivalent to 60% of the reference velocity (*e.g.*, V_{peak} or velocity associated with the occurrence of maximal oxygen uptake [vVO_{2max}]); after the warm-up, without interval, the velocity is automatically increased to 100% intensity, at which the individual should remain as long as possible until volitional exhaustion[4]. However, warm-up duration (5, 10 or 15 minutes) modified the test duration (t_{lim})[5].

Studies demonstrated that various warm-up types, such as stretching (static and dynamic)[6], whole-body vibration[7], and the traditional warm-up consisting of low-intensity cycling[8], could positively or negatively influence aerobic performance. For instance, Tomaras & Macintosh[8] investigated a sample of highly trained male track cyclists and compared the traditional warm-up (WU) for a 200-m sprint in a track cycling competition with an experimental WU that was designed to be shorter and less intense and examined the fatigue and cycling performance after traditional and experimental WU. Results from this study showed that peak active twitch torque was lower after the traditional than experimental WU when expressed as percentage of pre-warm-up amplitude, and Wingate test performance was better after experimental WU than traditional WU; indeed, the traditional track cyclist's WU results in significant fatigue, which corresponds with impaired peak power output, and shorter and lower intensity WU permits a better performance.

However, a recent study showed that warm-up duration (5, 10 or 15 minutes) modified the test duration (t_{lim}) of untrained men in which the warm-up comprising 15 minutes led the participants to exercise for a shorter time compared to other t_{lim} protocols[5]. Since t_{lim} is a variable that is used to determine the optimal stimulus durations in interval training sessions[9-11], this longer or short duration altered by warm-up will directly impact this prescription.

Nevertheless, to the best of our knowledge, there is still a lack of studies that analyzed the best duration of the warm-up[5] and knowing the importance of warm-ups prior to exercise and that the duration modifies the t_{lim}[5], the aim of this study was to compare two protocols (without and with a 15-minute warm-up) for the t_{lim} determination at 100% of V_{peak} in untrained men. Our hypothesis is that the t_{lim} determined without a warm-up will differ from that of the t_{lim} performed with a 15-minute warm-up.

Material and method

Twelve untrained young men, not included in systematic running training programs, with training volume less than 20 km per week, volunteered to participate in this study. The 5-km running times reported by participants were between 25 and 35 minutes, with a pace between 8.6 and 12 km•h^{-1} (≅ 36.1 and 50.4 % of the world record). The main characteristics of the participants were: age 21.4 ± 2.3 years, height 1.8 ± 0.1 m, body mass 76.7 ± 10.9 kg, body mass index (BMI) 24.2 ± 2.8 kg•m^{-2} and body fat 15.3 ± 4.2%. Prior to testing, written informed consent was obtained from all participants. The experimental protocol was approved by the local Human Research Ethics Comittee (#1.262.502/2015) and appropriate standards for human experimentation have been followed.

Experimental overview

Participants performed three tests on a motorized treadmill (Super ATL Inbrasport, Porto Alegre, Brazil), with the gradient set at 1%. In the first visit the evaluation of the anthropometric measurements was performed, and the participants were submitted to a maximal incremental test to determine V_{peak}. After, in a randomized order, two rectangular tests with warm-up durations of 15 minutes and without warm-up were performed to determine the t_{lim} at 100% of V_{peak}. The tests were performed over 2 weeks, with each test separated from the other by 48 hours. For all tests, participants were instructed to stay well-rested, well-nourished, and well-hydrated, wearing lightweight comfortable clothing. Participants were also instructed to avoid eating for 2 hours before the maximal exercise test, to abstain from caffeine and alcohol and to refrain from strenuous exercise for 48 hours before testing. Tests were conducted at the same time of the day, under normal laboratory conditions (temperature 20-22 ºC, relative humidity 50-60%).

Incremental exercise test to determine V_{peak}

After a warm-up, comprised walking at 6 km·h^{-1} for three minutes, the continuous protocol started with a speed of 8 km·h^{-1} and increased by 1 km·h^{-1} between each successive 3-minute stage until participants reached volitional exhaustion[12]. The V_{peak} of the incremental test was calculated as the speed of the last complete stage added to the completed fraction of the incomplete stage[13], calculated according to the equation:

$$V_{peak} = V_{complete} + (t/T \times \text{speed increment})$$

where $V_{complete}$ is the running speed of the last complete stage, t the time in seconds sustained during the incomplete stage, and T the time in seconds required to complete a stage (*i.e.,* 180 seconds), and speed incremental is the speed load increment. The maximal effort was deemed to be achieved if the incremental test met two of the following criteria: 1) $LA_{peak} \geq 8$ mmol•L^{-1} [14] 2) $HR_{max} \geq 100\%$ of endurance-trained age-predicted HR_{max} using the age-based (207 - 0.7 × age) equation[15] and 3) $RPE_{max} \geq 19$ in the 6-20 Borg Scale[16].

Rectangular tests to determine the t_{lim} at V_{peak}

The two rectangular tests differed only by presence or absence of the warm-up of 15 minutes. After the warm-up at 60% of V_{peak}, the treadmill speed was quickly increased (in approximately 6 seconds) to the individual at 100% of V_{peak}[4]. Participants were also encouraged to invest maximal effort and the time of permanency in this intensity was considered the t_{lim} at 100% of V_{peak}.

Psychophysiological and physiological variables

Before testing participants were familiarized with the 6–20 Borg scale[16], which was used to determine the rating of perceived exertion (RPE) during the last 15 seconds the stages of V_{peak} and every minute in t_{lim}. The highest RPE value was adopted as the maximal RPE (RPE_{max}). Heart rate (HR) was monitored throughout the tests (Polar RS800sd, Kempele, Finland) and in the last 10 seconds of each stage da V_{peak} and every minute in t_{lim} HR was registered; the maximal heart rate (HR_{max}) was defined as the highest HR value observed during the tests[15]. Earlobe capillary blood samples (25 µL) were collected in a capillary tube to determine the lactate concentrations. These samples were collected before (LA_{pre}) all exercise tests, after the incremental test at the third ($LA_{3\text{-}min}$) and fifth ($LA_{5\text{-}min}$) minutes, and at the end ($LA_{0\text{-}min}$), at the $LA_{3\text{-}min}$, $LA_{5\text{-}min}$ and seventh ($LA_{7\text{-}min}$) minutes after the rectangular tests. For the LA_{pre}, the participants remained at rest for 15 minutes in a comfortable chair prior to the sampling procedure. For the $LA_{0\text{-}min}$ blood sampled collection the participants remained standing upright on the treadmill, and for the $LA_{3\text{-}min}$, $LA_{5\text{-}min}$, $LA_{7\text{-}min}$ samples the participants remained sitting in a comfortable chair. Peak blood lactate concentration (LA_{peak}) was defined for each participant as the highest post-exercise blood lactate concentration value. The samples were subsequently determined by electroenzymatic methods using the YSI 2300 STAT (Ohio, USA) automated analyzer (accuracy ± 2%).

Statistical analysis

Data are presented as mean ± SD and were analyzed using the Statistical Package for the Social Sciences software v. 20.0 (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used and confirmed the normality of the data distribution. Maximal and submaximal values were compared using Student´s *t* test for dependent samples. Statistical significance was set at $P < 0.05$.

Results

The variables obtained during the exhaustion incremental test to determine the V_{peak} were: V_{peak} = 12.7 ± 1.2 km•h^{-1}, test duration = 17.1 ± 3.8 min, HR_{max} = 187 ± 8.7 bpm, RPE_{max} = 19.8 ± 0.5 and LA_{peak} = 8.6 ± 3.2 mmol•L^{-1}.

Table 1 compares t_{lim} test duration, maximal variables (HR_{max}, RPE_{max}, and LA_{peak}) and post-test lactate concentrations obtained during the two tests. Test duration at t_{lim0} was significantly higher than that at t_{lim15} ($P = 0.02$). However, no significant difference was seen in the other variables.

Comparisons between HR and RPE values obtained during the two tests for t_{lim} determination are shown in Table 2. Only the minutes in which the participants remained throughout the two tests were analyzed. Significant differences were noted in the HR and RPE values until the fifth minute ($P \leq 0.01$), in the RPE value at the sixth minute ($P = 0.04$), and in HR value at seventh minute ($P = 0.02$).

Table 1. Comparison between the variables: test duration (min), HR_{max} (bpm), RPE_{max} (6-20, AU) and blood lactate concentrations (mmol•L^{-1}) obtained during the t_{lim0} and t_{lim15} (N = 12).

Variables	t_{lim0}	t_{lim15}	*P*
Test duration (min)	9.4 ± 2.2	6.0 ± 2.0*	0.02
HR_{max} (bpm)	184 ± 11.0	184 ± 10.9	0.80
RPE_{max} (6-20, AU)	19.9 ± 0.3	19.9 ± 0.3	1.00
LA_{pre} (mmol•L^{-1})	1.1 ± 0.3	1.0 ± 0.2	0.30
$LA_{0\text{-}min}$ (mmol•L^{-1})	8.5 ± 2.0	7.1 ± 2.4	0.07
$LA_{3\text{-}min}$ (mmol•L^{-1})	8.6 ± 2.7	8.2 ± 3.1	1.00
$LA_{5\text{-}min}$ (mmol•L^{-1})	8.4 ± 2.3	7.7 ± 3.3	0.11
$LA_{7\text{-}min}$ (mmol•L^{-1})	8.1 ± 2.3	7.5 ± 3.3	0.42
LA_{peak} (mmol•L^{-1})	9.5 ± 2.6	8.4 ± 3.3	0.13

Note: AU: arbitrary units; bpm: beat per minute; HR_{max}: maximal heart rate; LA_{pre}: blood lactate concentration at the before of the test; $LA_{0\text{-}min}$: blood lactate concentration at the end of the test; $LA_{3\text{-}min}$: blood lactate concentration at the third minute after the test; $LA_{5\text{-}min}$: blood lactate concentration at the fifth minute after the test; $LA_{7\text{-}min}$: blood lactate concentration at the seventh minute after the test; LA_{peak}: peak blood lactate concentration; RPE_{max}: maximal rating of perceived exertion.
*$P < 0.05$ compared with t_{lim0}.

Table 2. Comparison between the HR (bpm) and RPE (6-20, AU) submaximal values (min) at each minute obtained during the t_{lim0} and t_{lim15}.

Time	HR (bpm)			RPE (AU)		
	t_{lim0}	t_{lim15}	*P*	t_{lim0}	t_{lim15}	*P*
1 min (n=12)	143±12.4	167±10.9*	< 0.01	8.0±2.4	13.8±2.6*	< 0.01
2 min (n=12)	159±11.6	175±10.3*	< 0.01	10.0±2.9	15.5±2.4*	< 0.01
3 min (n=11)	165±10.9	180±9.2*	< 0.01	13.0±3.3	16.9±2.1*	< 0.01
4 min (n=10)	170±10.8	183±9.2*	< 0.01	14.5±3.1	17.9±1.8*	< 0.01
5 min (n=9)	172±10.7	183±8.5*	0.01	16.0±2.7	18.6±1.7*	0.01
6 min (n=6)	174±10.3	184±7.9	0.07	17.0±2.8	18.8±1.2*	0.04
7 min (n=4)	177±9.8	185±10.5*	0.02	19.0±2.3	19.8±0.5	0.06
8 min (n=3)	179±10.5	190±2.0	0.07	19.5±2.2	20.0±0.0	0.42

Note: AU. arbitrary units; HR. heart rate; RPE. rating of perceived exertion.
*$P < 0.05$ compared with t_{lim0}.

Discussion

This study aimed to compare the two protocols (without and with a 15-minute warm-up) in the t_{lim} determination at 100% of V_{peak} in untrained men. The main finding of the present study was that the different protocols for the t_{lim} determination had different test durations;

in particular, the absence of the 15-minute warm-up period led participants to run for a longer duration than the heating test, confirming our hypothesis. Furthermore, the t_{lim} protocol influenced the HR and RPE during the test responses but did not modify lactate concentrations or the maximal variables (HR_{max} and RPE_{max}).

Previous investigations determined t_{lim} using a standard protocol with a 15-minute warm-up duration at 60% of maximal aerobic speed (MAS), vVO_{2max}, or V_{peak}[4,5,17]. Other studies used different warm-up durations (t_{lim10} and t_{lim5})[5,18,19], but none omitted the warm-up (t_{lim0}). This is the first study to investigate performance in a protocol for determining t_{lim} without a previous warm-up and compared it with the standard protocol (t_{lim15})[4]. Our results demonstrated that the runners participated for a longer duration in the protocol without a warm-up than in the protocol with a warm-up. This result was similar to those of Da Cruz *et al.*[5] and Bertuzzi *et al.*[18], who used shorter warm-up protocols (*i.e.*, t_{lim10} and t_{lim5}) when testing untrained young men and recreational long-distance runners, respectively. When investigating the influence of different warm-up durations on determining t_{lim} (*i.e.*, t_{lim15}, t_{lim10}, t_{lim5}), Da Cruz *et al.*[5] reported a longer participation time in the protocol with a shorter warm-up duration for t_{lim} determination. Similarly, Bertuzzi *et al.*[18] observed that the participants remained in the protocol with a 5-minute warm-up longer than they did in the protocol with a 10-minute warm-up. Thus, a longer warm-up time for the t_{lim} determination showed a negative effect on test duration and may be a tiring factor prior to exercise. The longer warm-up duration seems to cause greater physiological wear in the participants at the beginning of the test as demonstrated by the higher values of HR and RPE in the t_{lim15} protocol than in the t_{lim0} protocol observed in the present study.

In addition to warm-up duration, t_{lim} seems to be influenced by participant fitness level since there was an inverse correlation between MAS and t_{lim}[4,20,21]. Renoux *et al.*[20] reported a mean t_{lim15} value of 4.5 ± 1.3 minutes in trained runners, similar to that observed by Billat *et al.*[4] (*i.e.*, 5.01 ± 0.9 minutes) in a study of trained runners that showed a shorter t_{lim} duration than the results of our study for the t_{lim15} protocol (*i.e.*, 6.0 ± 2.0 minutes) as well as the study of Da Cruz *et al.*[5] (*i.e.*, 5.9 ± 1.7 minutes) that evaluated untrained young males. These results show that it is possible to observe a difference in t_{lim} duration despite use of the same protocol (t_{lim15}) due to differences in participant fitness levels.

Since t_{lim} is a variable that is used to determine the optimal stimulus durations in interval training sessions[9-11], this longer duration found by a lack of a warm-up will directly impact this prescription. Previous studies using t_{lim} to prescribe interval training showed that if these sessions do not have the ideal duration, runners may not complete the training and/or show no improvement because of a low stimulus intensity[10,11,22]. Billat *et al.*[10] tested the training effect in that the stimuli had a duration of 50% of t_{lim} in vVO_{2max} in the interval training sessions, and no differences were found in the aerobic variables associated with performance after 4 weeks of training. Similarly, some authors[11,22] tested different combinations of vVO_{2max} and its respective t_{lim} for individualized training with series of 60 and 75%; 60 and 70% of t_{lim} in vVO_{2max}, respectively. As a result, performance improvements were observed only for the groups that trained with the series duration at 60% of t_{lim} in vVO_{2max}. The results of these studies suggest that small changes in t_{lim} duration can have a great impact on the training prescription. Thus, the correct choice of the protocol for determining the t_{lim} is important because the warm-up time (its lack or presence) will directly affect the t_{lim} duration and, therefore, the training prescription.

Regarding HR, RPE, and lactate concentration responses during the test, the protocols with different warm-up durations (*i.e.*, t_{lim0} and t_{lim15}) were not expected to affect the maximal variables (HR_{max}, RPE_{max}, and LA_{peak}). However, when the during the test HR and RPE responses were analyzed during the different warm-up times, we obtained smaller values in the t_{lim0} protocol compared to the t_{lim15} protocol. A similar result was found by Da Cruz *et al.*[5], who observed higher values for these variables in the protocol with a 15-minute warm-up compared to protocols with 5- and 10-minute warm-ups. This change can be explained by the increase in cardiovascular activity after exercises with durations > 10 minutes caused by changes in thermoregulatory mechanisms, energy substrates, and increased blood flow[23,24], which also affected the participants final performances.

Despite the important findings of our study, one limitation was that the determination of the V_{peak} (and warm-up based on V_{peak}) could led to different individual intensities relative to the velocity of anaerobic threshold (vAT). Thus, despite of V_{peak} and vAT are correlated with endurance running performance[12,25] no previous study examined the relationship between V_{peak} and vAT. Future studies should investigate the relationship between V_{peak} and vAT and to better understand how differences in relative intensities of vAT could affect the time limit performance.

Conclusion

Therefore, we conclude that the lack of a 15-minute warm-up, based on the protocol proposed by Billat *et al.*[4], for determining t_{lim} leads to a longer test duration at 100% of V_{peak} and modifies the responses during the test variables (HR, RPE) in untrained men. This result may impact or interfere with the use of t_{lim} for interval training prescriptions. Hence, we suggest that further studies should be performed in training protocols with different warm-up durations to evaluate the impact of the use of time limits.

Conflict of interest

The authors do not declare a conflict of interest.

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Efectos agudos del ejercicio resistido y concurrente en el perfil lipídico de mujeres postmenopáusicas

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Resumen

El estado postmenopáusico se caracteriza por el aumento sistemático de los factores de riesgo cardiovascular, incluyendo las alteraciones negativas en metabolismo de lípidos. El ejercicio físico ha demostrado efectos benéficos en la regulación de marcadores lipémicos en diferentes poblaciones, sin embargo, en mujeres postmenopáusicas no están bien dilucidados sus efectos. El objetivo del estudio fue determinar el efecto que tiene sobre el perfil lipídico de mujeres postmenopáusicas la realización de una sesión de ejercicios resistidos (ER) o de ejercicios concurrentes (EC), comparados con un grupo control (GC). La metodología del estudio consto de una división aleatoria en tres grupos de 32 mujeres posmenopáusicas voluntarias, un grupo realizó una sesión de ER (n=11), otro grupo una sesión de EC (n=11) y un grupo control realizó ejercicios de flexibilidad (n=10). Inicialmente fue evaluado el perfil lipídico basal, la composición corporal, el *fitness* muscular y se calculó la tasa metabólica basal (TMB). Fue evaluado el perfil lipídico antes, inmediatamente después y 12 horas después de la sesión de ejercicio especifica. Como resultados se encontró que entre los tres grupos, no existieron diferencias significativas en las concentraciones plasmáticas de colesterol total, triglicéridos y LDL en ninguno de los momentos de evaluación (p>0.05). El grupo EC disminuyó las concentraciones de VLDL 12 horas después de la sesión de ejercicios, en comparación al grupo ER y GC (p<0.05); y aumentó significativamente las concentraciones de HDL con relación al grupo ER (p<0.05). De este estudio se puede concluir que en las mujeres postmenopáusicas con sobrepeso participantes, el EC puede tener efectos agudos más favorables en el metabolismo de lípidos que el ER, prolongando su efecto hasta 12 horas después de realizarse.

Palabras clave:
Postmenopausia. Ejercicio físico. Entrenamiento de resistencia. Fuerza muscular (MeSH).

Acute effects of resistance and concurrent exercise on the lipid profile of postmenopausal women

Summary

The postmenopausal condition is characterized by a systematic increase in cardiovascular risk factors, including negative alterations in lipid metabolism. Physical exercise has shown beneficial effects in the regulation of lipemic markers in different populations; however, its effects are not well understood in postmenopausal women. The aim of the study was to determine the effects of resisted exercises (RE), concurrent exercises (CE), compared with a control group (CG) on lipid profile in postmenopausal women. Thirty-two voluntary postmenopausal women were randomly assigned into three groups; one group performed a RE session (n = 11), other group a CE session (n = 11) and control group performed flexibility exercises (n = 10). The basal lipid profile, body composition, muscular fitness were evaluated and the basal metabolic rate (BMR) was calculated before the study. The lipid profile was evaluated before, immediately after and 12 hours after the specific exercise session. The results showed that there was no a statistical significant difference among all groups in plasma concentration of total cholesterol, triglycerides and LDL, in any of the evaluation moments (p> 0.05). After 12 hours of exercise session, the CE group decreased more VLDL concentrations than the RE group and control group (p <0.05). The CE group increased significantly HDL concentrations in relation to the ER group (p <0.05). Therefore, it can be concluded that CE had more favorable acute effects on lipid metabolism than ER, prolonging its effect up to 12 hours after being performed in overweight postmenopausal women.

Key words:
Postmenopause. Exercise. Resistance training. Muscle strength (MeSH).

Nota: Para la realización de este estudio bibliográfico se contó con apoyo económico de la Universidad Metropolitana de Barranquilla.

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Introducción

Las altas concentraciones de lípidos representan un factor de riesgo transcendental para el desarrollo de las enfermedades cardiovasculares (ECV), ya que comúnmente preceden a la disfunción endotelial vascular, protagonizando la formación de la placa aterosclerótica y la respuesta inflamatoria subsiguiente[1]. Estos fenómenos se asocian con el aumento en la secreción de citocinas precursoras de inflamación, de la expresión de moléculas de adhesión (ICAM, VCAM-1), del fibrinógeno y de la actividad de sustancias promotoras de la oxidación[2].

El ejercicio físico ha demostrado efectos benéficos en la regulación de marcadores lipémicos en diferentes poblaciones, asociando al total de energía gastada durante el ejercicio como el principal determinante de los fenómenos metabólicos subsecuentes[3,4]. La realización de una sesión de ejercicio aeróbico puede disminuir las concentraciones plasmáticas de lípidos que se asocian a la patogénesis ateroesclerótica, como las lipoproteínas de baja (LDL) y muy baja densidad (VLDL)[5], así como también puede aumentar la actividad de la lipoproteína de alta densidad (HDL) quien juega un papel trascendental en la regulación sistémica del exceso de colesterol[6]. Estudios más recientes, han evidenciado cambios favorables en el perfil lipídico después de una sola sesión de ejercicio aeróbico[7,8].

Por otro lado, los ejercicios para el fortalecimiento muscular con resistencias externas o ejercicios resistidos (ER), se asocian principalmente con respuestas en el sentido funcional de la fuerza y resistencia anaeróbica[9]. Los ER son catalogados como una medida para la prevención de enfermedades crónicas y eventos agudos catastróficos, como infartos o isquemias cerebrovascular[10]. El rol preventivo del ER tendría su razón de ser debido a su repercusión sobre la asimilación de lípidos y sobre la regulación de los marcadores pro y anti-inflamatorios en el organismo, durante y principalmente, después de la ejecución del ejercicio[11,12]. Pocos estudios han evaluado como una sesión de ER modifica los marcadores lipídicos en el torrente sanguíneo.

La combinación de ER y ejercicios aeróbicos, actualmente conocido como ejercicios concurrentes (EC), ha demostrado tener efectos beneficios sobre el estado de salud y condición física general si es ejecutado de manera regular[13]. No obstante, se ha observado beneficios, así como también mejoras en el perfil lipídico y en la aptitud física general en poblaciones vulnerables, como en personas con obesidad y mujeres postmenopáusicas[14].

Después de la menopausia, el riesgo de desarrollar ECV en mujeres aumenta[4], este aumento de la vulnerabilidad está relacionado con la disminución de los niveles del estrógeno, hormona que parece ejercer un papel protector contra el padecimiento de ECV en las mujeres, promocionando un perfil lipídico anti-aterogénico, perfil inmunológico anti-inflamatorio y por acción directa sobre las paredes de los vasos sanguíneos, evitando así la disfunción del endotelio vascular[15]. Las alteraciones fisiológicas, metabólicas y morfológicas asociadas se caracterizan por disminución en el nivel de actividad física, el aumento de índice de masa corporal (IMC), disminución en la masa muscular (sarcopenia), disminución en el metabolismo basal, el aumento en las concentraciones de triglicéridos (TG) y LDL[12]. La adopción del ejercicio físico en el estilo de vida de esta población, puede inducir a la incidir positivamente en varios de los factores de riesgo cardiovascular, como reducir la masa grasa corporal y regular algunos de los marcadores lipémicos de forma aguda[6].

El propósito de este estudio fue determinar el efecto agudo que tiene sobre el perfil lipídico de mujeres postmenopáusicas la realización de una sesión de ER y una sesión de EC, comparados con un grupo control.

Material y método

La presente investigación corresponde a un estudio cuasi-experimental con aleatorización y ciego simple, de exposición-respuesta, basado en los cambios agudos que proporcionan en dos grupos experimentales, dos modalidades de ejercicio físico en marcadores bioquímicos sanguíneos específicos, comparados con un grupo control.

Sujetos

La muestra consistió en un total de 32 mujeres posmenopáusicas voluntarias, trabajadoras de la Fundación Hospital Universitario Metropolitano en la ciudad de Barranquilla, con un promedio de edad de 54,66 ± 4,04 años, reclutadas a través de la oficina de bienestar laboral. Los criterios de inclusión fueron mujeres post menopaúsicas sin medicación hormonal sustitutiva. Fueron excluidas aquellas que participaran en algún tipo de entrenamiento resistido durante 6 meses antes del estudio y las que tenían un historial médico con enfermedades endocrinas graves, metabólicas y/o neuromusculares, determinados en la valoración realizada por un médico con especialidad en medicina interna. Antes de la participación, cada uno de los sujetos objeto de estudio fueron informados cuidadosamente del diseño del estudio, especialmente los posibles riesgos y molestias relacionadas con los procedimientos, posteriormente dieron su consentimiento informado por escrito.

Consideraciones éticas

El presente estudio se realizó de acuerdo a los estándares éticos en ciencias del ejercicio[16], de la Asociación Médica Mundial y la Declaración de Helsinki. El protocolo fue aprobado por el comité de ética e investigación Institucional de la Universidad Metropolitana de Barranquilla, Colombia.

Diseño experimental

La totalidad de sujetos objeto de estudio (n=32) fueron divididos aleatoriamente en 3 grupos, dos experimentales que llevan a cabo una sesión de ejercicios resistidos (ER, n=11) y una sesión de ejercicios concurrentes (EC, n=11), respectivamente; y un grupo control sin ejercicios con gasto energético de consideración (GC, n=10).

Previo a la realización del protocolo experimental, las mujeres fueron citadas para una evaluación inicial de las variables músculo esqueléticas (fuerza dinámica máxima y capacidad funcional de miembros inferiores), la composición corporal (% de grasa y masa magra), valoración antropométrica (talla, peso y perímetro abdominal), tasa metabólica basal y monitorización del comportamiento nutricional de acuerdo a los protocolos que se describen a continuación:

Fuerza dinámica máxima

Con el fin de determinar la fuerza dinámica máxima de los diferentes segmentos corporales de las mujeres, fueron empleados pruebas de una repetición máxima (1RM) para los grupos musculares que realizan los ejercicios resistidos en que se basan los grupos experimentales. La carga máxima de cada sujeto fue determinada con no más de 5 intentos con una recuperación de 4 minutos entre los intentos.

Evaluación de la capacidad funcional de miembros inferiores

El test de sentarse y levantarse en 30 segundos (30 *second sit-to-stand test*) mide la capacidad funcional de los miembros inferiores. La prueba se realizó de la siguiente manera: la posición inicial fue sentado en el centro de una silla (altura 43 cm), con la espalda recta y los pies en una superficie plana colocados sobre el ancho de los hombros, los brazos cruzados a la altura del pecho, con un ángulo de aproximadamente 90° de flexión de cadera y rodilla. A una señal verbal, los participantes se levantaron a bipedestación y luego volvieron a la posición inicial sentados. Se alentó a las participantes que completaran tantas repeticiones como sea posible dentro de un período de 30 segundos.

Evaluación antropométrica, composición corporal y tasa metabólica basal

Se realizó la valoración antropométrica de las mujeres, determinando la talla, peso, y perímetro abdominal utilizando una balanza digital, estadiómetro y cinta métrica marca SECA, de acuerdo a las indicaciones descritas en la resolución 2465 del Ministerio de Salud de Colombia[17], a partir de los datos obtenidos se calculó el IMC. Utilizando el impedanciómetro bioeléctrico marca Tanita (TBF-300WA Wrestling Body Composition Analyzer) fue determinada la composición corporal, calculando el porcentaje de grasa corporal y de masa magra. La Tasa Metabólica Basal (TMB) fue calculada con la fórmula de Harris-Benedict, modificada con el factor de actividad física (+ 20%): TMB = [655,0955 + (9,5634 x peso en kg) + (1,8449 x altura en cm) - (4,6756 x edad en años)].

Monitorización y direccionamiento del comportamiento nutricional

El día de la valoración inicial se proporcionó un documento impreso en el cual los sujetos objeto de estudio, previa explicación detallada de la nutricionista, registraron su comportamiento alimentario 3 días previos a la realización del protocolo experimental. Esto con el fin de contrarrestar resultados en el perfil lipídico inverosímiles, derivados del consumo de alimentos cargados excesivamente de grasa, con esto, se intentó reducir las alteraciones en los resultados obtenidos, subsecuentes a comportamientos nutricionales atípicos.

El día del protocolo experimental, fue controlada la ingesta de alimentos estandarizando el consumo calórico previo a la realización de ejercicios a un 60% de la TMB con factor de actividad física para cada caso. La estrategia incluyo un desayuno (cereales y frutas), una merienda (cereales) y un almuerzo (carne de pollo, papas y verduras). Toda la ingesta fue preparada, proporcionada y controlada por un nutricionista. Este procedimiento tuvo como objetivo, garantizar que al momento de ejecutar la sesión de ejercicios, las concentraciones de lípidos estuvieran influenciados por conductas nutricionales similares y en cantidades específicas para cada caso individual. La última ingesta de alimentos para cada caso, fue programada con al menos 3 horas previas a la realización de ejercicios, alentando a los participantes a mantenerse hidratados solo con agua.

Perfil lipídico basal

Este procedimiento se realizó a todos los sujetos en un día previo a la realización de ejercicios, en condición de ayuno de al menos 12 horas, las mujeres miembros de los grupos asistieron en las horas de la mañana a las instalaciones del laboratorio clínico de la Fundación Hospital Universitario Metropolitano donde se le realizó la extracción de 5 ml de sangre para la determinación del perfil lipídico basal, que incluye el análisis de las concentraciones séricas de Colesterol Total (CT), HDL, LDL, VLDL y TG.

Protocolo experimental

En un periodo máximo de semana después de la evaluación del *fitness* muscular, un nuevo encuentro fue programado con los sujetos objeto de estudio, a las 5:00 pm, en las instalaciones del gimnasio del Servicio de Fisioterapia de la Fundación Hospital Universitario Metropolitano. A la llegada de las sujetos, inicialmente el nutricionista autorizó la sesión de ejercicios a las mujeres sin comportamientos nutricionales atípicos que pudiesen interferir en los resultados y que siguieron correctamente los procedimientos alimentarios, basados en la revisión del documento de monitorización nutricional.

Muestras de sangre fueron extraídas a las mujeres por una bacterióloga experta, para la evaluación del perfil lipídico antes, inmediatamente terminada la sesión de ejercicios y 12 horas después, en la mañana del siguiente día (en condición de ayuno). Las muestras sanguíneas fueron entregadas en el laboratorio para su análisis inmediatamente después de ser extraídas. Las sesiones de ejercicios por cada grupo experimental y el grupo control se describen a continuación:

Protocolo de ejercicios

Los sujetos del grupo de ER realizaron un calentamiento de 10 min, que consistía en una caminata (5 min) y movilización articular general (5 min), luego ejecutaron un total de 8 ejercicios resistidos (1. *Leg Press*; 2. Extensión de rodilla en maquina; 3. Flexión de rodilla en maquina; 4. Flexión de codo con mancuernas; 5. Extensión de codo con mancuernas; 6. Aducción de hombros con mancuernas desde abducción en decúbito supino; 7. Serrucho unilateral; y 8. Abdominales con peso libre), cada uno a 3 series y cada serie a 15 repeticiones, con una intensidad del 75% de 1RM, la duración total aproximada de dicha sesión fue de 40 minutos.

El grupo de EC realizaron inicialmente un calentamiento de 10 min, que consistía en una caminata (5 min) y movilización articular general (5 min), seguidamente realizaron los mismos ejercicios que el grupo de ER, solo que cada ejercicio se realizaba por solo una serie a 15 repeticiones, al 75% de 1RM. Posteriormente realizaban 20 minutos de pedaleo continuo en cicloergómetro a una intensidad entre el 70 y 80% de la frecuencia cardiaca máxima, la duración total aproximada de esta sesión de ejercicios fue de 40 minutos.

Por indicación implícita del comité científico y de ética de la Universidad Metropolitana de Barranquilla, los sujetos que componen el grupo control (GC) no podían quedar sin alguna intervención que favoreciera, desde cualquier punto de vista, la salud física de los sujetos. Por ello, se decidió que los miembros de este grupo realizaran una serie de ejercicios de estiramientos pasivos que ha demostrado no tener implicaciones metabólicas en el metabolismo de lípidos[18]. La sesión de consistió en un calentamiento de 10 minutos (5 minutos de caminata libre y 5 minutos de movilización de articulaciones) y 30 minutos de estiramientos dirigidos. La duración promedio de esta sesión fue de 40 minutos.

Finalizado cada una de las sesiones de ejercicios, los sujetos fueron instruidos a consumir solo agua sin ningún componente calórico, hasta la mañana del día siguiente, cuando en condición de ayuno se extrajo la muestra de sangre correspondiente a 12 horas post la sesión de ejercicio.

Análisis estadístico

Se realizó un análisis estadístico descriptivo y comparativo con medidas de medias con respectivas desviaciones estándar. El test de normalidad utilizado fue el de Shapiro-Wilk y el Levene para la homogeneidad. Posteriormente, fue empleado el Test de Análisis de Varianza (ANOVA) *two-way,* intra-grupos y entre grupos. Cuando fue pertinente, fue considera como prueba post hoc el test de Bonferroni. El nivel de significancia fue de $p < 0.05$, considerándolo en todos los análisis.

Resultados

Los resultados de la valoración inicial de las mujeres, mostro que la asignación al azar no produjo diferencia significativa entre ninguno de los grupos y para ninguna de las variables de rendimiento antes de ejecutar el protocolo experimental (Tabla 1). El IMC en la totalidad de las mujeres estuvo en un rango entre 25,02 y 37,58, siendo entre 25 y 30 en 23 mujeres, mayor de 30 en 8 mujeres consideradas con obesidad tipo I y solo una mujer tuvo un IMC por encima de 35, siendo considerada con obesidad tipo II, la distribución de las mujeres con obesidad fue equitativa en los tres grupos. El valor de circunferencia abdominal estuvo en un rango entre 84 a 110 cm, estando todas las mujeres con obesidad abdominal acorde con los criterios establecidos por la resolución 2465 de 2016[17]. Los valores promedio de todas las variables analizadas en la valoración inicial de las mujeres para la población total y para cada uno de los grupos experimentales y control se describen en la Tabla 1.

La comparación estadística de los valores promedio entre los grupos experimentales, de las variables del perfil lipídico basal en ayunas y en cada uno de los momentos estipulados en el protocolo experimental (antes, inmediatamente después y 12 horas después del ejercicio), muestran que las sesiones de ejercicio realizadas por los grupos ER y EC no tienen variaciones significativas ($p>0.05$) en relación al colesterol total, triglicéridos y LDL. La evaluación de las VLDL, mostró ser de manera estadísticamente significativa, más baja en las mujeres del grupo EC 12 horas después de la sesión de ejercicios, comparado con los grupos ER y GC. Se observó también que las HDL a las 12 horas post ejercicio fueron estadísticamente superiores en el grupo de EC en relación al grupo ER (Tabla 2).

En la Tabla 3 se pueden observar las proporciones de variación dentro de los grupos, para cada uno de los componentes del perfil lipídico en ayunas, comparando el análisis basal con el recolectado 12 horas después de la sesión de ejercicios correspondiente. No se encontraron diferencias estadísticas para ninguna de las variables en la comparación de medias entre momentos ($p>0,05$). La media con mayor variación en el análisis del CT fue la del GC, disminuyendo 10,1%, seguida del grupo ER y EC, con una disminución del 9,8% y 3,5%, respectivamente. El grupo EC mostro mayor proporción de variación en el análisis de los

Tabla 1. Características de sujetos miembros de los diferentes grupos.

Variable	Población total (n=32)	Grupos experimentales			P[3] valor
		ER (n=11)	EC (n=11)	GC (n=10)	
Edad (años)	54,65±4,04	54,82±3,46	54,63±4,59	54,50±4,43	0,98
Características antropométricas					
Peso (kg)	71,31±9,29	70,31±9,44	71,88±10,32	71,80±8,85	0,91
IMC (kg/m^2)	28,52±3,33	27,76±3,28	29,03±3,70	28,82±3,16	0,64
Grasa corporal (%)	36,73±4,68	36,79±4,05	37,04±4,39	36,34±5,97	0,94
Masa magra (%)	44,20±5,69	44,48±3,58	42,66±8,45	45,60±3,58	0,50
Perímetro abdominal	96,23±7,61	94,88±7,56	97,09±8,63	96,78±7,28	0,77
Fuerza y capacidad funcional					
1RM extensión rodilla (kg)	22,78± 4,57	22,36±4,57	23,45±4,20	22,50±5,34	0,84
1RM flexión de codo (kg)	11,15± 3,69	11,45±4,11	10,36±2,50	11,70±4,47	0,68
30" *sit-to-stand test* (reps)	10,71±2,54	10,55±3,14	10,36±2,38	11,30±2,11	0,68
Requerimientos energéticos (Kcal)					
TMB	1374,4±104,26	1364,32±94,76	1374,95±116,11	1384,98±110,61	0,90
TMBAF	1649,3±125,11	1637,19±113,71	1649,92±139,33	1661,97±132,73	0,90

Valores promedio de las variables analizadas en la valoración inicial de las mujeres para la población total y para cada uno de los grupos experimentales. Valor de P[3] muestra la significancia estadística al comparar los valores promedio de las variables en los tres grupos experimentales. TMB: tasa metabólica basal; TMBAF: tasa metabólica basal con factor de actividad física.

Tabla 2. Comparación entre grupos del perfil lipídico en ayunas basal, antes, inmediatamente después y 12 horas en ayuno después de las sesiones de ejercicios.

Perfil lipídico (mg/dL)	Grupos experimentales			P[3] valor
	ER (n=11)	EC (n=11)	GC (n=10)	
CT				
12 horas ayuno basal	214,36±21,86	217,52±33,05	217,10±38,09	0,93
Pre ejercicio	228,45±73,34	220,18±68,08	222,00±70,16	0,95
Inmediatamente post ejercicio	244,09±66,86	249,27±67,39	213,10±59,38	0,40
12 horas ayuno post ejercicio	193,18±28,18	209,81±33,80	195,20±35,61	0,43
TG				
12 horas ayuno basal	171,09±71,73	167,36±44,12	172,00±51,76	0,98
Pre ejercicio	226,27±96,56	204,63±87,56	222,80±87,21	0,41
Inmediatamente post ejercicio	252,21±102,21	198,09±82,62	250,81±104,09	0,54
12 horas ayuno post ejercicio	166,18±63,93	144,00±29,50	175,50±54,90	0,36
LDL				
12 horas ayuno basal	135,95±15,59	140,63±18,60	137,35±32,48	0,88
Pre ejercicio	131,50±54,36	126,87±49,33	119,05±52,36	0,85
Inmediatamente post ejercicio	137,61±49,15	148,65±50,12	105,00±48,63	0,12
12 horas ayuno post ejercicio	140,46±39,22	155,94±47,84	130,40±23,06	0,32
VLDL				
12 horas ayuno basal	31,05±13,84	30,04±9,55	32,02±14,26	0,92
Pre ejercicio	45,25±19.31	40,92±15,38	44,56±20,72	0,84
Inmediatamente post ejercicio	50,45±29,74	39,61±16,45	50,16±29,86	0,54
12 horas ayuno post ejercicio	33,23±12,78[a]	23,34±5,50[b]	37,10±20,80[a]	<0,05
HDL				
12 horas ayuno basal	42,59±7,19	48,76±6,53	46,13±8,24	0,15
Pre ejercicio	51,70±11,30	52,38±10,36	58,39±21,18	0,53
Inmediatamente post ejercicio	56,02±9,12	61,05±7,99	57,94±16,03	0,59
12 horas ayuno post ejercicio	48,42±9,05[a]	56,90±7,40[b]	52,71±8,43[ab]	<0,05

Valores promedio por grupo de CT: colesterol total; TG: triglicéridos; HDL: lipoproteína de alta densidad; LDL: lipoproteína de baja densidad; VLDL: lipoproteína de muy baja densidad, basal, antes, inmediatamente después y 12 horas después del ejercicio. La comparación de los promedios entre los tres grupos es significativa cuando $P^3<0,05$. Los promedios en las filas que no comparten la misma letra del superíndice (a, b) son estadísticamente diferentes.

Tabla 3. Variaciones intra-grupos de los componentes del perfil lipídico en ayunas frente al ejercicio físico.

Variable	Basal	Post ejercicio	Δ%	P-valor
Colesterol total (mg/dL)				
ER	214,36±21,86	193,18±28,18	-9,8	0,06
EC	217,52±33,05	209,81±33,80	-3,5	0,59
GC	217,10±38,09	195,20±35,61	-10,1	0,16
Triglicéridos (mg/dL)				
ER	171,09±71,73	166,18±63,93	-2,9	0,86
EC	167,36±44,12	144,00±29,50	-13,9	0,15
GC	172,00±51,76	175,50±54,90	+2,0	0,87
LDL (mg/dL)				
ER	135,95±15,59	140,46±39,22	+3,3	0,72
EC	140,63±18,60	155,94±47,84	+10,9	0,19
GC	137,35±32,48	130,40±23,06	-5,0	0,58
VLDL (mg/dL)				
ER	31,05±13,84	33,23±12,78	+7,0	0,70
EC	30,04±9,55	23,34±5,50	-22,3	0,39
GC	32,02±14,26	37,10±20,80	+15,8	0,53
HDL (mg/dL)				
ER	42,59±7,19	48,42±9,05	+13,6	0,13
EC	48,76±6,53	56,90±7,40	+16,7	0,13
GC	46,13±8,24	52,71±8,43	+14,26	0,06

Valores promedio y proporción de variación del perfil lipídico por grupos. HDL: lipoproteína de alta densidad; LDL: lipoproteína de baja densidad; VLDL: lipoproteína de muy baja densidad, basal, antes, inmediatamente después y 12 horas después del ejercicio.

TG, disminuyendo 13,9% frente a un 2,9 del ER, mientras que en el GC aumento 2,0%. En los grupos ER y EC la tendencia del LDL fue aumentar, mientras en el GC disminuyo un 5,0%. Solo en el grupo EC se observó una atenuación de las concentraciones plasmáticas de VLDL en el periodo post-ejercicio (22,3%), aumentando las concentraciones de esta variable en el grupo ER (7,0%) y GC (15,8%). La tendencia del HDL en el análisis post-ejercicio fue aumentar en todos los grupos.

Discusión

Para cada individuo, el metabolismo de los lípidos a nivel sistémico es dependiente de muchos factores, incluyendo la alimentación, el estado de salud física y el gasto energético diario. Este estudio pretendió evidenciar en una población de mujeres postmenopáusicas con características similares, la influencia de las diferentes modalidades de ejercicio físico planteadas, comparado los resultados de los momentos de evaluación (basal, pre ejercicio, inmediatamente post-ejercicio y 12 h post-ejercicio) entre los grupos experimentales. Además, se procuró mostrar la posible influencia del ejercicio físico en la variación del perfil lipídico en ayunas dentro de cada grupo, aunque está claro que la influencia del ejercicio físico no es el único factor determinante de las variaciones del perfil lipídico, ya que en función del tiempo, el déficit energético general y los mecanismos de reposición fisiológica varían de sujeto a sujeto. Lo que realmente es importante clarificar es que, aunque existe limitaciones en cuanto al control de los factores biológicos y comportamentales que influyen en el perfil lipídico, el gasto energético adicional que supone la realización de ejercicio, influye en la magnitud de las respuestas fisiológicas que regulan el metabolismo de lípidos y otros sustratos energéticos.

Los análisis de los resultados derivados de la presente investigación, se basan en las respuestas agudas de las modalidades, volúmenes e intensidades de ejercicio físico planteadas, sobre los lípidos encontrados en el plasma sanguíneo. Estas respuestas no han sido dilucidadas completamente en mujeres postmenopáusicas, población con una relativa vulnerabilidad al padecimiento de ECV. La interpretación de repuestas en momentos subsecuentes a la realización programada de ejercicio físico, goza de gran importancia debido a que permite entablar una descripción útil de la fisiología del cuerpo humano, intentando respaldar la noción en la que se argumentan los beneficios del ejercicio físico no solo durante su ejecución, si no en las horas posteriores, en un periodo de recuperación y reorganización fisiológica.

Hallazgos en la literatura asocian a la realización periódica de ejercicio físico con cambios en variables metabólicas y funcionales, principalmente en combinaciones de ejercicios resistidos con ejercicios aeróbicos[9,19]. Para que existan cambios en IMC, el peso y porcentaje de grasa corporal es necesario implementar programas de ejercicios a largo plazo, lo que se convierte en un limitante de la presente investigación, ya que una sola sesión de ejercicios no produce cambios en la composición corporal. Sin embargo, se ha observado que una sola sesión de ejercicio puede modificar el perfil lipídico de jóvenes, adultos y sujetos con diversos trastornos.

La implementación del ER de manera sistemática por más de 8 semanas, ha mostrado hallazgos asociados a la reducción de las concentraciones séricas de CT, TG y LDL, así como el aumento de las concentraciones de HDL[20], aunque resultados de otros estudios discrepan, como el estudio de Kelley *et al.*[21], donde alegan que en diferentes periodos de ER (por ejemplo, entre 8 a 20 semanas) no se producen cambios sobre las concentraciones lipoproteínas en el plasma sanguíneo.

Refiriéndonos a los efectos agudos de una sesión de ejercicios, estos se asocian principalmente con el aumento en las concentraciones de HDL. De acuerdo a lo observado por Wallace *et al.*[22], en un estudio con hombres adultos sanos mostraron un aumento de 12% en las concentraciones plasmáticas de HDL dentro de las primeras 24 horas después de una sesión de ER, con alto volumen e intensidad moderada (7 ejercicios de 3 series y 12 repeticiones al 80% de la fuerza máxima), además de encontrar una disminución del 20% en las concentraciones de TG en el mismo periodo. Resultados muy similares a los encontrados en el presente estudio, el grupo de ER registró un aumento del 13,6% en la HDL con relación a sus registros basales, no encontrando grandes modificaciones en los TG 12 horas después de la realización del ejercicio.

Comparado con el grupo de controles, los sujetos que conforman el grupo ER no presentaron diferencias en las modificaciones de LDL y HDL, dato que refuta los hallazgos del estudio de Correa *et al.*[23], donde en mujeres postmenopáusicas, los ejercicios resistidos de alto o bajo volumen no redujeron las concentraciones de CT, como tampoco influyo en los niveles de LDL y VLDL, tanto en valores basales como en análisis postprandiales. En la población estudiada, estos resultados asociarían a los ejercicios resistidos a respuestas agudas débiles con respecto al metabolismo de lípidos. Sin embargo, es necesario que exista más evidencia que soporte dicha afirmación, especialmente teniendo en cuenta que la variabilidad en las prescripción de los ejercicios resistidos en cuanto a volumen, intensidad, numero de ejercicios, grupos musculares, intervalos de recuperación y velocidad de contracción, puede demostrar resultados disímiles en combinaciones alternas a las planteadas en este estudio.

Una tendencia denotada en los resultados del perfil lipídico antes e inmediatamente después de la sesión de ejercicios, fue que ninguna de las variables mostro diferencia estadística entre los grupos. Sin embargo, a las 12 horas después del ejercicio, el grupo que combino ejercicios aeróbicos y resistidos evidenció diferencias con el grupo ER y el control, demostrando una reducción importante de la VLDL, rondando aproximadamente el 22% con relación a los registros basales en ayunas del mismo grupo. Parece ser que la realización de ejercicios aeróbicos impacta de mejor manera el metabolismo energético de mujeres postmenopáusicas que solo hacer ejercicios resistidos, el estudio de Weise *et al.*[5], demostró en esta población que una sesión de ejercicio aeróbico puede disminuir 8,5% las concentraciones de TG y aumentar un 5% las concentraciones de HDL después de las 12 horas de su realización. La magnitud en la variación de TG y HDL dentro del grupo EC en el presente estudio mostro mejores resultados que en la investigación mencionada con anterioridad, disminuyendo los TG un 13% y aumentando la HDL hasta un 16,7% 12 horas después de su realización. Este hallazgo puede ser un indicador de que la combinación de actividades aeróbicas y anaeróbicas repercute de mejor forma en el metabolismo de lípidos de forma aguda en postmenopáusicas.

Los resultados anteriores pueden sugerir que dosis altas de ejercicios resistidos no estimulan la formación de HDL, debido a que

probablemente la movilización inversa de lípidos (hacia el hígado) esta disminuida por las demandas energéticas derivadas del musculo esquelético ejercitado, el cual solicitaría la movilización típica de ácidos grasos. Resultados muy similares a los encontrados en el estudio de Wooten *et al*.[24] y Zotou *et al*.[25], donde si bien demostraron que hay una influencia positiva de los ejercicios resistidos en la atenuación aguda de los marcadores lipídicos basales y postprandiales en mujeres postmenopáusicas, las altas dosis los estos ejercicios no mostraron modificaciones positivas en las concentraciones sanguíneas de HDL.

Son muchos los autores que no solo han mencionado la reducción en los niveles de actividad física como factor trascendental en potenciamiento del riesgo cardiovascular en mujeres postmenopáusicas, sino que también encuentran agravantes fisiológicos que pueden ser controlados con la realización periódica de ejercicio físico, especialmente en mujeres con sobrepeso. Según el Colegio Americano de Medicina Deportiva, la práctica regular de ejercicios resistidos puede proporcionar mejoras en la salud física general de la mujer, así como ayudar a prevenir y tratar enfermedades relacionadas con riesgo cardiovascular como la diabetes o hipertensión, por lo que estos ejercicios, bajo la supervisión de especialistas, hacen parte actualmente de programas de rehabilitación y acondicionamiento físico, dirigidos a dicha población[26]. Es muy poca la evidencia en la literatura que describe las implicaciones metabólicas agudas de los ejercicios concurrentes en el perfil lipídico de mujeres postmenopáusicas, aunque estudios como los de Figueroa *et al*.[19] y Libardi *et al*.[27] muestran efectos positivos en el control de factores de riesgo cardiovasculares cuando esta modalidad de ejercicio se desenvuelve a largo plazo. De los hallazgos más importantes de la presente investigación, se puede iniciar a suscitar la idea que argumente la ejecución combinada de ejercicios resistidos y aeróbicos para lograr garantizar influencias positivas agudas en el perfil lipídico sanguíneo de mujeres postmenopáusicas, lo que a largo plazo, puede convertirse en un factor protector contra el padecimiento de ECV.

Del análisis de los resultados del presente trabajo de investigación podemos concluir que, en comparación a la realización de una sesión de ejercicios resistidos, una sesión de ejercicio concurrente, podría influir de manera positiva el perfil lipídico de mujeres postmenopáusicas con sobrepeso, principalmente 12 horas después de su realización, disminuyendo las concentraciones plasmáticas de VLDL y aumentando las concentraciones de HDL.

Conflicto de interés

Los autores no declaran conflicto de intereses alguno.

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Sweating and core temperature in athletes training in continuous and intermittent sports in tropical climate

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Summary

Higher sweat rate values have been reported during intermittent compared to continuous type exercise in hot conditions in the laboratory. Studies in the training field are scarce.

Objective: Document sweat rate, rehydration and core temperature (T_c) during training in long duration-continuous (CON) and intermittent (INT) type sports, and determine the presence of a mutation in the CFTR gene in athletes with high sodium concentration ([Na^+]) in sweat.

Methods: Athletes (CON =50 and INT=123) were tested during training in tropical climate. Sweat rate, sweat [Na^+], T_c, dehydration level, and presence of Δ F508 gene mutation in the CFTR gene in athletes with high sweat [Na^+] were evaluated.

Results: Sweat rate was higher in CON (1.5 ± 0.4 L/h) compared to INT (1.2 ± 0.5 L/h) and CON athletes finished training with higher dehydration (2.1 ± 0.8 *vs* 1.2 ± 0.7%) $P < 0.05$. Sweat [Na^+] was higher in INT (62.0 ± 21.1 mmol/L) compared to CON (53.9 ± 18.1 mmol/L), $P < 0.05$. A tennis player with high [Na^+] was heterozygous for the ΔF508 mutation. Average and highest Tc was similar for CON (38.4 ± 0.3 and 38.8 ± 0.4 °C) and INT (38.3 ± 0.3 and 38.7 ± 0.4 °C), $P > 0.05$.

Conclusion: During training in a tropical climate, sweat loss and dehydration level are lower, and fluid intake is higher in intermittent compared to continuous type sports. Core temperature may rise to a similar level in intermittent type sports due to the repeated high intensity bouts and/or the effects of clothing worn while training in hot venues. Healthy athletes with high [Na^+] in sweat who are heterozygous carriers of CFTR mutations may be at increased risk for hyponatremic dehydration and whole-body muscle cramps.

Key words:
Sweating. Tropical climate. Dehydration. Athletes. Body temperature. Sodium.

Sudoración y temperatura interna en atletas durante entrenamiento para deportes continuos e intermitentes en clima tropical

Resumen

Se reportan tasas de sudoración más altas durante ejercicio intermitente comparado con continuo en condiciones de calor en el laboratorio. Estudios en el campo de entrenamiento son escasos.

Objetivo: Documentar la tasa de sudoración, rehidratación y temperatura central (T_c) durante entrenamiento para deportes de tipo continuo (CON) e intermitente (INT), y determinar presencia de mutación genética en el gen CFTR en atletas con alta concentración de sodio ([Na^+]) en sudor.

Metodología: Se evaluó la tasa de sudoración, la [Na^+] en sudor, la T_c, y el nivel de deshidratación en atletas (CON =50; INT =123) durante entrenamiento en clima tropical, y la presencia de la mutación genética ΔF508 en el gen CFTR en aquellos con alta [Na^+] en sudor.

Resultados: La tasa de sudoración fue mayor en CON (1,5 ± 0,4 L/h) comparado con INT (1,2 ± 0,5 L/h) y los atletas en CON terminaron el entrenamiento con mayor deshidratación (2,1 ± 0,8 *vs* 1,2 ± 0,7%) $P < 0,05$. La [Na^+] en sudor fue más alta en INT (62,0 ± 21,1 mmol/L) comparado con CON (53,9 ± 18,1 mmol/L), $P < 0,05$. Un tenista con alta [Na^+] era heterocigoto para la mutación ΔF508. La T_c promedio y más alta fueron similares para CON (38,4 ± 0,3 y 38,8 ± 0,4 °C) e INT (38,3 ± 0,3 y 38,7 ± 0,4 °C), $P > 0,05$.

Conclusión: Durante el entrenamiento en clima tropical, la pérdida de sudor y el nivel de deshidratación son más bajos, y la ingesta de líquido es más alta en deportes intermitentes que en deportes continuos. La temperatura interna puede aumentar a nivel similar en deportes intermitentes debido a periodos repetidos de alta intensidad y/o la vestimenta usada durante el entrenamiento. Atletas saludables con alta [Na^+] en sudor que son heterocigóticos para mutaciones de CFTR pueden estar en mayor riesgo de deshidratación hiponatrémica y calambres musculares.

Palabras clave:
Sudoración. Clima tropical. Deshidratación. Atletas. Temperatura corporal. Sodio.

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Introduction

Exercise in tropical environments may cause considerable elevations in core temperature that contribute to high sweat production and sodium loss, impairment in athletic performance[1] and heat related illnesses[2]. The risk is higher if athletes begin training in a state of body fluid deficit and do not drink enough during exercise to replenish losses[2]. Sweat losses of 1 to 2 L/h are common during training and competition in hot and humid tropical environments and may reach or exceed 2.5 L/h in heavy sweaters. Heat acclimatized elite athletes with high sweat production that train for long duration-continuous type (CON) sports, are most prone to dehydration. Athletes in intermittent type (INT) sports, such as team, ball and combat sports, are also at risk since multiple high intensity time periods elevate metabolic heat production and core temperature and induce heavy sweating[3]. This may be particularly true in athletes who wear heat-retaining clothing and/or protective equipment that decreases the effectiveness of heat loss through the evaporation of sweat.

Athletes with high sweat rates are more susceptible to large electrolyte losses in sweat, which have been implicated in the development of skeletal muscle cramps[4]. Athletes born and raised in the tropics may be protected from large sodium losses because regular exposure to high environmental temperatures induces physiological adaptations in the sweat glands such as an increased sodium reabsorption which result in a decreased sweat sodium concentration ([Na^+]) for a given sweat rate[5,6]. However, a proportion of athletes exhibit "salty sweat". Those whose sweat [Na^+] is typically higher than 55 mmol/L[4,7] may have a reduced Cl^- and Na^+ reabsorption across the sweat duct membrane.

Studies have identified persons without cystic fibrosis (CF) have sweat Na^+ levels like those of CF patients[8]. It is possible that some healthy "salty sweaters," are heterozygous for a CF mutation and have a malfunction of plasma membrane CF transmembrane conductance regulator (CFTR) in the sweat glands that results in sweat with high sodium chloride concentration like CF patients[9]. Approximately 1 in 46 Hispanics carry one mutation of the CFTR gene that causes hypo-absorption of Na^+ in sweat gland ducts and high sweat [Na^+][10]. In the United States, the most common mutation in the CFTR gene associated to the development of CF is the deletion of phenylalanine 508 (ΔF508)[11] and its prevalence in athletes with salty sweat is currently unknown.

Studies in the laboratory have shown that prolonged variable intensity exercise with periods of high intensity exercise (≥15 minutes) may elicit similar or higher heat storage, core temperature (T_c), and sweat production, as prolonged constant intensity exercise with no rest periods[3,12-14]. Studies in the playing field show a predisposition to heat strain due to hyperthermia and dehydration in American Football players[15] but very little is known about other intermittent type or endurance sports in tropical environments. Particularly lacking are data in female athletes.

The aims of the present observational field study were to: 1) document the sweating response and rehydration during training sessions in tropical climate in CON and INT sports in both genders; 2) investigate the presence of the ΔF508 mutation in the CFTR gene in athletes with high sweat [Na^+]; and 3) compare the T_c response in a subset of male and female athletes in CON and INT sports. We hypothesized that athletes in INT sports would show a lower sweat rate, a lower average T_c and a higher sweat [Na^+].

Material and method

Subjects

One hundred and seventy three competitive athletes participating in long duration-continuous (endurance=50; 30 males [M] and 20 females [F]) or intermittent (ball/team= 94, 45 M and 49 F; combat =29, 15 M and 14 F) sports (Table 1) were tested during a typical training session for their sport. The subjects were recruited from teams in a Central American and Caribbean competition in the summer in Puerto Rico and from National teams, top ranked university teams, and recreational athletes ranked in the top of their age categories in Puerto Rico. All were natives of tropical countries with a predominantly warm and humid climate all year long.

All subjects were informed of the purpose and procedures of the study and written informed consent was obtained. There were 52 athletes between the ages of 17 and 21 who gave their written assent, and written consent was also obtained from their parents. The study was approved by the Institutional Review Board of the University of Puerto Rico, Medical Sciences Campus.

Study design and procedures

Athletes were studied under environmental conditions typical of training sessions for their sport, and wearing uniforms and equipment used in competition. This field study design allowed us to collect information in conditions that are difficult to simulate in the laboratory. Athletes completed a questionnaire about heat exposure during exercise and past history of muscle cramps. General health status was also documented to assure they did not have a medical condition that would affect thermoregulatory or body fluid balance variables.

All subjects were tested during the summer months in Puerto Rico. The average WBGT (10 am to 4 pm) was 29.9 ± 1.6 °C[16]. The runners, cyclists, triathletes, soccer, tennis, and beach volleyball players trained outdoors exposed to direct sunlight, while the judo, basketball, team

Table 1. Athletes in long duration-continuous (CON) and intermittent (INT) sports.

CON (N=50) Endurance Sports	F	M	INT (N=123) Team/Ball Sports	F	M
Running	8	13	Soccer	10	18
Cycling	7	9	Tennis	3	10
Triathlon	5	8	Basketball	7	0
			Team Handball	13	0
			Beach Volleyball	16	17
			Combat Sports	**F**	**M**
			Judo	7	3
			Fencing	7	12
Total	20	30		63	60

handball, and fencing athletes trained indoors in non-air conditioned gyms. The triathletes were tested while running. All athletes wore official competition uniforms required for their sport. The judokas and fencers wore t -shirts and shorts underneath the uniforms.

- *Pre-training session*. Subjects urinated into a pre-weighed container. Nude body weight was determined using an electronic scale accurate to 50 g (precision health scale uc321). After cleaning the area with distilled water, absorbent patches (Tegaderm +pad, 3m Health Care, Borken, Germany) were applied to the subject's right posterior forearm and right anterior thigh for regional sweat collection in all but the beach volleyball players, in which it was applied to the right anterior thigh only. Athletes were then fitted with an accelerometer (Actigraph GTX3; Actigraph, Pensacola, FL, USA) that was programmed to record activity counts in one-minute epochs. The cyclists wore the accelerometer on the right thigh.
- *Training session*. The duration of training was similar to a typical session for the sport. Training sessions were organized and directed by the athletes' coaches. Environmental conditions were measured before, every 30 min, and at the end of training, using a heat stress monitor (Questemp 32, Quest Technologies, Wisconsin), which was placed in the training area. Athletes drank voluntarily from labeled bottles with water and/or sports drinks. Any subject who needed to urinate during the training session did so into a pre-weighed container and the volume was measured. The absorbent patches were removed when saturated and placed in sealed plastic tubes.
- *Post-training session*. Athletes removed the accelerometer and clothes, towel dried and pre-training measures were repeated (urine sample, nude body weight).
- *Measures and calculations*
- *Hydration status*. Urine specific gravity (USG) was used as an index of pre-exercise hydration status[17] and determined using a hand-held refractometer (URC-NE, Atago Clinical, Japan).
- *Environmental conditions*. Dry bulb (DB), wet bulb (WB), globe temperature (GT), and relative humidity (RH) were measured on site. The wet bulb globe temperature (WBGT) heat stress index was calculated using the following equations: CON sports: (WB x 0.7) + (GT x 0.2) + (DB x 0.1); INT sports: (WB x 0.7) + (GT x 0.3)[18].
- *Regional sweat [Na^+]*. Sweat was extracted from each patch using a 5-ml syringe and two 100 µl samples were analyzed using an ion selective electrolyte analyzer (Easylyte Plus, Medica, Bedford, MA) to determine the [Na+].
- *Body fluid balance*. The bottles with the fluid that was used for hydration during the session were weighed before and after the session with a scale accurate to 1 g (CS2000 Compact Scale). Sweat loss was calculated as: change in body mass, corrected for fluid intake and urine loss. Sweat rate was calculated as sweat loss divided by exercise duration. The level of dehydration was determined using the following formula: (body mass pre-training – body mass post-training) / body mass pre-training.
- *Core temperature*. Core temperature was measured in 62 athletes that lived and trained in Puerto Rico (females, CON= 10 and INT=34; males, CON=13 and INT=5) using ingestible sensors (Cortemp™, HQ Inc.) before, every 10 minutes, and at the end of training. We measured T_c only in athletes who could satisfy requirements for valid measurements (sensor calibration, timing of ingestion and electromagnetic interference). Eight hours prior to the beginning of the exercise session, each subject swallowed a disposable pill that contained a temperature sensor for T_c determination. Pre-exercise T_c was the value taken after sitting quietly for five minutes in the exercise area before the start of training. The T_c of the exercise session was the average of measures taken every 10 minutes. The change in T_c was calculated as the highest minus the pre-exercise T_c. A final measure was taken immediately after the coach indicated the session had finished.

Genetic analysis

Athletes with a sweat [Na^+] ≥ 70 mmol/l were identified for subsequent genetic analysis[19]. Athletes were asked to provide two ml of saliva which were collected into a DNA genotek's oragene® DNA self-collection vial. The container had approximately 2 ml of cell lysis solution or DNA-preserving fluid, that was mixed with the saliva. Genomic DNA was assayed for the Δ F508 mutation in the CFTR gene, using restriction fragment length polymorphism (Ambry Genetics, Aliso Viejo, CA). As per standard procudedures, DNA was extracted from saliva and purified. The purified DNA was digested using restriction endonucleases. The restriction fragments produced during DNA fragmentation were analyzed using gel electrophoresis.

Statistical Analysis

Means and standard deviations were calculated for each variable. Student's *t*-tests were used to compare CON and INT in pre-exercise urine specific gravity, sweat rate, percent dehydration, percent rehydration, minutes of exposure to exercise in the heat in the past month, activity counts/min, sweat [Na^+], pre, average, change and highest T_c, and the WBGT index. An alpha level of $P < 0.05$ was considered significant.

Results

Subjects, environmental conditions and training sessions

Descriptive characteristics of the subjects and training session characteristics are presented in Table 2. The WBGT index for CON and INT was > 28 °C, which is typical of tropical countries during the summer and indicates that all subjects were exposed to a high level of heat stress without exhibiting symptoms of heat illness. Activity counts per minute[20] revealed that in INT sports the training sessions were of predominantly light- to- moderate intensity whereas in CON sports they were shorter and of vigorous intensity. The average time spent training exposed to solar radiation in the month preceding the study was 17% higher in CON.

Hydration status and fluid balance

Athletes in INT arrived to the training session in a state of hypohydration as evidenced by a mean pre-exercise USG of 1.021 ± 0.006. Athletes in CON had a higher sweat rate ($P< 0.05$) and finished training with higher ($P < 0.05$) level of dehydration (2.1 ± 0.8 *vs* 1.2 ±0.7%) due

Table 2. Descriptive characteristics of the subjects, environmental conditions and training sessions in long duration-continuous (CON) and intermittent (INT) type sports.

	CON (N=50)			INT (N=123)		
	Females N=20	Males N=30	Total N=50	Females N=63	Males N=60	Total N=123
Age (y)	26.0 ± 6.5	26.2 ± 5.4	26.1 ± 5.8	23.4 ± 5.2	23.9 ± 4.4*	23.6 ± 4.8
Height (cm)	159.7 ± 5.5	173.9 ± 7.1	168.2 ± 9.6	167.2 ± 9.4*	179.0 ± 8.9*	173.1 ± 10.9*
Weight (kg)	53.8 ± 5.9	68.5 ± 10.7	62.6 ± 11.6	65.8 ± 10.2*	76.5 ±11.2*	71.0 ± 11.9*
Training exposed to sun (min/day in past month)	122.0 ± 63.2	164.3 ± 83.1	147.4 ± 78.0	96.7 ± 84.4	147.5 ± 90.0	121.9 ± 90.5
Duration of Training Session (min)	69.6 ± 20.6	78.7 ± 24.0	75.0 ± 22.9	91.6 ± 19.1*	86.8 ± 20.1	89.2 ± 19.7*
Activity counts (counts/min)	7,695.0 ± 1,666.7	7,189.7 ± 2,367.7	7,414.3 ± 2,078.9	2,421.9 ± 539.6*	2,909.0 ± 882.4*	2,654.7 ± 760.9*
Minutes at light intensity (< 1,952 counts/min)	1.7 ± 1.9	8.6 ± 18.9	5.6 ± 14.4	46.4 ± 18.2*	32.6 ± 17.2*	39.8 ± 19.0*
Minutes at moderate intensity (1,952 – 5,724 counts/min)	10.4 ± 21.7	16.6 ± 30.1	13.8 ± 26.6	37.8 ± 11.6*	45.5 ± 17.1*	41.5 ± 14.9*
Minutes at vigorous intensity (> 5,724 counts/min)	57.1 ± 28.2	54.9 ± 28.3	55.9 ± 27.9	6.8 ± 5.0*	8.7 ± 8.4*	6.9 ± 0.6*
WBGT heat stress index (ºC)	30.9 ± 1.1	30.8 ± 1.7	30.8 ± 1.1	28.9 ± 1.4*	30.2 ± 1.7	29.5 ± 1.7*

*Significant difference between CON and INT, P < 0.05.

Table 3. Hydration status and fluid balance in long duration-continuous (CON) and intermittent (INT) type sports.

	CON			INT		
	Females N=20	Males N=30	Total N=50	Females N=63	Males N=60	Total N=123
USG Pre (mg/dL)	1.017 ± 0.001	1.018 ± 0.001	1.017 ± 0.000	1.020 ± 0.001	1.022 ± 0.000*	1.021 ± 0.006*
Sweat rate (L/h)	1.3 ± 0.3	1.6 ± 0.4	1.5 ± 0.4	0.9 ± 0.3*	1.5 ± 0.4	1.2 ± 0.5*
Dehydration (%IBW)	1.9 ± 0.7	2.2 ± 0.8	2.1 ± 0.8	0.9 ± 0.6*	1.4 ± 0.8*	1.2 ± 0.7*
Fluid replaced (% of fluid loss)	30.9 ± 20.9	29.3 ± 20.0	29.9 ± 20.1	57.8 ± 27.5*	52.8 ± 19.3*	55.4 ± 23.9 *
Sweat [Na^+] (mmol/L)	57.2 ± 20.6	57.2 ± 18.2	53.9 ± 18.1	63.2 ± 22.6	67.7 ± 18.7*	62.0 ± 21.1*

*Significant difference between CON and INT, P < 0.05.

to lower fluid replacement. Sweat [Na^+] was higher ($P < 0.05$) in INT compared to CON and there was no difference between genders and history of muscle cramps.

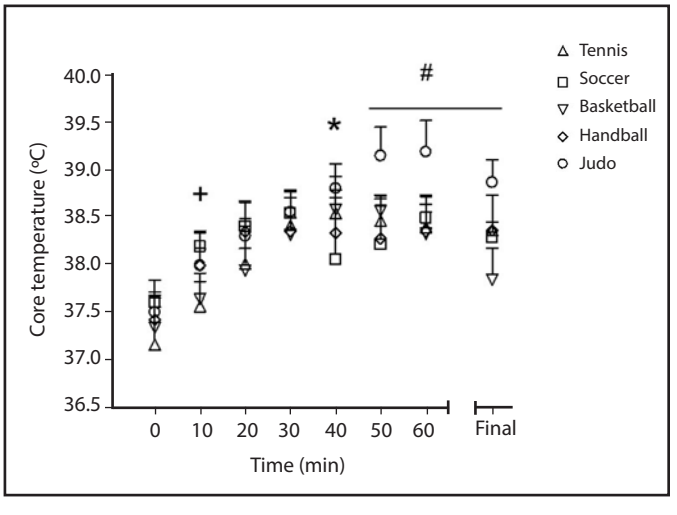
Sixty athletes (28% of the group) had a sweat [Na^+] >70 mmol/L and sweat [Cl^-] > 60 mmol/l. Forty-nine of those (82%) provided saliva samples for genetic analysis. One male tennis player was identified as having heterozygous presence of the ΔF508 mutation in the CFTR gene. He had a history of whole body muscle cramps and his sweat [Na^+] was 74.9 mmol/L (average of thigh and forearm regional sweat samples).

Core temperature

We measured core temperature in 23 athletes in CON (females=10; males=5) and in 39 athletes in INT (females=34; males=5). For this sub-group, the CON sports were running, cycling, and triathlon and the INT sports were soccer, basketball, handball, and judo. For the whole group, the average and highest T_c for the session was similar for CON (38.4 ± 0.3 and 38.8 ± 0.4 ºC) and INT (38.3 ± 0.3 and 38.7 ± 0.4 ºC), $P < 0.05$.

In Figure 1 we present the T_c before, during and at the end of the INT training sessions. The judo athletes, who were exposed to a high

Figure 1. Core temperature before, during, and at the end of the intermittent intensity training sessions.



+Soccer higher than tennis ans basketball; *Judo higher than soccer and handball; #judo higher than all; P<0.05.

level of heat stress while wearing two layers of clothing, showed the highest values for T_c during the final part and at the end of the INT exercise sessions.

Discussion

The present study examined the body hydration status and thermoregulatory responses to exercise under tropical conditions in athletes in continuous and intermittent type sports. The main findings were: 1) sweat rate and the change in core temperature were higher in CON compared to INT; 2) low fluid intake resulted in a higher level of dehydration in CON; 3) a proportion of athletes exhibit "salty sweat" and one was a healthy carrier of a CFTR gene mutation; and 4) athletes in INT exhibited maximal T_c similar to athletes in CON who trained at high intensity for longer periods.

Hydration status and fluid balance

Athletes in our study are indigenous to the tropics and have physiological adaptations induced by repeated exposure to a hot and humid environment that lead to increased capacity and sensitivity of the sweat glands[21]. The sweat rate values in males (1.6 ± 0.4 L/h) and females (1.3 ± 0.3 L/h) in CON and in males in INT (1.5 ± 0.4 L/h) in the present study are higher than normative data reported for adult male (1.42 ± 0.72 L/h) and female (1.10 ± 0.57 L/h) athletes[22].

Whole body sweat rate comparisons between continuous and intermittent type exercise in the heat in controlled, artificial, thermoneutral[13,23], and hot-dry[3] conditions have revealed mixed results. Drust *et al*[13] found a similar sweat rate during a laboratory-based soccer protocol in male athletes that ran on a treadmill for 45 minutes either intermittently (7.5 min exercise/1.2 min rest) or continuously in a thermoneutral environment. In contrast, Mora-Rodriguez *et al*.[3] found higher sweat rate during 90 min of variable intensity intermittent exercise (1.5 min high intensity/4.5 min low intensity) compared to same amount of work performed at a constant load in endurance-trained, heat-acclimated males exercising in hot-dry environment. In the present field study, in which we did not control for exercise intensity or environmental conditions, we found higher sweat rates in athletes in CON which may be expected for two reasons: 1) a greater proportion of the CON sessions were at high exercise intensity; and 2) athletes in CON were exposed to a higher heat stress.

Our data are consistent with the observation that athletes replace less than 50% of their sweat losses during exercise and thus, they are hypohydrated at the end of training[24]. In CON sports opportunities to drink may be frequent but athletes may be reluctant to drink, to avoid slowing down and the abdominal discomfort associated with large fluid consumption. On the other hand, in intermittent type sports, regular opportunities for hydration are available during substitutions, pauses in play, time-outs, intermissions, and change of sides of court, which leads to frequent and better fluid replacement.

Sweat sodium and genetic mutation in CFTR gene

When the sweat rate is high, sodium reabsorption capacity in the sweat gland can be exceeded resulting in a higher [Na^+] appearing in sweat. However, the linear increase seen in sweat [Na^+] as sweat rate increases can be modulated by heat acclimation[5]. For example, Buono *et al.*[5] showed that heat acclimation may increase the absorptive capacity of the sweat gland duct, reducing the sweat [Na^+] for a given sweat rate up to 1 mg. cm^{-2}. min^{-1}. In the present study athletes in CON showed a lower sweat [Na^+] despite their higher sweat rate in comparison to athletes INT, which may be attributed to their higher level of heat exposure and acclimatization. An advantage of a higher sweat rate coupled with a lower sweat [Na^+] for athletes in CON is a lower risk for developing hyponatremia during exercise in the heat[25].

A factor proposed for high Na^+ excretion in healthy athletes is the presence of genetic mutations in the CFTR that affects the Cl- channel in the sweat glands[7,8]. The majority of CF patients have the ΔF508 mutation and exhibit [Na^+] in their sweat that may be up to five times higher than healthy individuals[26]. It is estimated that 2% (1 in 46) of Hispanic Americans are heterozygous carriers of a mutated CFTR gene[10] and may be genetically predisposed to high sweat Na^+ loss. The prevalence of CF mutations in athletes with salty sweat is currently unknown.

A reduced ductal luminal membrane expression of the Cl^- channel was found in six healthy recreationally active subjects with a mean sweat [Na^+] of 94.9 ± 15.2 mmol/l[7]. However, in that study, none of the subjects was a carrier of any of the 39 most common CFTR mutations in the United States. The authors concluded that a full CFTR gene sequencing of the subjects would be required before excluding a possible genetic link between excessive Na^+ loss in sweat and CFTR mutations.

A novel finding of our study was that one of 45 Hispanic athletes (2%), classified as "salty sweaters" was heterozygous for the ΔF508 mutation in the CFTR gene. That athlete was a tennis player with a history of whole body muscle cramps that lead to collapse on court requiring medical attention.

Core temperature response

During prolonged high intensity exercise, the heat stored is higher and Tc rises faster when the same amount of exercise is performed in a variable intensity mode that includes short (1.5 to 7.5 min) high intensity bouts followed by rest periods compared to constant intensity mode[3,13,23,27]. However, if longer bouts (15-30 min) of high intensity exercise are used, a similar T_c rise is observed[28,29]. We found that although athletes in INT spent the majority of the exercise session at lower exercise intensity with multiple resting periods, they exhibited a maximal T_c (38.7 ± 0.4 °C) similar to athletes in CON (38.8 ± 0.4 °C) who trained at high exercise intensity for most of the session. This response suggests that the heat stored during the few periods of high exertion was not dissipated significantly and T_c remained elevated instead of decreasing as expected during low intensity exercise periods.

The highest core temperature response in INT was observed in judokas who trained in a non-air-conditioned gym (WBGT= 30.0 °C). Similar to our previous report[30], judokas in the present study arrived to training with a fluid deficit, as evidenced by USG. The combination of a pre-exercise fluid deficit that worsened during training because of inadequate fluid Intake, hot and humid environmental conditions, and insulation properties of the uniform that decreased heat dissipation, predisposed the athletes to hyperthermia during training. In fact, 8 of the 9 judokas felt overheated and 7 of them had maximal $T_c \geq 39.0$ °C.

Two athletes reached a T_c of 39.6 ºC and felt dizzy, had a headache, and stopped training with symptoms of exhaustion. High T_c and increased physiologic strain have been reported in American football athletes wearing a full uniform while training in similar climatic conditions[15]. We believe this to be the first study documenting the rate of T_c rise in judo athletes during training in the heat. Our data indicate that training in full uniform in a non-air conditioned gym in the tropics predisposes judo athletes to heat illness and should be discouraged.

Conclusions

This observational field study demonstrates that during training in a tropical climate, sweat loss and dehydration level are lower, and fluid intake is higher in intermittent compared to continuous type sports. Nonetheless, core temperature may rise to a similar level in intermittent type sports due to the repeated high intensity bouts and/or the effects of clothing worn while training in hot venues. For athletes in continuous sports, high sweat rates may not provide a thermoregulatory advantage in a tropical climate because humidity hinders the evaporation of sweat. Coaches should pay special attention to factors that may increase fluid intake, such as availability of cool, palatable fluids, encouragement to drink, and frequent, short pauses. Healthy athletes with high [Na^+] in sweat who are heterozygous carriers CFTR mutations may be at increased risk for hyponatremic dehydration and whole-body muscle cramps during exercise.

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Conflict of interest

The authors do not declare a conflict of interest.

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The effect of tapering and *Nigella sativa* on the histological structure of the lung after increasing interval exercise training

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Summary

Objectives: During maturation period in which the immune system of lung tissue is not fully developed, physical exercises may have a negative effect and cause inflammation. This study aimed to investigate the effects of tapering and *Nigella sativa* (*NS*) hydro-alcoholic extract on the reduction of lung tissue inflammation caused due to increasing interval exercise training (IIET) during maturation period by histological and stereological methods.
Methods: Nighty-five three weeks old rats after adaption were randomly divided into two control and exercise groups and 19 subgroups. The exercise group carried out a period of six weeks of undulating IIET followed by three weeks of load reduction performed by three models in two different times. Rats entered the taper phase were administrated by *NS* supplement in tapering and control groups. The lung tissue samples were processed by standard paraffin embedding, stained by H&E and examined by using point counting method through systematic random sampling in stereological study. The results were analyzed using by two-way ANOVA and LSD post hoc in α=0.05.
Results: The result showed that IIET caused severe inflammation in lung tissue and an increase in infiltration of inflammatory cells and lymphocytes into the connective tissues surrounding the respiratory air ways, vessels and interstitial lamellae. This severity of inflammation was considerably and similarly more in comparison to the basic and control groups (p=0.001). Stereological analysis in the taper exercise training groups with *NS* and without *NS* as well, reveled a significant decrease in the degree and intensity of lung tissue inflammation in the examined times in comparison to the IIET group (p=0.001).
Conclusion: Generally it can be concluded that performing *NS* and a three weeks period of tapering has a noticeable effect in the reduction of inflammation in lung tissue followed by interval exercise training.

Key words:
Increasing interval exercise training. Tapering. *Nigella sativa*. Lung. Inflammation.

El efecto del *tapering* y *Nigella sativa* sobre la estructura histológica del pulmón después de aumentar el entrenamiento de ejercicio de intervalo

Resumen

Objetivos: Durante el período de maduración en el que el sistema inmunitario del tejido pulmonar no está completamente desarrollado, el ejercicio físico puede tener un efecto negativo y causar inflamación. Este estudio tuvo como objetivo investigar los efectos del *tapering* y del extracto hidroalcohólico de *Nigella sativa* (*NS*) sobre la reducción de la inflamación del tejido pulmonar causada por el aumento de entrenamiento interválico (IIET) durante el período de maduración mediante métodos histológicos y estereológicos.
Métodos: Noventa y cinco ratas de tres semanas de edad, después de la adaptación, se dividieron aleatoriamente en dos grupos de control y ejercicio y 19 subgrupos. El grupo de ejercicio llevó a cabo un período de seis semanas de IIET ondulado seguido de tres semanas de tapering realizadas por tres modelos en dos momentos diferentes. Las ratas entraron en la fase de tapering y se les administró un suplemento de *NS* en ambos grupos. Las muestras de tejido pulmonar se procesaron mediante inclusión convencional de parafina, se tiñeron con H & E y se examinaron mediante el método de conteo puntual mediante muestreo aleatorio sistemático en un estudio estereológico. Los resultados se analizaron usando ANOVA de dos factores y LSD *post hoc* en α = 0,05
Resultados: Los resultados mostraron que el IIET causó inflamación severa en el tejido pulmonar y un aumento en la infiltración de células inflamatorias y linfocitos en los tejidos conectivos que rodean las vías respiratorias, los vasos y las lamelas intersticiales. Esta gravedad de la inflamación fue considerablemente mayor y similar en comparación con los grupos básico y de control (p = 0,001). El análisis estereológico en los grupos de *tapering* con *NS* y sin *NS* también, reveló una disminución significativa en el grado e intensidad de la inflamación del tejido pulmonar en las mediciones examinados en comparación con el grupo IIET (p = 0,001).
Conclusión: en general, se puede concluir que la realización de *NS* y un período de *tapering* de tres semanas tiene un efecto notable en la reducción de la inflamación en el tejido pulmonar seguida de entrenamiento de ejercicios a intervalos.

Palabras clave:
Aumento del entrenamiento de ejercicio interválico. *Tapering. Nigella sativa*. Pulmón. Inflamación.

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Introduction

Physical exercises with different intensity create different responses on the immune system function[1,2]. Increase in the volume and intensity of the exercise training along with a decrease in the recovery time may cause an overtraining in athletes and affect their immune system[3]. On the other hand, physical exercise can be a strong stimulus in the development of lung inflammation[4]. Findings of several studies shows that exercise training load beyond the normal range increases the risk of upper respiratory tract infection (URTI)[2,5] while moderate exercise not only decrease these risks but also reinforce the function of respiratory immune system[1,6]. Researches showed that the URTI symptoms in the most of the elite athletes are similar to general population[6], however, usual seasonal patterns of URTI are not seen in these athletes[7]. It is found out that short and long term physical exercise trainings with different grades and intensities affect the immunity and inflammatory factors in childhood and adulthood period[8]. There are still many unanswered questions on physical exercise mechanisms influencing inflammatory index before and during puberty[9].

Since mild inflammation in early stages is a helpful protective response against primary cellular damage factors which eliminates external invaders and necrotic tissue and also because too much inflammation causing severe damage to lung tissue can be life-threatening[10], it seems necessary to take some strategies in exercise training programs including taper to prevent overtraining and immune function decline[11,12]. Taper can be performed in the forms of frequency reduction, repetition and intensity of exercise training[3,13] in different time periods. One of the hardest challenges for sport science researchers and trainers is considered as to determine the most appropriate taper program[14]. Limited studies about intensity of exercise training during taper period showed athletes can make use of training intensity reduction programs in order to improve their performance in competition season[15]. Some reports reveled that time execution of swimmers[16], runners[17] and bike riders[18] improved due to taper programs. Previous studies suggest the favorable time period for taper is between 4 to 28 days or even more[8,13]. Though many studies have confirmed a two-week period taper, there have been some reports on the improvement of athletes' performance due to very short or very long period tapers[19]. Thomas *et al*.[3] concluded that the optimal time duration for taper depends on the training before the taper and no particular time limit can be specified for that.

Today, there are several methods other than taper such as medicinal plants using for reducing the symptoms of inflammation and boosting the immune system. Among these plants, *Nigella sativa L. (NS)* is a medicinal plant known in Iranian traditional medicine. This native plant has been used for the treatment of headaches, nasal congestion, asthma, and allergy as well as for boosting the immune system[20,21]. The biological properties of the seed of this plant include Anti-oxidative, anti-inflammatory, anti-tumor, anti-viral and anti-microbial effects as well as strengthening the immune system[22]. Previous studies indicated that *NS* has a protective effect in lung injury and pulmonary fibrosis[23,24]. Gholamzadeh *et al.*[25] revealed that *NS* has an anti-inflammatory effect and reduces pro/anti-inflammatory cytokine ratio in overtrained animals. They showed that this effect of *NS* is more pronounced in overtraining animals than control or moderate exercise animals. In fact, *NS* causes an immunoregulatory effect which somehow homogenizes immune state during different physiological status[25].

Since in the previous studies, the compatibilities of the high intensity trainings, the effects of taper and *NS* use during maturation period as to the inflammatory response of the lung did not come to a clear conclusion, this study was designed to investigate the effect of the performing different patterns of taper following a high-intensity interval training (HIIT) as well as influence of interactive effect of taper and *NS* on the microscopic properties of inflammation in lung tissue of male Wistar rats during maturation period.

Material and method

Animals

In this study, 95 male Wistar rats with an approximate age of 3 weeks and an average weight of 68±9 g were obtained from Pasteur Institute of Iran. In order to adaptation, animals (5 rats per cage) were maintained in transparent polycarbonate cages under controlled environment with a temperature of 23±2 ºC, humidity of 45-55 % and 12:12 hours light/dark cycle for two week. Throughout all stages of the study, ethics of working with laboratory animals such as free access to standard pellet diet and water *ad libitum*, euthanizing without pain, prevention of pain associated with surgery and sampling were taken into consideration according to the international recommendations about clinical and laboratory animals' researches, ratified in Helsinki and updated in 2008 by the American Physiology. After one weeks of familiarity with laboratory and manipulation, the rats were randomly divided into two control and exercise groups matched for their weight.

Exercise training program

The rats were divided into two control and exercise groups at first. Then, for getting acquainted with the treadmill, they performed the exercise training with the main pattern training including increasing interval training (IIT) but with a lower intensity for two weeks. After one week period of getting acquainted with the environment and the treadmill, they performed increasing interval undulating exercise training for six weeks and that was followed by 3 weeks of load reduction (taper) carried out by 3 models in two different times. Treatment and un-treatment with *NS* supplement was also observed during the tapering (Table 1). Finally, according to research design and sampling procedure after 6 weeks increasing interval exercise training, the first and third week of tapering, the animals were divided into 19 groups and each group included 5 rats.

The familiarity and compatibility phase included 4 sessions of interval exercise training per week with the speed of 10 to 25 meters per minute and the slope of zero percent lasting for 15 to 30 minutes. The increasing interval exercise training program was carried out in the form of 10 repetitions of 1 minute length and active rests of 2 minute length minutes in such a way that the total daily workout time for each rat was 30 minutes-long. The animals started the increasing interval exercise training at the speed of 25 m/min and ended it at the speed of 70 m/min[26]. Apart from the main activity, 5 minutes was estimated for warm-

Table 1. General specification of research protocol.

Weeks of training	Familiarization	1	2	3	4	5	6	7	8	9
Age (week)	4	5	6	7	8	9	10	11	12	13
Control	Control orientation	Control						taper control with *NS*		
								taper control without *NS*		
Interval training	Orientation	Training period						taper with *NS*		
								taper without *NS*		

Table 2. Increasing interval 6-weeks training program.

Week	Familiarization	First	Second	Third	Fourth	Fifth	Sixth
Training speed (m/min)	10-25	25-35	30-45	45-55	50-65	60-70	65-70
Rest speed (m/min)	10	10-20	15-25	25-30	25-35	30-35	30-35
Training duration (min)	1	1	1	1	1	1	1
Rest time between replications (min)	2	2	2	2	2	2	2
Set number	10	10	10	10	10	10	7
Session number per week	4	5	6	6	6	6	5

Table 3. Three weeks training program for reduced training load.

Groups	Last week pattern of increasing interval training All groups	Taper program		
		First taper (volume)	Second taper (frequency)	Third taper (intensity)
Training duration (min)	70	70	70	50
Rest duration (min)	25	25	25	25
Training duration (min)	2	2	2	2
Rest time duration (min)	10	7	10	10
Replication	6	6	4	6

ing up and 5 minutes for cooling down. This program was conducted in 6 weeks and each week included 6 sessions (Table 2). Following the increasing interval exercise trainings, the rats entered the taper phase in which *NS* supplement was used for the taper and control groups[27].

Preparation of hydro-alcoholic extract

Fifty five grams of *NS* powder was weighed with a scale of 0.001 precision and then was soaked in 30% distilled water mixed with 70% ethanol solution for 72 hours. During this period, the container of the solution was well sealed with paraffin and was kept at 20 to 25 ºC room temperature. The mixture was stirred with a glassy rod every six hours. After this period, the mixture was filtered through Whatman filter paper and its solvent was removed by mild temperature rotary (under 60 °C). Control and *NS* tapering groups was treated by extract via oral gavage at a dose of 500 mg/kg body weight.

Tissue sampling and histological studies

At the end of six week period of increasing interval exercise training, and at the end of the first and the third week of tapering (Table 3), the animals were euthanized with a mixture of ketamine hydrochloride (50 mg/kg) and xylazine (10 mg/kg), intraperitoneally and left lung was removed and fixed in a 10% buffered formalin solution. Lung tissue samples were dehydrated by passing through a graded series of ethanol and cleared by xylene and impregnated by paraffin. Tissue processing was done by histokinette 2000 (Lica, Germany) and samples were embedded in paraffin blocks. Then, 20 to 25 non-serial 5 µm sections from each block were obtained using rotary microtome and stained with hematoxylin-eosin (H&E). For quantitative and qualitative microscopic analysis of lung tissue, at least 10 microscopic fields from each section were examined at × 400 magnification using point counting and based on systematic uniform random strategy and unbiased stereological studies by a version 9 stereo-investigator system software (MBF Bioscience, Micro Bright Field, Inc., Germany). In each microscopic field, 0.016 mm^2 of lung tissue were analyzed. Inflammation index of lung tissue was evaluated using grading scale described by Braber *et al.*[28] based on the frequency and manner of the inflammatory cell presence. A value of 0 was assigned when no inflammation was detectable, a value of 1 was adjudged for occasional cuffing with inflammatory cells, a value of 2 when most bronchi or vessels were surrounded by a thin layer (one to

five cells thick) of inflammatory cells, and a value of 3 was given when most bronchi or vessels were surrounded by a thick layer (more than five cells thick) of inflammatory cells. Total lung inflammation was defined as the average of the peribronchial and perivascular inflammation scores[28]. All analyses were carried out by one evaluator who was blinded to the treatment groups.

Statistical analysis

All statistical analyses were performed using the SPSS software version 21. For the analysis of normal distribution of data, Kolmogorov-Smirnov test and for the comparison of the variables among groups, a two-way analysis of variance (ANOVA) followed by LSD post hoc test were used. Descriptive statistical data expressed as mean ± SD; differences of $p \leq 0.05$ was considered as significant and the rejection of null hypothesis.

Results

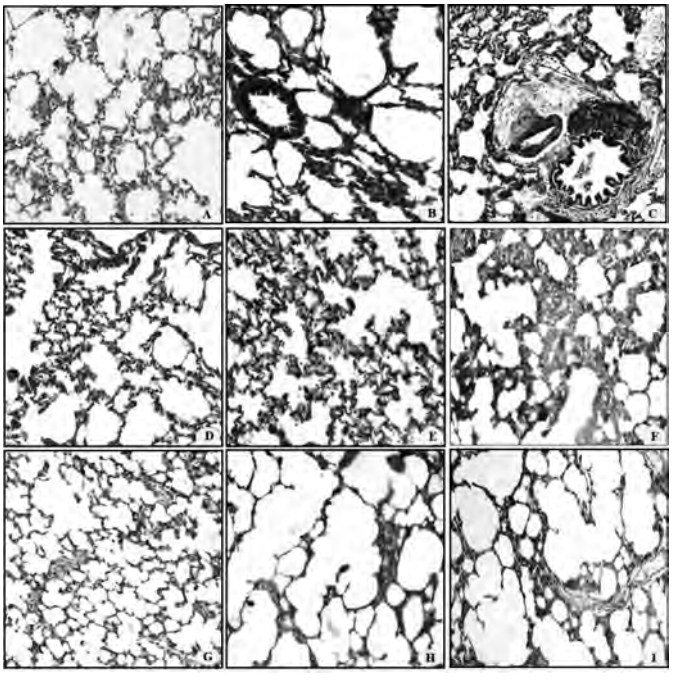
The study of histological structure of lung tissue has revealed that the lung parenchyma was normal in both control and basic groups (Figure 1-A and B). Structural integrity of lung tissue in taper groups treated by *NS* was greater and better than in the taper groups without *NS*. Furthermore, among the groups with *NS*, the third week taper groups had a better structure and a more integrated alveolus wall. The results of microscopic investigations showed that IIT had a significant effect on the lung tissue of rats during maturation period. These results indicated that the IIT caused severe inflammation in lung tissue and infiltration of inflammatory cells and lymphocytes into the connective tissue around the respiratory airway, vessels and interstitial lamellae (Figure 1-C). The taper exercises could decrease these damages in the lung tissue (Figure 1-D to 1-F). Although a small amount of emphysema, and mild interstitial inflammation was observed in some taper groups , this damage was less in the groups with *NS*, but the relative inhibitory effect of all three taper types were rather good (Figure 1-G to 1-I). Among these groups, the taper group treated with *NS* in the third week showed a better improvement in comparison to the other groups.

As it is shown in Figure 2, results indicated that the severity of lung tissue inflammation in control groups increased until the second week of tapering (age of 13 weeks) and then decreased. The severity of lung tissue inflammation in control groups without *NS* increased as similarly and significantly as in the basic and interval control groups (age of 11 weeks), (p=0.002). A similar and significant increase of inflammation has also been observed in the second week control animals with *NS* comparing with the basic and interval control groups (p=0.02). There was not a significant difference in the severity of lung tissue inflammation in the second week taper groups (age of 14 weeks) with and without *NS* comparing with the basic group (respectively p= 0.07 and p=0.30).

Figure 3 indicates that the implementation of the 6- week undulating and IIT (Table 2) during maturation period caused the most severe inflammation in lung tissue (grade 3) and the occurrence of this inflammation was similarly and significantly more frequent in comparison to the control and basic groups.

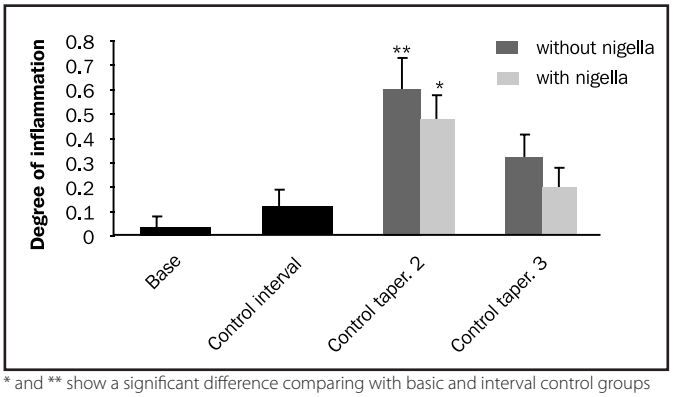
The results showed that the implementation of the three kinds of taper exercise training programs (frequency, repetition, intensity) following the IIT, could significantly decrease the amount and severity of lung tissue inflammation (p=0.001) in the studied times in comparison to interval training (Figure 4). After two weeks of frequency, repetition and intensity tapering, the degree of lung inflammation decreased 32, 49 and 52 percent respectively compared to the interval training and this decrease continued until the third week of the tapering (51, 52 and

Figure 1. Microscopic view of lung tissue in different groups (H&E, ×200).



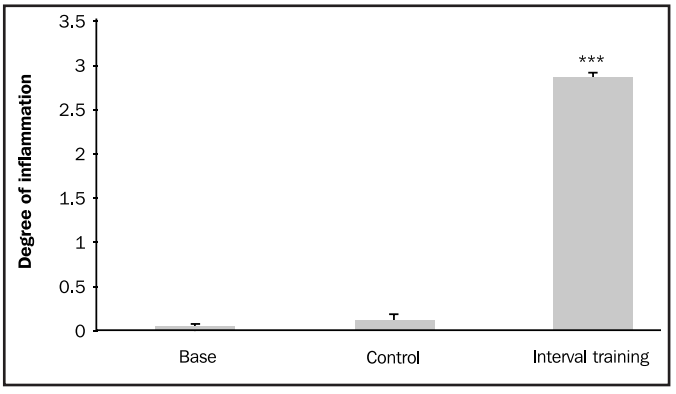
A) Normal lung tissue in the basic group; B) Lung tissue in the interval control group; C) IIT group with aggregation of lymphoid tissue and inflammatory cells around respiratory air way (solid arrow) and vessels (hollow arrow); D) two weeks control group without *NS*; E) two weeks frequency taper group without *NS*; F) two weeks repetition taper group without *NS*; G) three weeks frequency taper group with *NS*; H) three weeks repetition taper group with NS; I) three weeks intensity taper group with *NS*.

Figure 2. Comparison of lung tissue inflammation in control groups.



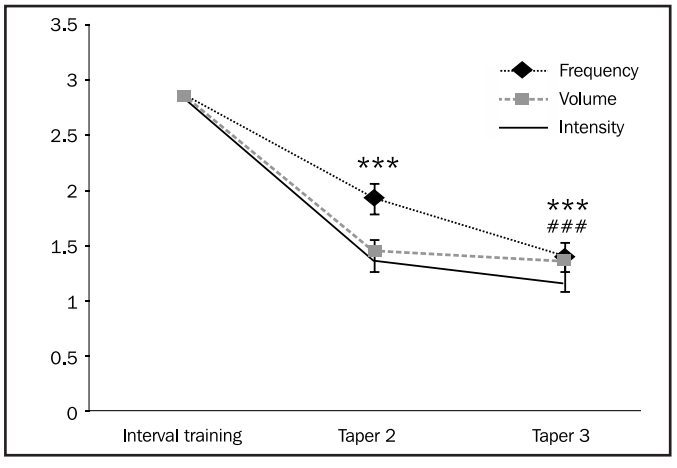
* and ** show a significant difference comparing with basic and interval control groups (respectively p<0.05 and p<0.01).

Figure 3. Comparison of lung tissue inflammation in the basic, control and increasing interval training groups.



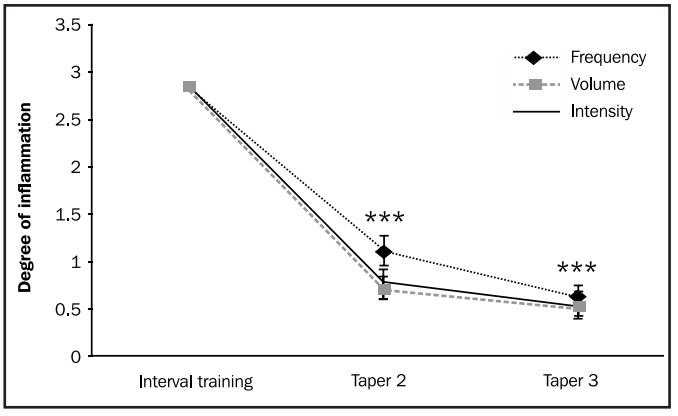
*** shows a significant difference (p<0.001) comparing with basic and interval control groups.

Figure 4. Comparison of lung tissue inflammation in interval and frequency, repetition and intensity taper groups without *N. sativa* over two and three weeks of tapering.



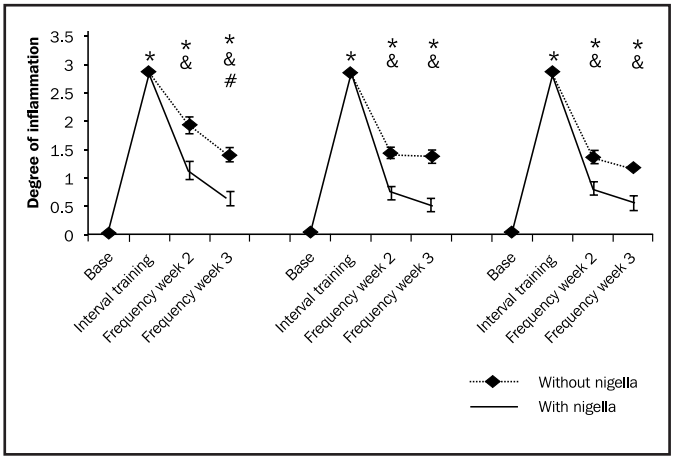
*** shows a significant difference (p<0.001) in three type of tapering comparing with increasing interval training group. ### shows a significant difference (p<0.001) in third week comparing with second week of frequency taper group.

Figure 5. Comparison of lung tissue inflammation in interval groups and frequency, repetition and intensity taper groups treated with *N. sativa* during the taper period.



*** shows a significant difference (p<0.001) in three type of tapering comparing with increasing interval training group.

Figure 6. Comparison of lung tissue inflammation in all groups of the study.



* shows a significant difference comparing with basic group. & shows a significant difference comparing with increasing interval training group. # shows a significant difference between 2nd and 3rd week of frequency taper group.

59 percent respectively in frequency, repetition and intensity taper). The results as summarized in Figure 4 also revealed that, compared to frequency and repetition taper groups, intensity decreasing taper group acted more effectively in the reduction of lung tissue inflammation.

The evaluation of the time effect on lung tissue inflammation showed that lung tissue inflammation was reduced 27, 6 and 15 percent respectively in the frequency, repetition and intensity taper groups of the third week compared to the second week (Figure 4). This reduction was significant only in frequency taper (p=0.001, p=0.60 and p=0.195 respectively in frequency, repetition, and intensity groups).

The evaluation of interactive effect of *NS* hydro-alcoholic extract use (as a supplement) and the implementation of different patterns of taper revealed the same amount of decrease in lung tissue inflammation as the groups without *NS* (Figure 5). The frequency, repetition and intensity groups, with a decrease of respectively 61%, 75% and 72% in the second week and a decrease of 77%, 82% and 80% in the third week, showed a similar and significant decrease in lung tissue inflammation comparing with interval exercise training group (p=0.001). In the survey of the time effect, a decrease of 43%, 28% and 30% in lung tissue inflammation was observed in the third week frequency, repetition and intensity taper groups compared to the second week taper groups. This change was significant only in frequency taper group (p=0.002, p=0.195, p=0.120 respectively in frequency, repetition, intensity groups).

The results of the present study showed that the degree of lung tissue inflammation in all taper groups was significantly higher comparing to their counterpart (p=0.04) and basic (p=0.001) groups. As it is shown in Figure 6, the use of hydro-alcoholic extract of *NS* in the taper groups could decrease the amount of lung tissue inflammation caused by interval exercise. Lung tissue inflammation in the frequency, repetition and intensity groups treated with *NS* in the second week decreased

respectively 42%, 54%, and 50% comparing with the groups untreated with *NS* and this decrease was respectively 62%, 41% and 52% in the third week. In short, it can be concluded that the increasing interval exercise along with the implementation of intensity and repetition tapers and using the hydro-alcoholic extract of *NS* in a time period of three weeks had the most decrease in lung tissue inflammation.

Discussion

This study analyzed the microscopical changes and structural remodeling of lung tissue caused by inflammation in it through implementation of a period of increasing interval exercise followed by different patterns of tapering during maturation period. Since changes in the control groups can indicate changes in the lung tissue during maturation period, this study was designed to analyze the maturation process as well. The age range for the research protocol was 5-14 weeks. According to Sengupta[14] this age range in rats is equivalent to the age range of 6-16 years old in humans. Therefore the male rats in the control groups, treated and untreated with *NS*, were in their maturation period in the second week of tapering. It is assumed that the significant increase of lung tissue inflammation in these groups is due to being in the critical period of maturation which is related to developmental changes of immune system brought about by maturation and increasing efficiency of antigenic system[9].

Our results showed that the implementation of increasing interval exercise during maturation period causes severe lung tissue inflammation and leads the inflammatory and lymphoid cells into it. Although the amount of lung tissue inflammation in different periods and different patterns has decreased in animals both treated and untreated with *NS* hydro-alcoholic extract, but it is still significantly higher in comparison to the basic and control groups. It is concluded that this is because of the downfall of immune system which occurs following a high-intensity exercise over a long period of time[5].

Although several different studies have been done about the influence of high intensity exercise on the immune system and the inflammatory factors in the body, but this study is unique for the microscopical analysis it makes on the influence of high intensity exercise on the immune system of lung tissue and occurrence of inflammation in it, using histological and stereological methods. A few studies have been done about the effects of high intensity exercise on immune system function The presence of pulmonary macrophages is very essential in adjusting the acute and chronic inflammatory responses and the call of into the spreadable site of inflammation in the lung[29]. Michna *et al*.[30] observed that, after a period of intense training, the immigrant peritoneal macrophages of humans and mice had a better performance in responding to the chemotactic factors. The previous studies showed that acute and chronic exercise training has an effective catalytic role in many macrophage functions. On the other hand, the increasing rate of macrophage function varies according to the intensity and duration of exercise[31].

Previous study by Sobhani *et al*.[32] showed that HIIT in maturing rats cause in airway narrowing of the lung parenchyma. Yadegari *et al*.[33] also indicated that HIIT leads to parenchymal remodeling in lung tissue by induction of inflammation. Our recent research revealed that six weeks HIIT significantly increase number of alveolar macrophage in lung tissue[34]. Review of Ramel *et al*.[35], Murphy *et al*.[36] and Yamamoto *et al*.[37] studies suggested that high intensity physical activities increases the number of neutrophils, while this increase has not been observed in low intensity physical activities.

Some studies showed that, the function of lymphocytes, in long periods, is sensitive to the increase of exercise intensity in endurance activities[38,39]. It can be concluded that, high intensity exercises decrease the function of lymphocytes and macrophages due to an increase in the circulation of stress hormones, especially cortisol, and a change in the balance of pro-inflammatory or anti-inflammatory cytokines when responding to the exercise training[38]. In a study conducted on 18 swimmers on the national level and 11 healthy untrained volunteers, it was found out that the number of monocytes, neutrophils and dendritic cell subsets as well as the amount of IL-1β, IL-6, and IL-12 decreases in these athletes during the training season. The results of this study supported the idea that long-term high intensity exercise may affect the innate immune cells function, reduce their capacity in responding to acute challenges, and increase the risk of URTI[40].

Previous studies have shown that daily repeated physical activity during long periods, in athletes and especially endurance athletes, induces damage to the epithelium cells and increases the inflammation in their respiratory mucosa[41]. Thus, it can be concluded that despite of multiple mechanisms of innate and adaptive immunity being there, the implementation of high intensity exercise training, weakens the immune system of the lung tissue. The reported severity of inflammation in the lung tissue of IIT animals in this study also confirms this possibility.

For a reduction of disorders in immune system, physiological capacity and mood state profiles of athletes following a long-term and intensive exercise, performing a taper with a gradual reduction in the load of exercise can be recommended by the sport trainers to the athletes as an appropriate approach[13]. The results of this study showed that the implementation of taper patterns (frequency, repetition and intensity) after a period of IIT, could significantly decrease the lung tissue inflammation caused by intensive exercise training but the inflammation was still significantly higher in comparison to the control group after 3 weeks of taper. Regarding the time effect of the taper, the implementation of a three-week repetition and intensity taper was more effective in enhancing the immune system and reducing the lung tissue inflammation subsequent to intensive exercise than a two-week taper. The results of this study were in line with previous studies[3,42].

Mujica *et al*.[42], having observed the trained athletes during 1-3 weeks of taper, reported enhanced performance often accompanied by increased anabolic activity, reduced physiological stress and restoration of mucosal immunity and immune function. It has also been shown that a 6-day taper in the middle-distance runners improved the performance in 800 meter runners[16]. Two weeks taper in triathletes[43], one week taper in rugby league players[44,45] and two weeks taper in judo athletes[11] resulted in increased T/C ratio and improved performance. It can be concluded that the recovery or the enhancement of immune system function during taper is dependent on the amount of immune system diminution during intensive exercises[3].

On the other hand, by the increase of volume and intensity of training during the pre-competitive season, sport trainers will also concern

about serious matters other than increased risk of sport injuries and URTI development. One of these concerns is the increasing tendency of athletes to take sport medicines and chemical supplements, some of which are completely ineffective in long term use[3]. Herbal drugs and supplements as natural treatment (complementary treatment) with fewer side effects and multiple properties can be the best alternative for athletes[46].

In the last three decades, extensive research has been done on the biological effects of *NS* seeds. In numerous scientific articles, the antioxidant, anti-inflammatory, immune booster and antihistamines properties of numerous compounds in *NS* hydro-alcoholic extract have been pointed out[47]. One of the special features of *NS* is its role in regulating immune function in treadmill exercised rat[25]. The effect of *NS* hydro-alcoholic extracts use on the reduction of lung tissue inflammation[23,24] specially induced by intensive exercise training has also been observed in this study. While the implementation of different patterns of taper reduced the lung tissue inflammation, but *NS* hydro-alcoholic extracts use enhanced this reduction.

Although the amount of lung tissue inflammation in the animals significantly decreased in all three types of taper treated with *NS*, in comparison to their counterparts, but the implementation of three weeks of intensity and repetition taper accompanied by *NS* hydro-alcoholic extracts use, was more effective in the reduction of lung tissue inflammation induced by intensive exercise. Previous studies have indicated that some of *NS* compounds have the effect of reinforcing the cellular immunity[48]. Thymoquinone's anti-inflammatory properties, the major compound of *NS* extract, works through the suppression of inflammatory mediators such as prostaglandins and leukotrienes[49,50].

This study is among the few studies that examine the effect of taper on lung tissue safety mechanism during maturation period. The results of this study showed that although increase of interval training intensity has been undulating and gradual but the immune system of the lung tissue is not able to cope with that and it causes severe inflammation in the lung tissue. This problem during pre-maturation period may have a negative effect on the performance of the athletes and the results of the competition or even negative effects on the future of their sport. Our results indicated that the implementation of three types of taper decreases the lung tissue inflammation induced by IIT. It can be concluded that a reduction in the load of exercise alone can compensate for the induced weakness, or enhance the immune function so that the lung tissue inflammation decreases. But since the interactive effect of *NS* hydro-alcoholic extract use and taper was more effective in the reduction of lung tissue inflammation, we can conclude that reducing the exercise load accompanied by *NS* hydro-alcoholic extract use associated with particular anti- inflammatory properties, has a more prominent role in safety mechanism of lung tissue. Thus the implementation of taper along with *NS* hydro-alcoholic extract use will enhance the immune system of the lung tissue during maturation period and subsequently reduces the induced damages. It may also make the sport life span longer. Decrease of the intensity or frequency of the exercise load is a good pattern for taper program. However the results of the study revealed that the implementation of 3 weeks taper is more effective in the reduction of lung tissue inflammation than 2 weeks taper. It is suggested in the future studies, Changes in various factors of innate and adaptive immunity of lung tissue in pre-maturation period induced by increasing interval exercise or taper as well as the optimal taper duration in human models should be studied.

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Conflict of interest

The authors do not declare a conflict of interest.

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Androgens from physiology, through pharmacy and pharmacology to the status of lifestyle drugs - are we going in the right direction?

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Summary

The aim of this review was to evaluate the current cognition about androgens (A) physiology, their pharmaceutical development and place in modern medicine. Special aspect was to explore the reasons and consequences of A use as so-called "lifestyle drugs" (LD).

To write this review, we used the scientific papers in English of a recent date on PubMed, reference textbooks, books and monographs of different disciplines, as well as official documents and reports of some internationally recognized organizations (European Medicines Agency, World Anti-Doping Agency, Medicines and Healthcare products Regulatory Agency).

Endocrinological role of A is generally known, but their non-hormonal effects are still the subject of intensive investigation. For decades, testosterone (T) and its esters have been the substitution therapy of the first choice in clearly defined clinical conditions. When it comes to pharmaceutical development, there are large number of effective and safe T formulations on the market which provide a very good patients' compliance. Regarding clinical application of synthetic A with dominant anabolic activity, the only acceptable indication nowadays is severe burn injuries, while others have to be proven by high-quality clinical studies. Particularly worrying is the wide-spread use of anabolic steroids (AS) for non-medical purposes, as so-called LD. Although numerous and serious side-effects are well-documented, general impression is that both users of AS and clinicians should know more about the risks of their use.

This review points to the need of better information and more comprehensive education at different levels, as well as implementation of additional preventive strategies, especially in the youth population, in order to avoid potentially serious consequences of the AS use.

Key words:
Androgens. Physiology. Pharmacy. Pharmacology. Lifestyle drugs.

Andrógenos, de la fisiología, a través de la farmacia y la farmacología al estado de las drogas de vida, ¿vamos en la dirección correcta?

Resumen

El objetivo de esta revisión fue evaluar el conocimiento actual sobre la fisiología de los andrógenos (A), su desarrollo farmacéutico y su lugar en la medicina moderna. Un aspecto especial fue estudiar las razones y consecuencias del uso de llamadas "medicamentos de estilo de vida" (LD).

Para llevar a cabo esta revisión, se realizó una búsqueda de artículos científicos en inglés recientes en PubMed, libros y monografías de diferentes disciplinas, así como documentos oficiales e informes de algunas organizaciones reconocidas internacionalmente (Agencia Europea de Medicamentos, Agencia mundial Antidopaje, Agencia Reguladora de Medicamentos y Productos Sanitarios).

El papel endocrinológico de los A es generalmente conocido, pero sus efectos no hormonales siguen siendo objeto de una investigación intensiva. Durante décadas, la testosterona (T) y sus ésteres han sido la primera elección para terapia de sustitución en condiciones clínicas claramente definidas. Cuando se trata del desarrollo farmacéutico, hay una gran cantidad de formulaciones de T eficaces y seguras en el mercado que proporcionan un muy buen cumplimiento por parte de los pacientes. Con respecto a la aplicación clínica de A sintético con actividad anabólica dominante, la única indicación aceptable en la actualidad son las lesiones por quemaduras graves, mientras que otras deben ser probadas por estudios clínicos de alta calidad. Particularmente preocupante es el uso generalizado de los esteroides anabólicos (AS) para fines no médicos, como los llamados LD. Aunque los efectos secundarios son numerosos y graves, la impresión general es que tanto los usuarios de AS como los clínicos deberían saber más sobre los riesgos de su uso.

Esta revisión apunta a la necesidad de una mejor información y una educación más integral en diferentes niveles, así como la implementación de estrategias preventivas adicionales, especialmente en la población joven, para evitar consecuencias potencialmente graves del uso de AS.

Palabras clave:
Andrógenos. Fisiología. Farmacia. Farmacología. Medicamentos de estilo de vida.

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Introduction

Male sex hormones or androgens (A) and their role in the human body are being learnt from elementary school. Later, at schools and faculties of health care, students learn about diseases and conditions that result from their insufficient or excessive secretion. Medical doctors and pharmacists know most about A as medicines, while other professions, as well as the general public, know very superficially or to the extent of their own needs or interests. As with many other medicines, some indications for A use are unquestionable and generally accepted from both clinicians and regulatory bodies, while others are still waiting for valid evidence.

However, unlike most other drugs it is well-known that different substances with androgenic actions were used by people without any medical diagnosis, in order to increase muscle mass, strength and endurance[1-4]. Available data show that those were first German soldiers[1], later Russian and American athletes[2,3], and since the eighties of the last century these substances have "entered" into the widest population of young and middle-aged individuals whose physical appearance and muscle mass have become the basic life preoccupation[4]. In official literature these substances got the status of lifestyle drugs (LD)[5]. Possible risks and consequences of their use, including cases of death, are well-documented[6-8]. The extent and importance of this problem is indicated by the data that in some countries, such as Netherlands, an outpatient clinic for past and current users of those substances was established in 2011 in order to acquire more knowledge about the health risks associated with anabolic androgenic steroids abuse[9].

The objective of this review was to evaluate critically and in detail the current cognition about A physiology, their pharmaceutical development and place in modern medicine. Special aspect was to explore the reasons and potential consequences of their use for non-medical purposes as so-called LD and to point out the importance of better education and preventive strategies in this area, especially in youth population.

Methods

Various literary sources were used to write this review. Initial data were obtained from textbooks, monographs and other books in pharmacology and clinical pharmacology, physiology, pharmacy, endocrinology and various sports sciences. The inclusion criteria for these publications were the following: a publication of a newer date which is internationally recognized (or used in university teaching), written in English and issued by a renowned publisher. Older date publications that are not of an international character and not published in English were not taken into account. For a more detailed insight into individual parts of this review, we searched the "PubMed" database, using a number of keywords and determinations. Here the criteria for inclusion were the following: publication had to be original scientific paper or review (including studies on animals and other types of experimental studies) published in English in the period 2000-2018. Priority was given to the results of randomized, controlled, double-blind clinical studies with a large number of participants. In exceptional cases, older papers were quoted, where this was of substantial importance for the research subject. Case studies, papers without the author's name and papers which weren't written in English were not taken into consideration. The last source of information was official websites of internationally recognized regulatory institutions (European Medicines Agency-EMA, Medicines and Healthcare products Regulatory Agency-MHRA and World Anti-Doping Agency-WADA) from which the latest reports, recommendations and documents were taken. The authors accessed these sites for the last time in November 2018.

Androgens as physiologically important substances - can we live without them?

Testosterone (T) is a major natural A. It is mostly synthesized in testicular Leydig's cells and smaller amounts in the ovaries and adrenal cortex from cholesterol as the initial substance. In a healthy adult male, 4-9 mg of T is excreted daily and only 1-2% is free in plasma[10].

Androgenic effects of T are spermatogenesis and development of primary and secondary sexual characteristics of a man, including characteristic hair distribution on the body, baldness, a specific voice depth, increased skin thickness and firmness of the subcutaneous tissue, increased secretion of the sebaceous glands with the appearance of acne, etc. Anabolic effects of T include protein synthesis and muscle development, bone growth and calcium storage, increased basal metabolism, increased number of erythrocytes, and others[11]. Behavioral effects of T include the regulation of sexuality, aggression, cognition, emotion, and personality[12,13].

T precursors, dehydroepiandrosterone (DHEA) and androstenedion are less potent A which are synthesized in the gonads and adrenal cortex in both sexes. In the liver they are being converted into more potent T[14]. DHEA and its metabolites regulate glandular and neurotransmiter secretions, influence glucose homeostasis and cyclic release of GnRH, control the activity of skeletal and smooth muscle and increase the tolerance to ishemia[15]. Additional neuroprotective effects, positive modification of human mood, emotions and behavior were also found[16]. Although in recent decades the popularity of these substances has grown because of their use in doping[17], existing data doesn't confirm their effectiveness regarding the lean body mass, muscle strength or performance improvement compared with placebo[18,19] (Figures 1 and 2).

In most peripheral tissues T is being converted in more active dihydrotestosterone (DHT) by 5alpha-reductase. Inhibitors of this enzyme (finasteride and dutasteride) have being traditionally used in the

Figure 1. Structural formula of dehydroepiandrosterone.

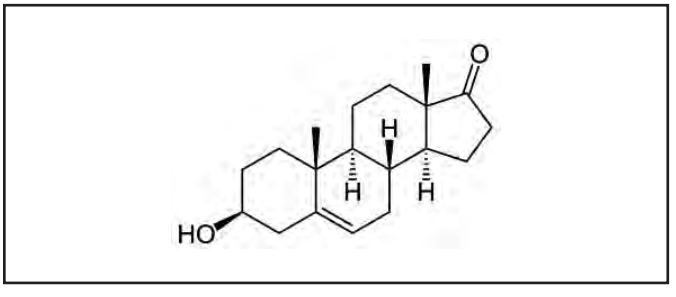
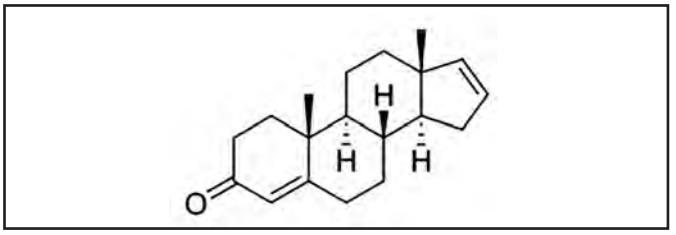


Figure 2. Structural formula of androstenedione.



treatment of benign prostatic hyperplasia. Their use reduces the incidence of low-grade prostatic carcinoma in high-risk patients[20,21]. Recent studies in experimental animals have found some non-hormonal effects of these medicines, such as reduction of dyskinesia in Parkinson's disease, anti-nociceptive and anti-inflammatory actions and the improvement of motor, EEG and celular changes in hepatic encephalopathy[22-24]. This could expand the existing knowledge about A physiology and open new possibilities in the treatment of some CNS diseases. Paba S, *et al*.[25] identified the 5alpha-reductase as possible novel therapeutic target in the treatment of schizophrenia.

Androgens as medicines - is the science fully dedicated exclusively to the well-being of the patient?

There have always been pathological states that have caused a lack or complete absence of A in the body of a man, with accompanying clinical manifestations. In that sense, it was imposed the need for designing and synthesizing substances which could, if applied exogenously, replace their deficiency and improve clinical symptoms. According to recent data, approximately 2.4 million males in USA aged 40-69 years old suffer from hypogonadism[26]. About 2.3% of men in their 40s and 3.8% of men in their 60s were taking some form of T replacement therapy in 2011[27].

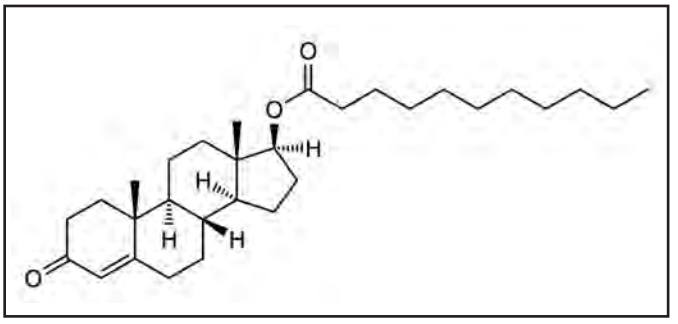
Testosterone and testosterone esters

Knowing the fact that T administered orally is the subject of so-called "metabolism of the first pass" through the liver to a significant extent[14], Butenandt and Ruzicka synthesized T in the injection for the first time in 1935, that is considered as the beginning of the golden age of steroid chemistry. Four years later these scientists got the Nobel Prize in Chemistry[1]. However, T administered even in this way had a short duration of action due to intense biotransformation (half-life of 10 minutes)[28], so patients were forced to receive it frequently.

In order to ensure the prolonged action of T, the science went on. In the 1940s and 1950s, the first T esters were synthesized (propionate, cypionate, enanthate). These esters are still in use and they are administered as intramuscular depot injection at intervals of 1-6 weeks, according to patients individual requirement[29,30].

In the mid-seventies there was a new progress. It was synthesized T undecanoate, also T ester in the form of depot intramuscular injection[10]. It has provided stable plasma levels of T over three months, which has been a significant advantage for patients[31] (Figure 3).

Figure 3. Structural formula of testosterone undecanoate.



Certainly, the revolutionary discovery of the 1980s was transdermal application of T as an alternative to painful injection[28]. The first effective transdermal patches were applied in the scrotum area because of very good pharmacokinetics and potency[10,29]. Smaller skin surface area and application challenges (hair clipping), as well as the apparence of transdermal patches which could be applied at back, abdomen, upper arms or thighs limited the use of formulations for scrotum application[29].

Further discoveries went in the direction of hydroalcoholic gels/liquid solutions for transdermal absorption[10]. In order to minimize transfer, recommended sites for their application are areas which will be covered by clothing[29]. There are also formulations for application to buccal mucosa, from which T is gradually absorbed, bypassing hepatic metabolism[10]. Modern T implants for subcutaneous administration provide the replacement of T for a period of even 6 months[29]. The latest discovery was nasal gel, as another non-invasive treatment[29].

Synthetic androgens

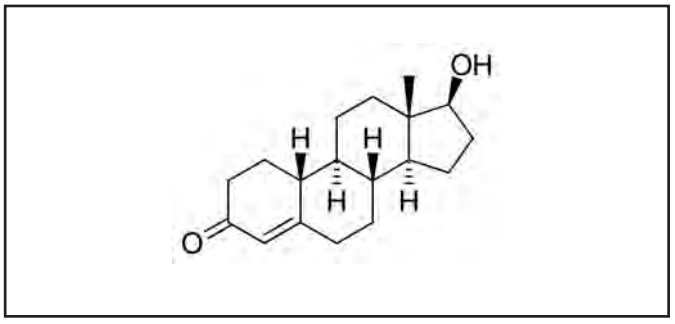
There were three main reasons for design and synthesis of synthetic androgens (SA): the possibility of oral administration, the prolongation of biological activity in vivo and the increase of anabolic compared to androgenic effects[32]. Those modifications were expected to improve the possibility of clinical application of SA, that can be considered justified from the professional, scientific and ethical point of view.

Oral activity was achieved by substitution of the 17α-H on the steroid nucleus with a methyl or ethyl group, which prevented the deactivation by first-pass metabolism in the liver[12]. Methyltestosterone was the first synthesized medicine in this group (1935), and others were synthesized later[17]. However, the attempt to introduce these medicines into the long-acting replacement therapy (LART) was unsuccessful because of their hepatotoxicity[17].

Another form of structural modification of A was 5α- reduction. Mesterolone was synthesized in this way, but it's oral administration in LART was limited due to relatively weak pharmacological activity[12] and unconfirmed efficacy in standard doses[33].

Nandrolone (N) is 19-demethylated analogue of T which also cannot be taken orally because of extensive first-pass metabolism in the liver[34]. However, the third goal (very high ratio of anabolic to androgenic action[12] was achieved with N, that could be an explanation for its current status of the most popular A in sports doping and bodybuilding[35] (Figure 4).

Figure 4. Structural formula of nandrolone.



In order to enable its medical application, there were developed long-acting pro-drug esters of N (but not for oral use, for intramuscular injection again!), such as N decanoate (ND). Both experimental and clinical studies confirmed positive effects of ND on bone tissue. Li X *et al.* found ND blocked bone loss by inhibition of bone resorption in ovariectomized rats with osteopenia[36]. Newer investigation on young adult rats found a positive effect of ND on bone callus formation after a complete femoral fracture[37]. In women with postmenopausal osteoporosis ND increases bone density and reduces the incidence of fractures[38,39], but according to reference recommendations, such as UK Clinical Guideline for the Prevention and Treatment of Osteoporosis[40], bisphosphonates are considered as drugs of the first choice.

Androgens as medicines - what does the evidence-based medicine say?

Substitution therapy

T is used as substitution therapy of the first choice in conditions which cause primary testicular insufficiency, such as bilateral anorchia, Klinefelter's karyotype (XXY), surgical removal of the testes, chemotherapy and radiotherapy, but also in secondary testicular insufficiency which occurs as the result of disturbance on the hypothalamic-pituitary axis. Another reason for T clinical use is delayed puberty in boys ages 16 and older[10].

Substitution of T in aging men in andropause, according to some authors[41-43] has a positive effect on bone mineral density and lean mass, sexual function, mood, general sense of well-being and reduction of the amount of adipose tissue. Considering this issue in recent review, Singh P concluded that "disparate results of clinical trials suggest an incomplete picture of complex interaction between aging and A deficiency". Before commencing T treatment, he suggested clear discussion with the patient about potential benefits and risks of the therapy, as well as to consider the assessment of prostate and other risk factors[44].

Controversies regarding the diagnosis of female hypoandrogenism and possible T substitution are still unresolved[45]. T therapy is not approved for women in North America[46]. In EU, T-containing medicines are licensed only for the treatment of male hypogonadism[47]. Additionaly, the long-term side effects of T in women have not yet been fully investigated[48,45].

Due to relatively weak anabolic effect, as well as adverse A effects, T is rarely used in catabolic conditions. The exception is hypogonadism as the consequence of the AIDS[17]. Rabkin JG *et al.* found in their double-blind, placebo-controlled trial that T is effective and well tolerated in the short-term treatment of clinical hypogonadism in men with symptomatic HIV illness, restoring libido and energy, alleviating depressed mood and increasing muscle mass[49]. Long-term studies regarding this issue are still missing.

Pharmacological therapy

Except in physiological doses that are used in replacement therapy, A may be administered in considerably higher doses as pharmacological therapy. This type of therapy was mainly used in some non-reproductive diseases in order to improve the patients' quality of life (QoL) by enhancing muscle, bone, or other A-sensitive functions, but without ability to influence the course of underlining disease[35]. This type of A therapy was mentioned in the literature mostly from the last decades of the XX century for several medical indications, including anemia as a result of bone marrow aplasia or renal failure[50-51], osteoporosis[38-39], advanced ER-positive breast cancer[52-53], endometriosis[54-55], burn injuries[56-57], and others[35,58]. Woerdeman J, *et al.*[59] analyzed relevant clinical studies with anabolic androgenic steroids (AAS) in the treatment of non-hormonal chronic disorders published in the period 1950-2010 and they concluded that although the beneficial effects of AAS were promising, clinically relevant endpoints such as QoL, improved physical functioning and survival were mainly missing or not significant, except for burn injuries. Both Woerdeman[59] and Handelsman[35] pointed to the need for additional, high-quality clinical studies with the exact clinical end points in order to confirm the long term safety and efficacy of AAS in other non-hormonal clinical conditions. An additional reason for current status of A as adjuvant, supportive or adjunctive second-line therapy is the introduction of newer, more selective and more effective medicines in these indications (erythropoietins for anemia in renal failure, biphosphonates for osteoporosis, etc.).

After the previously stated, it can be concluded that modern, evidence-based medicine clearly positions T and its esters as the first-line therapy in LART in men, but when it comes to the pharmacological application of SA with dominant anabolic activity, the only reasonable indication is severe burn injuries, while others have to be proven.

Anabolic steroids - medical indications as a goal or a justification?

According to Thieme D, *et al.*[1], anabolic steroids (AS) were first synthesized by German scientists during the Second World War, shortly after the discovery of T itself. They are believed to have been tested on people, especially prisoners, but those results have never been published. Some personal war experiences of the surviving German soldiers speak of how they were given AS in order to increase the strength and aggressiveness. Adolf Hitler also used steroids in order to strengthen his aggressive personality, that was confirmed by notes of his doctor[1]. Thus, the first use of AS in healthy people and for non-medical purposes was

in German soldiers during the Second World War in order to increase their strength, endurance and aggressiveness.

The use of AS in athletes was noted for the first time at the weight-lifting championships in Vienna in 1954 by Russian competitors[2]. Two years later CIBA Laboratories in Basel synthesized metandienone (Dianabol®) for the US Olympic Team[3]. In following decades A abuse quickly spread into competition bodybuilding, track and field events and other sports where performance is dependent on muscle strength or speed of recovery during training[60].

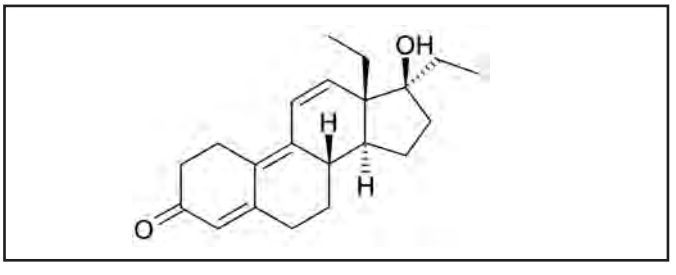
However, at the beginning of 1980s, the conditions were changed globally and AS gradually shifted from top-class sports to the general population[4]. According to Kanayama G, *et al.*[4], a typical "user" of AS nowadays is young to middle-aged man whose motivation for their use is primarily personal appearance and muscle mass. It is clear that the use of those substances in this context is not caused by any existing medical diagnosis.

Although 23 different definitions of LD can be found in the literature[61], the most operational one is that "LD are drugs that could modify or change non-medical or non-health-related goal or conditions at the margins of health and wellbeing" [62,63]. The examples of LD should be sildenafil citrate in the treatment of erectile dysfunction, minoxidil for the baldness, botulinum toxin for "ironing" wrinkles, etc.[61] Satisfying the criteria of LD definition, AS "found their place" among substances of the modern times which alter not only the personal appearance, but also the physical and mental capabilities. Although all of these substances have the status of LD, a significant difference should be noticed: erectile dysfunction and male-pattern hair loss are official medical diagnoses that are treated by licensed medicines, but facial wrinkles and personal dissatisfaction with the amount and tonus of muscle mass in own body are not yet, that doesn't mean that they will not be soon. Or, maybe they actually exist, but we still don't know their name(s).

Designer steroids - did things get out of control?

Designer steroids (DS) are AAS which are synthesized from a known parent steroid and chemically modified with the intent to circumvent controlled substances laws[64-65]. They are often identical to physiological substances and/or their metabolites whose concentrations in human plasma otherwise vary significantly, which makes it difficult to detect them[5]. The first DS, tetrahydrogestrinone (THG) was discovered in 2003 in the Olympic Analytical Laboratory at the University of California, Los Angeles[66] (Figure 5).

Figura 5. Structural formula of tetrahydrogestrinone.



The disappointing thing is that, unlike the previously described AS, the discovery and development of DS have never been linked (in theory or practice) with any medical indication, which could justify their design and synthesis to a certain extent, at least from the ethical point of view. Cheating athletes have a double motivation to use DS: to achieve performance enhancement and to escape from testing positive in anti-doping tests. Both can be considered as deception in sport and human sense. The fact that the first and probably many other DS were synthesized in laboratories belonging to universities could be considered as the deception of science. In their discovery and development are working persons (scientists) for which the ethics and the truth should be the basic principles of their professional dealing. An increasing number of DS on the market which are mainly sold as dietary supplements[67] should be the next fraud in sequence. "Bypassing" a strong regulatory rules that refer to licensed medicines, DS become more easily accessible and potentially more dangerous for end-users.

According to Pope HG, *et al.* (2004), AAS users rated physicians as no more reliable source of information about those substances than their friends, Internet sites, or the persons who sold them the steroids[68]. On the other side, most general practitioners had some contact with AAS users in their practice, but only 40% of them reported that they would be willing to provide harm minimization advice[69].

Previously stated indicates the seriousness and complexity of this phenomenon globally, as well as the need for additional effective actions at different fields.

How anabolic steroids act on healthy human organism - do we know possible consequences?

For years, AS have been the most commonly detected doping substances in athletes[70]. In 2015, according to the WADA report, AS participated exactly 50% in all positive findings on doping[71]. In combination with training and high protein intake, AS undoubtedly increase muscle mass and body weight, but there is little evidence that they increase muscle strength more than it would have been possible by the training itself, or that their use would improve sports results in general[5].

Given the disturbing fact that in the last decades AS have been increasingly used to improve the physical appearance of young people who are not primarily athletes[4] for aesthetic, psychological, sociological and other non-medical and non-sporting reasons, then we can state regrettably that, in this sense, these substances are likely to satisfy the needs of their users, at least for a limited period. On the other hand, since they are applied for a long time in supra-physiological doses, which are usually up to 50-100 times higher compared to endogenously produced T in an adult healthy male[72], their application is associated with long-term and serious adverse effects, of which cardiovascular, neuroendocrine and psychiatric are dominant[6,7]. The entity of side effects depends on the sex, the dose, the duration of treatment, whether AS are taken during exercise training or under sedentary conditions, and individual susceptibility to A exposure[73].

Adverse *cardiovascular disorders* include hypertension, an increase of LDL and reduced HDL, potentiation of thrombosis and cardiac arr-

hythmias, cardiomyopathy, left ventricular hypertrophy and myocardial ischemia[74,75]. Melchert and Welder[76] categorized cardiovascular effects of AS in four types of actions: vasospastic, atherogenic, thrombotic and direct myocardial injuries. Frati P, *et al*. (2015) identified nineteen sudden cardiac deaths (SCD) in AS users in the period 1990-2012[8], which probably could be attributed to an imbalance of autonomous nervous system activity[77]. Some authors suggest that in the cases of SCD in athletes the use of AS should be excluded[74].

The *endocrinological effects* of AS depend on the age and sex of the person using them[14]. In adult males, anabolic effects may be accompanied by salt and water retention. The skin becomes thick and often darker, the sebaceous glands become more active, resulting in the appearance of acne[14]. AS use causes gynecomastia, priapism, hypogonadism, inhibits spermatogenesis and reduces the man's fertility[78]. These influences adversely affect the mood, that forces a man to take these substances repeatedly. BPH and prostate cancer in AS users were also described[78]. In women AS cause hairiness, male pattern baldness, menstrual cycle disorders, breast atrophy, changes in voice depth, acne, etc.[14,78]

At the *psychological plane*, AS cause a sense of well-being, increase competitive spirit and aggressiveness, in some cases even to the level of psychosis[14]. Violence, aggression and impulsivity are explained by some authors as the consequence of decrease in the functional correlation of key centers in the brain responsible for emotional and cognitive behavioral regulation[79]. Depression which usually requires long-term psychiatric treatment develops very often at the end of applied "cycle" of AS[5]. A numerous cases of suicide in AS users with some specificities in comparison to suicides caused by psychoactive substances were described[80,81]. AS users more easily take other substances in order to increase muscle mass, reduce fat tissue and improve body appearance[82]. These substances, so-called "body image drugs" include other hormones (growth hormone, insulin), beta-agonists (clenbuterol), stimulants (amphetamine, ephedrine), laxatives, diuretics, etc.[82] Even greater problem is that AS users are more likely to reach to so-called "street" drugs, predominantly opiates, compared to people who do not use AS[83]. Particularly worrying are the results of Arvary and Pope[84] according to which 9% of male sex heroic users began using it during the use of AS, that as many as 81% of respondents bought opiate for the first time from the same dealer who sold them AS, and 67% of the respondents took opiates in order to fight with AS abstinence syndrome. Ten years ago, Graham et al. accused the medical profession who didn't accept the fact that AAS use dependency is a psychiatric condition[85].

Adverse effects of AS on the liver include adenomas, hepatocellular carcinoma, cholestasis and peliosis hepatis[86,87]. Bond P, *et al*.[88] assume oxidative stress as the causative factor of AS-induced hepatotoxicity.

At the end of this chapter, the question arises is there the need to use other medicines in order to cure the "lifestyle improvement" caused by AS?

Conclusions

The hormonal effects of A are generally known in the professional, but also in general population, through various ways and levels of formal and informal education and experience. Scientists' attention is now occupied by non-hormonal effects of A, metabolites and enzymes involved in their biotransformation. These substances and enzymes have been shown to influence the various aspects of human functioning, primarily the CNS, that opens up the new possibilities in the treatment of certain diseases.

In clinical terms, T and its esters are clearly positioned as the first line replacement therapy in male hypoandrogenism, while T-containing medicines, in the absence of effective evidence, are still not licensed for women. When it comes to the type and selection of T pharmaceutical formulations, it can be concluded that there is a fairly wide selection of effective and safe preparations, both traditional and modern, which ensures a good patients compliance and minimal negative impact on their QoL.

When SA are concerned, it can be concluded that in the pharmacokinetic sense their discovery and development fulfilled the expectations, but in clinical terms it is still not the case. Although there are undoubtedly promising results, scientific and professional community are still expecting the outcomes of high-quality clinical studies in order to confirm the long-term efficacy and safety of SA in most non-hormonal clinical conditions they are proposing.

However, thanks to their anabolic properties, SA have long been present in the population of healthy people without medical diagnosis. First of all they were soldiers, and then athletes. In the past decades, tight muscle and physical appearance were imposed as superior living values, which SA "have dropped" into the population of "ordinary" people around the world and give them the status of LD in reference literature. It went so far that nowadays DS are synthesized and used as dietary supplements without any medical reason, in order to deceive in achieving sports results and to circumvent the institutional control, that is disappointing from many aspects.

Existing research shows that both healthcare professionals and AS users don't know enough about them. Users don't have too much trust in doctors, and doctors admit that they don't know enough about these substances. Although they have the status of LD, numerous side effects, including deaths, warn and point to the need for development of additional comprehensive measures and clear strategies at different levels in order to prevent or minimize potential risks and consequences of AS abuse.

Conflict of interest

The authors do not declare a conflict of interest.

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Sport classification regulations for athletes with differences in sexual development (DSD)

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Summary

The classification systems for sports competition are based primarily on the sex of the athlete and generate the male and female categories in almost all existing sports.

There have been some cases of fraud, in which men have competed in the female category, and others, in which some female competitors have caused suspicions about their sex. The last known case is the South African athlete Caster Semenya, who won the final of the 800 m in the World Championships in Berlin in 2009 with 2.45 seconds less than the second classified, with a distance of 16 m in the final straight.

After a multitude of studies, it was verified that the athlete presented a medical condition called difference of the sexual development (DSD), with a production of high levels of testosterone.

High testosterone levels, with sensitivity to this hormone in women, may represent a huge advantage in sports performance, which has been quantified by a range over 9%.The International Athletics Federation (IAAF) has promulgated a rule requiring female athletes with high levels of testosterone and sensitive to it, who want to participate in 400m to a mile tests, to decrease testosterone levels by using estrogens. This work analyses sports classification systems, the physiological effects of testosterone, the basis of sexual differentiation, and presents the medical and deontological arguments to refute the obligation of hormonal treatment of women to be able to compete in sports.

Key words:
Sports classification. Differentiation of sexual state. DSD. Testosterone. Performance. Athletics. Sports regulations.

Reglamento de clasificación deportiva para atletas con diferencias en el desarrollo sexual (DSD)

Resumen

Los sistemas de clasificación para competición deportiva se basan fundamentalmente en el sexo del deportista y generan las categorías masculina y femenina, en la práctica totalidad de deportes.

Ha habido algunos casos de fraude, en los que hombres han competido en la categoría femenina, y otros, en los que algunas competidoras femeninas han suscitado sospechas sobre su sexo. El último caso conocido es el de la atleta sudafricana Caster Semenya, ganadora de la final de los 800 m en el Campeonato del Mundo de atletismo de Berlín de 2009 con 2:45 segundos menos que la segunda clasificada, a la que superó en 16 m en la recta final.

Tras multitud de estudios, se comprobó que la atleta presentaba una condición médica denominada diferencia del desarrollo sexual (DSD), con producción de elevados niveles de testosterona.

Las cifras elevadas de testosterona, con sensibilidad a esta hormona en mujeres, pueden suponer una enorme ventaja en el rendimiento deportivo, que se ha cuantificado en un rango sobre el 9%.

La Federación Internacional de Atletismo (IAAF) ha promulgado una normativa que obliga a las atletas femeninas con altos niveles de testosterona y sensibilidad a la misma, que quieren participar en pruebas de 400 m a la milla, a disminuir las cifras de testosterona mediante la utilización de estrógenos.

Este trabajo analiza los sistemas de clasificación deportiva, los efectos fisiológicos de la testosterona, las bases de la diferenciación sexual, y presenta los argumentos médicos y deontológicos para rebatir la obligación de tratamiento hormonal de mujeres para poder competir en especialidades deportivas.

Palabras clave:
Clasificación deportiva. Diferenciación del estado sexual. DSD. Testosterona. Rendimiento. Atletismo. Normas deportivas.

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Introduction

On 23 April, 2018, the International Association of Athletics Federations (IAAF) published the following: ELIGIBILITY REGULATIONS FOR FEMALE CLASSIFICATION (ATHLETES WITH DIFFERENCES OF SEX DEVELOPMENT)[1] that was scheduled to come into force on 1 November, 2018, but this was suspended on the basis of the appeal made by the female athlete, Caster Semenya, before the Court of Arbitration for Sport (CAS) and conditional upon its final ruling.

These regulations were drawn up as a consequence of the debate which arose due to the sports results of women athletes who had achieved very significant advantages over their opponents. All this was particularly significant in the case of the South African athlete mentioned above. This female athlete won the women's 800 m trial in the 2009 World Championship in Berlin with a time of 1:55.45 min, while the athlete coming in second took 1: 57.90: a difference of 2.45 seconds i.e. a distance of more than 16 meters (Figure 1). In this 800 m trial Semenya won the final of the Olympic Games in Rio de Janeiro 2016 and was World Champion in Berlin in 2009 and in London in 2017. Her best time was 1:54.25 and she also won international competitions between 400 m and 1500 m. However, it should be borne in mind that she was also defeated on the track in the 800 m women's race in the London Olympics in 2012 and the 2011 Daegu World Championship, both times by an athlete who was subsequently stripped of both gold medals for having used doping and who was suspended for that reason for 4 years. Both medals were then also awarded to Caster Semenya.

The case of Semenya has been giving rise to speculations in the media, like she had used doping substances, or that she was in fact a man.

As a result of all this, Semenya has undergone a number of different medical and genetic studies, some of whose results seem unfortunately to have been leaked to the media. In the case of other studies, numerous speculations have been reported. What seems clear is that the athlete suffers from androgenism and that she has a blood testosterone level higher than the reference values for women of her characteristics.

Before moving forward, it must be considered that other elite athletes have also been subjected to intense media exposure for the same reasons: their physical appearance and exceptional sports performance.

Figure 1. Arrival of the women's 800m final of the World Athletics Championships, Berlin 2009.

The perception that several of them are competing or have competed at the highest level in the 800 m trial, like the holder herself of the world record for that distance (1: 53.28 since 1983) seems very strange.

Back in 2010, Semenya underwent a thorough examination by a group of specialists who determined that she should compete as a woman and without any limitation. However, her exceptional performance and its media impact led the IAAF to look for a method to avoid such major differences between competitors, to the point of producing the regulations of 2018, already cited[1].

As a result of all the above, this report aims to analyse the regulations that the IAAF intends to impose in order to reduce the differences in performance in women's athletics, from the points of view of Sports Ethics and especially of Medicine.

Physiological aspects

It is undeniably clear that men have significant advantages in muscle size, strength and power, compared with women. Table 1, produced by the authors, shows the percentage differences between men and women, in some of the world records in athletics. To this end, only trials where women and men competed under equal conditions (ruling out obstacle races, which have different height, and throwing with different weights) have been considered. In order to compare these differences in jumps and races, the records of female athletes have been expressed by transforming the record time into the race speed (metres per second^{-1}).

Generally, this difference is quantified as a 10-12% advantage for men[1]. This is attributed to man's higher testosterone levels from puberty, among other possible causes. The cellular and molecular mechanisms of the advantage that a higher rate of testosterone provides are clearly described[2].

Table 1. Analysis of the percentage differences between men and women for some world records in athletics.

Trial	World record male	Speed (msec^{-1}) or distance (m)	World record female	Speed (mseg^{-1}) or distance (m)	Difference (%)
100 m	9,58	10,44	10,49	9,53	8,7
200 m	19,19	10,42	21,34	9,37	10,1
400 m	43,03	9,30	47,60	8,40	9,6
800 m	1:40,91	7,93	1:53,28	7,08	10,7
1500 m	3:26:00	7,28	3:50,07	6,52	10,5
5000 m	12:37,35	6,60	14:11,15	5,87	11,0
10000 mm	26:17,53	6,34	29:17,46	5,69	10,2
Marathon	2:01,39	5,75	2:15,25	5,17	10,2
20km walk	1:16,36	4,35	1:24,38	3,94	9,5
Relay 4x100	36,84	10,86	40,82	9,80	9,8
Relay 4x400	2:54,29	9,17	3:15,17	8,19	10,7
Long jump	8,95	8,95	7,52	7,52	16,0
Triple jump	18,29	18,29	15,50	15,50	15,3
High jump	2,45	2,45	2,09	2,09	14,7
Pole vault	6,16	6,16	5,06	5,06	17,9

In Table 1 it can be seen how, in race trials, the advantage of male athletes would be between 8.7% and 11.0%, however specifically in the distances between 400 m and one mile (including the 4x400m relay) they do not seem to have a wider difference (between 9.6 and 10.7%) than the rest of the distances. In addition, it can be seen how, in the case of jumps, where rapid use of muscle strength is of major importance, the differences are greater (advantages for male athletes are between 14.7% and 17.9%). Although this cannot be compared, one could venture that it is very possible that in throwing that difference would be even greater.

Gender and sport. Classification and verification systems

Sport-based classification, separated by gender, in practically all sports and sports specialties, is something totally accepted today. The almost insurmountable differences in performance between women and men is the clear reason for this separation.

To maintain this separation and avoid the pitfalls in gender classification, in 1950 the IAAF set down a regulation including physical medical examinations, regulations that, in the long run, were extended to other sports. Back in 1950, an athlete was prevented from continuing her sports career due to refusing to undergo one of these medical examinations. The standards developed further and in 1966 Barr's chromatin began to be studied in female athletes who wanted to participate in female trials, using the karyotype in a saliva sample as an initial test. If in this test some Y chromosome was detected, medical examinations were carried out, including the morphological verification of external genitalia.

Although these physical explorations ended up being considered degrading and were happily repealed in all sports. In the early 1990s the use of the Polymerase Chain Reaction (PCR) technique was advocated for the extension and examination of DNA strands, as a method which was more objective and scientific.

Finally, in 2011 the IAAF set down two different regulations, one for people with sex reassignment[3], and another for female athletes with hyperandrogenism[4]. However, in 2015, a female Indian athlete brought an appeal to the CAS regarding her suspension due to a diagnosis of hyperandrogenism, after a process described by her, as "horrible and humiliating". The athlete obtained a favourable ruling, since the CAS finally accepted that there was not enough evidence of the advantage that a higher level of testosterone could produce in female athletes[5]. Thus, the IAAF regulation on hyperandrogenism was repealed.

As can be seen, this is a recurrent issue, which appears to be harming a number of women athletes, until institutions are persuaded that the matter should be left off the agenda. Now, in 2018 and 2019, we are once again in the worst possible position as regards the rights of certain athletes.

Sexual differentiation

Biological gender is a general term that includes different aspects of chromosomal, gonadal, hormonal and phenotypic sex, each of which is fixed in an individual. Generally, all these classifications of gender are aligned in a conventional binary: male and female. However, it must be considered that there are congenital conditions that cause misalignment and atypical development of the chromosomal, gonadal and / or anatomical genders. As a medical description of these conditions, terms such as "disorders or anomalies of sexual development[6,7] and later "intersexual states" or "intersex" began to be used. The term "anomalies of sexual differentiation" was introduced in 2006[6], however all of these have been widely contested in the scientific literature[6-10].

Currently they are classified as "differences in sexual development" or DSD, although later the term "variations in sexual development" (VSD) was proposed[10].

As will be seen later, DSD may involve ambiguity of external genitalia and various combinations of chromosomal genotypes and sexual phenotypes other than XX-woman and XY-man[7,11]. In the administrative field, there are a number of national systems that recognize legal genders which are different from "man" and "woman", such as "intersex", "X" or "other".

Different institutions with powers in the field of the protection of human rights attempt to avoid harmful practices and discrimination against people with these conditions. In 2015, the United Nations High Commissioner launched a campaign for the free equality of rights of people classified as "intersex" [12].

Equally, in 2015 the Council of Europe made a statement asking member states for a non-binary gender classification and to seriously consider the implications of a new and better classification of "intersex" individuals[13]. In 2016, numerous Committees and U.N. subcommittees (Against Torture, of the Rights of the Child, of the Rights of Persons with Disabilities), together with the Council of Europe and the Human Rights Commissions of Africa and the Americas, launched a document calling for an end to the violent and harmful medical practices on "intersex" children and adults[14].

We should not forget that disclosing information about the medical history of any patient can lead to very serious consequences[15]. Furthermore, in these sensitive cases public knowledge of this protected data will have irreparable consequences for the normal physical development of young people and the psychosocial sphere of all those affected[16,17], as established by the World Health Organization[18].

Regarding the embryological aspect of foetal sexual differentiation, it should be observed that this encompasses a series of processes whose determination and regulation involve numerous genes, proteins and hormones. Starting from a first stage of gonadal and genital development (6 weeks post-fertilization), which is common to both sexes, it is in the period of differentiation when these conditions may occur and have been given the controversial classifications previously identified. These comprise a broad spectrum of discrepancies between chromosomal, gonadal and phenotypic (genital) criteria that define sexual differentiation and are now considered "Differences in Sexual Development (DSD)". Their classification can be seen in Table 2[19].

As regards the involvement of testosterone, it should be remembered that the majority of women (including elite athletes) have circulating blood testosterone levels (0.12-1.79 nmol.L^{-1}) which are lower than those of post-pubertal males ((7.7-29.4 nmol.L^{-1}). It is accepted that, in the absence of DSD or tumour, no woman should have serum testosterone levels equal to or greater than 5 nmol.L^{-1}[20].

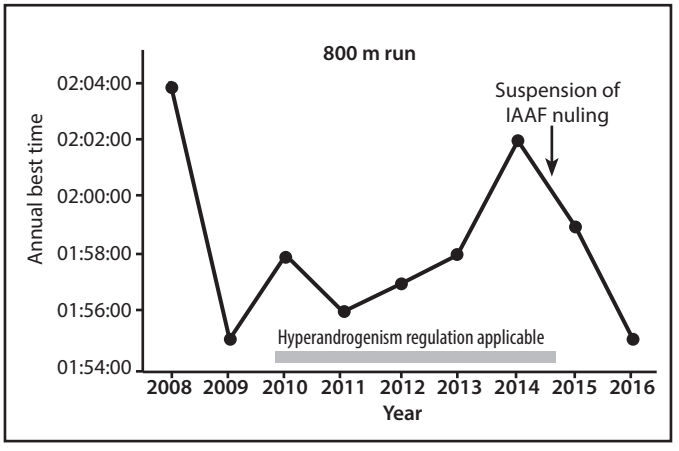
Table 2. Classification of Differences in Sexual Development (DSD)[19].

Chromosome changes	47,XXY: Klinefelter syndrome and variants 45,X0 and mosaics 45,X0 / 46, XX: Turner syndrome and variants 45,X0 / 46,XY: Mixed gonadal dysgenesis 46,XX / 46,XY: ovotesticular ADS/DSD, 47,XYY chimerism
Karyotype 46,XY Anomalies in gonadal development	Gonadal dysgenesis 46,XY (complete or partial) (SRY, SOX9, NR5A1, WT1, DHH, etc.) ovotesticular 46, XY Testicular regression syndrome (includes anorchy and testicular leakage syndrome)
Anomalies in genital development due to changes in hormonal synthesis or action	Changes in androgen synthesis Mutations in the LH receptor (plasia or aplasia of Leydig cells; LHCGR) Smith-Lemli-Opitz syndrome (deficit in 7-dehydrocholesterol reductase: DHCR7) Defects in the synthesis of testosterone Congenital lipoid suprarenal hyperplasia (StAR) Deficiency in cholesterol desmolase (CYP11A1) Deficiency in 3_-hydroxysteroid dehydrogenase (HDS3B2) Deficiency in 17_–hydroxylase / 17-20 lyase (CYP17A1) Deficiency P450 oxidoreductase (POR) Deficiency in cytochrome b5 (CYB5) Deficiency in 17_-hydroxysteroid dehydrogenase (HDS17B3) Deficiency in 5_-reductase type 2 (SRD5A2) Changes in the action of androgens Insensitivity to androgens (AR; total or partial = CAIS or PAIS) Drugs and environmental modulators Changes in the synthesis or action of the antimullerian hormone Persistent Mullerian duct syndrome (AMH / AMHR2)
Others	Malformation syndromes with changes in male genital development (e.g.: cloacal anomalies, Aarskog syndrome, Robinow syndrome, etc.) Severe early-onset intrauterine growth restriction Isolated hypospadias (CXorf6 or MAMLD1) Congenital hypogonadotropic hypogonadism Cryptorchidism (INSL3, RXFP2 [o INSL3R or GREAT])
Karyotype 46,XX Anomalies in gonadal development	Gonadal dysgenesis 46,XX Ovotesticular 46,XX Testicular 46,XX ADS/DSD (SRY, dup SOX9, RSPO1) or male 46,XX Foetal production Deficiency in 21-hydroxylase (CPY21A2) Deficiency in 11-_-hydroxylase (CYP11B1) P450 oxidoreductase deficiency (POR) Deficiency in cytochrome b5 (CYB5) Deficiency in 3-_-hydroxysteroid dehydrogenase (HSD3B2) Mutations of the glucocorticoid receptor (NR3C1) Fetoplacental production Deficiency in placental and foetal aromatase (CYP19A1) P450 oxidoreductase deficiency (POR) Foetal or placental tumours that produce androgens Maternal production Androgenic drugs Maternal virilising tumours (e.g. luteomas, Krukenberg tumour)
Others	Malformation syndromes Hypoplasia/agenesis of Mullerian structures (Rokitansky-Hauser syndrome type I and type II - MURCS) Uterine anomalies (e.g. MODY 5) Vaginal atresia Adhesions of vaginal labia

People with DSD may have very high levels of natural testosterone that may be similar to, or higher than, normal male values[20]. There is a broad medical and scientific consensus that, if these people are sensitive to androgens, i.e. if they have normo-functioning androgen receptors, and record such high levels of natural testosterone, their muscle mass, strength and haemoglobin level may also be much higher and, therefore, significantly improve their sports potential[21-35]. It can be considered that an increase of blood testosterone rate in women between 0.9 and 7.3 nmol.L^{-1} produces an increase in muscle mass of 4% and in muscle strength of 12-26%. The increase in testosterone to levels of: 5, 7, 10 and 19 nmol.L^{-1}, increases the amount of haemoglobin by 6.5%, 7.8%, 8.9% and 11%, respectively.

It is therefore estimated that the ergogenic advantage of testosterone levels in the male range instead of the female range is over 9%[21].

Figure 2. Best annual times in the 800 m for an elite female athlete with DSD between 2008 and 2016, with control of her testosterone rate between 2010 and 2014[21].



All this indicates that, for the most part, the competitive advantages of men are attributable to the action of male sex hormones, in such a way that the increase in testosterone in women from the range of female values to the male range would cause this increase in muscle mass, strength and the rate of haemoglobin.

The ergogenic power of testosterone and that of all its derivatives and other substances with similar chemical structure or biological effects, is manifested by its inclusion in the World Anti-Doping Agency's (WADA) List of Prohibited Substances and Methods[36]. These substances are prohibited at all times (in and out of competition) and in all sports, as Non-Specific Substances in Category S1: Anabolic Agents. These are included in that list since it has existed, and their use is considered to be a case of utmost seriousness.

However, from the legal point of view, the CAS ruling of 2015 should be recalled[5], stating that there is not enough evidence of the advantage that a higher rate of testosterone may give to female athletes.

For its part, the IAAF has compiled observational data on the effects of artificial suppression of high testosterone levels on athletes with DSD, depending on whether or not their testosterone levels are suppressed. The suppression of circulating testosterone levels in the case of three female athletes with DSD from between 21 and 25 nmol.L^{-1} down to a rate below 2 nmol.L^{-1} led to a decrease in their performance on average of 5.7%, as can be observed in Figure 2[21,37].

This study shows that athletes with DSD with circulating testosterone levels in the normal male range have a significant competitive advantage over athletes with testosterone levels in the normal female range, and for the IAFF this would justify forcing these athletes with DSD to reduce testosterone levels to the normal female range to continue competing in the female category.

Application of the IAAF regulations[1]

Sphere

The IAAF data would indicate that the advantages of some athletes with DSD have had a significant effect on mid-distance track events, so it is inferred from this that the rule only applies to events from 400 m to a mile (which the regulations term "Restricted Events"). In international competition and outdoor track events, these events are: 400 m., 400 m hurdles, 800 m, 1500 m and one mile, alone or as part of a relay race or a combined trial.

The special eligibility requirements described apply only to "Relevant Athletes" in the female classification in a Restricted Event in International Competition.

The regulations describe as "Relevant Athlete" those who meet the following three criteria:

- Women with one of the following DSDs:
  - Deficiency of 5α-reductase type 2.
  - Partial androgen insensitivity syndrome (PAIS). or Deficiency of 17 β-hydroxysteroid dehydrogenase type 3) or Congenital adrenal hyperplasia or Deficiency of 3 β-hydroxysteroid dehydrogenase.

  Ovotesticular DSD, or Another genetic disorder with impaired gonadal steroidogenesis.
- Has circulating blood testosterone levels of ≥ 5 nmol.L^{-1}.
- Has sufficient sensitivity to androgens so that these testosterone levels have an androgenizing effect.

Conditions for eligibility

- Being recognized by law as a woman or as intersexual (or equivalent).
- Reducing the rate of circulating blood testosterone to below 5nmol.L^{-1} for a continuous period of at least 6 months, using, for example, contraceptives.
- Maintaining the circulating blood testosterone level below 5 nmol.L^{-1} continuously (in or outside competition) for as long as wished to maintain eligibility to compete in the female classification in Restricted Events in international competition (or setting a world record in a Restricted Event in a competition that is not an international contest).

Taking part without suppressing high levels of testosterone

The regulations allow women athletes who do not want to follow the above guidelines to participate in the following circumstances:

- In the female classification:
  - In any competition that is not an international competition.
  - In international competitions: in any discipline other than track events of between 400 m and one mile.
- In the men's classification: In any competition at any level, in any discipline, without restriction.
- In any 'intersex' classification (or similar) that the organizer of the event can offer in any competition at any level, in any discipline, without restriction.

Reasons given by the IAAF for implementing this rule

The arguments expressed by the IAAF in the text[1], are as follows:

- To guarantee fair and valid competition in athletics within categories that create a level playing field and to guarantee that success

is determined by talent, dedication, hard work, other values and characteristics that sport embodies and celebrates.
- To benefit a broad class of female athletes.
- To encourage athletes to achieve the great commitment and sacrifice required to excel in sport, and thus inspire new generations to take up sport and to aspire to the same excellence. It does not wish to risk discouraging those aspirations by having conditions of unfair competition, which would deny female athletes a fair chance of succeeding.
- Because of the significant advantages in size, strength and power that men generally possess over women from puberty, largely due to much higher levels of circulating testosterone in males, and the impact these advantages may have on sport performance, it is generally accepted that competition between male and female athletes would not be fair and would risk discouraging women from participating in sport. Therefore, in addition to the separate competition categories based on age, the IAAF has also created separate competition categories for male and female athletes.

Sports ethics arguments against the IAAF regulations

We must begin with the very concept of competitive sport as a human activity based on inequality between people. Competition attempts to measure precisely that inequality that is what gives rise to the victory of some over others. Setting down rules that try to eliminate or reduce this inequality would transform athletic competition into something else.

Sports performance is an extremely complex phenotypic trait that in turn is influenced, although not determined, by many other traits, such as the distribution of muscle fibre type, aerobic power and capacity, strength and anaerobic capacity, and the ability to train physical skills[38]. Although the extrinsic determinants of human athletic performance, such as training, nutrition, living conditions, etc., have an undoubted and significant impact on sports performance, the importance of extrinsic determinants must not be trivialized, among these the genetic ones. It is clear that it is impossible to establish a single formula for anyone to become a sports champion and that quantifying the contribution of each of these determinants continues to be a challenge to research in sports science[39-42].

However, certain people who have not undergone scheduled training is already able to demonstrate extraordinarily high levels of physical performance. Some people also show a better response to training and improve their performance much more than others. when following the same working programme[40,41].

The fact that genetics is a very significant intrinsic factor in athletic performance is shown by the analysis of athlete rankings (year 2018 on 17 December) where it can be seen that, in the 1500 m, 14 of the 15 best all-time records were set by athletes born on the African continent, and that the first 7 athletes in this trial in 2018 were born in Ethiopia, while only one thrower with one of the top 60 world times (15 in each of the weight-lifting, discus, hammer and javelin trials) was born in Africa, and only 4 in total (7%) had a phenotype for that continent.

The IAAF intends to delimit a group of Restricted Events (400 m to one mile) to apply this regulation, without stating any objective reason why this is done in these trials and not in other events. It should be borne in mind that, as has already been explained, there is no evidence that high testosterone levels in women may be more advantageous in these trials than in others, and it has already been seen that in the jump disciplines this advantage may be greater. In this way the IAAF would be legislating in violation of the principle of generality by derogating a la carte and committing injustice towards a very specific population, almost singling out specific female athletes.

In addition, it seems essential to consider that the artificial reduction of the advantage that nature has granted to certain women in the form of higher blood testosterone levels, could be somewhat random, since there is no evidence of a direct relationship between the reduction in the rate of testosterone in female athletes, hyperandrogenism and the impact on sports performance. Consequently, with the same decrease in blood testosterone, even taking this at the same level, this could affect the running speed to a different extent in one female athlete from another.

And what happens in men who have circulating testosterone levels higher than the reference values? In the 80s, the genetic basis of Polycystic Ovarian Syndrome began to be studied[43], a basis that has become much better known over the last decades[44-45]. Today, numerous studies are advancing in the description of a genetic load similar to the cases of female hyperandrogenism with Polycystic Ovarian Syndrome and various types of male hyperandrogenism[46-50]. Why should not men who could obtain good results in those Restricted events or any other trial have applied to them regulations similar to those that the IAAF wants to apply to women?

We cannot conclude without taking into account the efforts that the governments of the world and the sports movement have been making to eradicate the scourge of doping. As the World Anti-Doping Code says in justifying this effort in its Fundamentals: *"Anti-doping programs seek to preserve what is intrinsically valuable about sport. This intrinsic value is often referred to as "the spirit of sport." it is the essence of Olympism, the pursuit of human excellence through the dedicated perfection of each person's natural talents. It is how we play true. The spirit of sport is the celebration of the human spirit, body and mind, and is reflected in values we find in and through sport, …"*

As can be seen, natural talent is the excellence that is sought to be preserved, so how can this fight be justified, if when these natural talents appear, the attempt is to eliminate them in an artificial way? That way we cannot defend fair play[51].

Medical ethics arguments against the IAAF regulations

If sports ethics arguments against these regulations seem overwhelming evidence, medical arguments that are very clear and concise seem much more important - and any medical professional will undoubtedly understand these.

The rules of Medicine prohibit the use of medication that is not destined to treat a disease or pathology. Moreover, medications must be used following the established indications and not for any other purposes. The use of medication outside these circumstances is con-

trary to medical practice and is therefore an offence on the part of the prescribing physician[52].

These regulations, which aim to reduce performance in people who have innate qualities of genetic origin and have not been obtained by illegal means, would undoubtedly apply in these cases, and doctors who prescribe treatments for this purpose could clearly be committing an offence.

But above all, it should be noted that in the mind of every doctor, in their relationship with their patients, the side effects, contraindications and risks that prescribed medication could have should take pride of place. It should not be forgotten that the drugs that affect the hormonal sphere of individuals involve significant health risks, risks that are accentuated exponentially if these drugs are used beyond their medical indications[53].

Finally, it is necessary to add the problem that arises in cases like these with respect to the protection of data and even individuals' rights. We are seeing women who, as a result of wanting to exercise their right to practice sports, find themselves involved in the maximum possible circulation internationally of their tests results, examinations and medical diagnoses, to then be exhibited in the media at the same level as cheating athletes who use doping to excel in sports.

Conclusion

Faced with these regulations that clearly fly in the face of unquestionable evidence from the point of view of sportsmanship, against the oath of medical practice, and even against the rights of individuals, we can only demand their immediate repeal.

Conflict of interest

The authors do not declare a conflict of interest.

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Sociedad Española de Medicina del Deporte

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MEDICINA DEL BALONCESTO

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PROGRAMA CIENTÍFICO (PRELIMINAR)

DÍA 22 DE NOVIEMBRE, VIERNES

09.00-10.30 **PONENCIA: La Medicina del Deporte en el Baloncesto.**
Moderador: ***Francisco Javier Rubio Pérez***

Baloncesto femenino. ***Silvia Treviño Monjas***

Organización y control médico en Selecciones Españolas. ***Pilar Doñoro Cuevas***

Baloncesto en la discapacidad – baloncesto en silla de ruedas. ***Josep Oriol Martínez Ferrer***

11.00 -12.30 **PONENCIA: Lesiones y Baloncesto**
Moderador: ***Alfredo Rodríguez Gangoso***

La rodilla. ***Jaume Perramon Llavina***

El tobillo. ***Cristóbal Rodríguez Hernández***

Músculo y tendón. ***Javier Valle López***

12.30 -13.30 **CONFERENCIA INAUGURAL**
Presentación: ***Luis Franco Bonafonte***

La historia del dopaje en el deporte olímpico
Eduardo Henrique De Rose

15.30 -17.00 **PONENCIA: Muerte Súbita y Deporte**
Moderador: ***J. María Alegret Colomé***

Recomendaciones sobre participación deportiva en la cardiopatía isquémica. ***Mats Borjesson***

El electrocardiograma en la prevención de la muerte súbita del deportista. ***Gonzalo Grazioli***

Arritmias y muerte súbita del deportista.
Xavier Viñolas Prat

17.30 -19.00 **TALLER**
Electrocardiograma en deportistas.
Emilio Luengo Fernández

DÍA 23 DE NOVIEMBRE, SÁBADO

10.00 -11.30 **PONENCIA: Controversias: Nutrición - Ayudas Ergogénicas. Los mitos de la alimentación en el deporte.**
Moderador: ***Mónica Bulló***

¿Influye el tipo de dieta en la microbiota y el rendimiento deportivo?
Teresa Gaztañaga Aurrekoetxea

Dietas détox y antioxidantes alimentarios en la práctica deportiva. ***Nuria Rosique***

Ayudas ergogénicas, realidad o mito.
Begoña Manuz González

12.00 – 13.00 **PONENCIA: Manejo del dolor en Medicina del Deporte.**
Moderador: ***Isabel Tello Galindo***

Bloqueos nerviosos en lesiones del aparato locomotor en Medicina del Deporte.
Eduardo Marco Sánchez

Distrofia Simpático Refleja y Lumbalgia – Síndrome facetario en deportistas. ¿Qué ofrece la Unidad de Dolor? ***Guillem Bujosa Portells***

13.00 -13.45 **CONFERENCIA DE CLAUSURA**
Presentación: ***Pedro Manonelles Marqueta***

Actualización en dopaje. ***José Luis Terreros Blanco***

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- Fisiología del esfuerzo.
- Nutrición y ayudas ergogénicas.
- Cineantropometría.
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PERFECCIONA TU ENTRENAMIENTO

Por: Nick Tumminello
Edita: Ediciones Tutor. Editorial El Drac.
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Cada sesión de entrenamiento pretende solo una cosa: maximizar los resultados. Tanto si los resultados son la forma física, la función y el rendimiento, la pérdida de grasa o mejorar el físico, tu mayor deseo es que el esfuerzo merezca la pena.

Esta obra contiene 243 ejercicios y 71 programas, e incluso sesiones alternativas para desarrollarlas en casa o en el gimnasio de un hotel y en las que se utiliza el peso corporal. Además, el lector podrá aprender: los errores que pudiera estar cometiendo; pequeños cambios en la técnica que pueden producir grandes resultados; por qué ciertos ejercicios son preferibles a otros; si el hombre y la mujer deben entrenar de modo diferente; ejercicios que han de evitarse y principios probados que han de seguirse; y combinaciones y secuencias que maximizan los resultados. Altamente didáctico y de aplicación inmediata, este libro ayudará al deportista a ajustar el progreso en la forma y acondicionamientos físicos.

CÓMO RESPIRAR PARA MEJORAR EL RENDIMIENTO

Por: Eric Franklin
Edita: Ediciones Tutor. Editorial El Drac.
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E-mail: info@edicionestutor.com Web: www.edicionestutor.com
Madrid 2019. 72 páginas. P.V.P: 15 euros

El maestro internacional Eric Franklin enseña, a través de las páginas de este libro, a desarrollar más energía y atención y a mejorar el rendimiento físico y deportivo optimizando algo que solemos dar por hecho: la respiración. Respirar es necesario para producir energía; una respiración sumamente funcional abre oportunidades para alcanzar un rendimiento máximo. La presente obra es un texto conciso y ampliamente ilustrado que ayudará al lector a aprender a: mejorar su función respiratoria para beneficiar su salud e incrementar el rendimiento deportivo; comprender la anatomía de la respiración, todos los músculos implicados y cómo interactúan entre sí; practicar 35 ejercicios respiratorios para mejorar la técnica respiratoria funcional; estudiar y entrenar el músculo vital de la respiración, el diafragma; comprender la función y el movimiento de la caja torácica y su relación con la respiración; e integrar todos los elementos involucrados en la respiración para conseguir una óptima función respiratoria.

Durante más de 30 años de enseñanza, el autor ha puesto a prueba las ideas y ejercicios presentados en este libro. Bailarines, practicantes de yoga, monitores de pilates, actores, logopedas, profesores de canto, fisioterapeutas, nadadores, corredores y otros muchos profesionales han utilizado sus principios. Su descripción detallada de la anatomía implicada, su presentación de los ejercicios y su capacidad de integrar esta información de manera práctica convierten este texto en una referencia importante para quienes persiguen alcanzar su máximo rendimiento en el deporte y en la vida.

MUERTE SÚBITA EN EL DEPORTE. MÉTODOS DE CRIBADO

Por: E. Luengo, P. Manonelles
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Barcelona, 2016. 72 páginas. P.V.P: 25 euros

La muerte súbita es un hecho fatal en la práctica deportiva, especialmente por la trascendencia que tiene, tanto para el que la sufre como por la repercusión que tiene. Su familia, sus compañeros de actividad física, los practicantes de su mismo deporte, la sociedad en general, los dirigentes deportivos y las autoridades, todos quedan afectados.

La muerte súbita es un episodio frecuentemente cardiovascular. Este manual está orientado a apoyar la decisión de los médicos que harán el reconocimiento a los deportistas, para detectar las anomalías cardiovasculares más frecuentes que pueden desembocar en ese fatal acontecimiento.

2019		
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International Conference on Medicine and Science in Athletics	3-5 Mayo Doha (Qatar)	web: www.aspetar.com
1er Congreso Internacional de Podología Deportiva	10-11 Mayo Plasencia (Cáceres)	web: www.sepod.es
3rd International Conference Sport, Recreation, Health	10-11 Mayo Belgrado (Serbia)	E-mail: conference@vss.edu.rs
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57º Congreso SERMEF	15-18 Mayo Sevilla	web: http://congresosermef.com/index.php
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22nd International Symposium on Adapted Physical Activity (ISAPA)	14-18 Junio Charlottesville (EE.UU.)	web: http://isapa2019.org
2019 AIESEP International Conference	19-22 Junio Nueva York (EE.UU.)	web: https://aiesep2019.adelphi.edu
Curso Nacional de Rehabilitación deformidades del Raquis	20-21 Junio Barcelona	web: http://www.aulavhebron.net/aula/index.php?go=info_cursos&curso=223&idioma=es
30 Jornadas AEMB	20-22 Junio Madrid	web: http://aemeb.es/madrid-2019/
XL Juegos Mundiales de la Medicina-International Sports Medicine Symposium	22-29 Junio Budva (Montenegro)	web: http://www.medigames.com
VIII Congreso Iberoamericano de Nutrición	3-5 Julio Pamplona	web: http://www.academianutricionydietetica.org/congreso.php?id=7#
24th Annual Congress of the European College of Sport Science	3-6 Julio Praga (Rep. Checa)	E-mail: office@sport-science.org
II Congreso Mexicano de Medicina del Deporte	3-6 Julio Mérida-Yucatán (México)	web: https://comede.mx/
13th Congreso Mundial de la International Society of Physical and Rehabilitation Medicine	9-13 Julio Kobe (Japón)	web: http://www.isprm.org
2nd International Conference on Physical Education, Sports Medicine and Doping Studies	15-16 Julio Sídney (Australia)	web: https://sportsmedicine.conferenceseries.com/
15th European Congress of Sport and Exercise Psychology	15-20 Julio Münster (Alemania)	web: https://www.fepsac2019.eu

Congreso colombiano de nutrición y dietética y II Internacional en alimentación y nutrición	15-17 Agosto Manizales (Colombia)	web: https://acodin.org/congreso-2019/
9th VISTA Conference	4-7 Septiembre Amsterdam (Países Bajos)	web: www.paralympic.org/news/amsterdam-host-vista-2019
Congress on Healthy and Active Children	11-14 Septiembre Verona (Italia)	web. http://i-mdrc.com/fourth-assembly/
14th International Congress of shoulder and elbow surgery (ICSES)	17-20 Septiembre Buenos Aires (Argentina)	web: www.icses2019.org
56º Congreso SECOT	25-27 Septiembre Zaragoza	web: www.secot.es
IX Congreso de la Sociedad Cubana de Medicina Física y Rehabilitación	1-4 Octubre La Habana (Cuba)	web: http://www.rehabilitacioncuba.com
11th European Congress on Sports Medicine	3-5 Octubre Portorose (Eslovenia)	web: http://www.efsma.eu
13th European Nutrition Conference On Malnutrition In An Obese World	13-18 Octubre Dublín (Irlanda)	web: www.fens2019.org
50 Congreso Nacional de Podología y VI Encuentro Iberoamericano	18-19 Octubre Santander	web: https://50congresopodologia.com/
Congreso Internacional de Fisioterapia	25-26 Octubre Toledo	web: congreso@coficam.org
5th World Conference on Doping in Sport	5-7 Noviembre Katowice (Polonia)	web: http://www.wada-ama.org
26th Word Congress TAFISA	13-17 Noviembre Tokyo (Japón)	web: www.tafisa.org
2019 FIP World Congress of Podiatry	14-16 Noviembre Miami (EEUU)	web: www.podiatry2019.org
VIII Jornadas Nacionales de Medicina del Deporte: "Medicina del Baloncesto"	22-23 Noviembre Reus (Tarragona)	E-mail: femede@femede.es web: www.femede.es
10th Annual International Conference: Physical Education Sport & Health	23-24 Noviembre Pitesti (Rumanía)	web: http://sportconference.ro/
56 Congreso Argentino de COT	28 Noviembre-1Diciembre Buenos Aires (Argentina)	web: www.congresoaaot.org.ar
2020		
14th ISPRM World Congress – ISPRM 2020	4-9 Marzo Orlando (EE.UU.)	web: http://www.isprm.org/congress/14th-isprm-world-congress
Congreso FESNAD	11-13 Marzo Zaragoza	web: http://www.fesnad.org/
IOC World Conference Prevention of Injury & Illness in Sport	12-14 Marzo Mónaco (Principado de Mónaco)	web: http://ioc-preventionconference.org/
37º Congress International Society for Snowsports Medicine-SITEMSH	1-3 Abril Andorra la Vella (Principat d'Andorra)	E-mail: andorra2020@sitemnsh.org

9º Congrés Societat Catalana de Medicina de l'Esport-SCME	3-4 Abril Andorra la Vella (Principat d'Andorra)	E-mail: andorra2020@sitemnsh.org
25th Annual Congress of the European College of Sport Science	1-4 Julio Sevilla	E-mail: office@sport-science.org
International Congress of Dietetics	15-18 Septiembre Cape Town (Sudáfrica)	web: http://www.icda2020.com/
XXXVI Congreso Mundial de Medicina del Deporte	24-27 Septiembre Atenas (Grecia)	web: www.globalevents.gr
26th TAFISA World Congress	13-17 Noviembre Tokyo (Japón)	web: www.icsspe.org/sites/default/files/e9_TAFISA%20World%20Congress%202019_Flyer.pdf
VIII Congreso HISPAMEF	15-17 Octubre Cartagena de Indias (Colombia)	web: http://hispamef.com/viii-congreso-hispamef-15-17-de-2020/
XVIII Congreso Internacional SEMED-FEMEDE	Murcia	web: www.femede.es
2021		
Congreso Mundial de Psicología del Deporte	1-5 Julio Taipei (Taiwan)	web: https://www.issponline.org/index.php/events/next-world-congress
26th Annual Congress of the European College of Sport Science	7-10 Julio Glasgow (Reino Unido)	E-mail: office@sport-science.org
22nd International Congress of Nutrition (ICN)	14-19 Septiembre Tokyo (Japón)	web: http://icn2021.org/
European Federation of Sports Medicine Associations (EFSMA) Conference 2021	28-30 Octubre Budapest (Hungría)	web: http://efsma.eu/
Congreso Mundial de Psicología del Deporte	Taipei (Taiwan)	
Congreso Mundial de Podología	Barcelona	web: https://cgcop.es/newweb/eventos/
2022		
8th IWG World Conference on Women and Sport	5-8 Mayo Auckland (N. Zelanda)	web: http://iwgwomenandsport.org/world-conference/
XXXVII Congreso Mundial de Medicina del Deporte FIMS	Septiembre Guadalajara (México)	web: www.femmede.com.mx

Cursos *on-line* SEMED-FEMEDE

Curso "ENTRENAMIENTO, RENDIMIENTO, PREVENCIÓN Y PATOLOGÍA DEL CICLISMO"

Curso dirigido a los titulados de las diferentes profesiones sanitarias y a los titulados en ciencias de la actividad física y el deporte, destinado al conocimiento de las prestaciones y rendimiento del deportista, para que cumpla con sus expectativas competitivas y de prolongación de su práctica deportiva, y para que la práctica deportiva minimice las consecuencias que puede tener para su salud, tanto desde el punto de vista médico como lesional.

Curso "ELECTROCARDIOGRAFÍA PARA MEDICINA DEL DEPORTE"

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (ON-LINE 1/5/2018 A 1/5/2019) CON 2,93 CRÉDITOS

Curso dirigido a médicos destinado a proporcionar los conocimientos específicos para el estudio del sistema cardiocirculatorio desde el punto de vista del electrocardiograma (ECG).

Curso "FISIOLOGÍA Y VALORACIÓN FUNCIONAL EN EL CICLISMO"

Curso dirigido a los titulados de las diferentes profesiones sanitarias y a los titulados en ciencias de la actividad física y el deporte, destinado al conocimiento profundo de los aspectos fisiológicos y de valoración funcional del ciclismo.

Curso "AYUDAS ERGOGÉNICAS"

Curso abierto a todos los interesados en el tema que quieren conocer las ayudas ergogénicas y su utilización en el deporte.

Curso "CARDIOLOGÍA DEL DEPORTE"

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (ON-LINE 1/5/2018 A 1/5/2019) CON 6,60 CRÉDITOS

Curso dirigido a médicos destinado a proporcionar los conocimientos específicos para el estudio del sistema cardiocirculatorio desde el punto de vista de la actividad física y deportiva, para diagnosticar los problemas cardiovasculares que pueden afectar al deportista, conocer la aptitud cardiológica para la práctica deportiva, realizar la prescripción de ejercicio y conocer y diagnosticar las enfermedades cardiovasculares susceptibles de provocar la muerte súbita del deportista y prevenir su aparición.

Curso "ALIMENTACIÓN, NUTRICIÓN E HIDRATACIÓN EN EL DEPORTE"

Curso dirigido a médicos destinado a facilitar al médico relacionado con la actividad física y el deporte la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para prescribir una adecuada alimentación del deportista.

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE"

Curso dirigido a los titulados de las diferentes profesiones sanitarias (existe un curso específico para médicos) y para los titulados en ciencias de la actividad física y el deporte, dirigido a facilitar a los profesionales relacionados con la actividad física y el deporte la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para conocer la adecuada alimentación del deportista.

Curso "ALIMENTACIÓN Y NUTRICIÓN EN EL DEPORTE" Para Diplomados y Graduados en Enfermería

ACREDITADO POR LA COMISIÓN DE FORMACIÓN CONTINUADA (NO PRESENCIAL 15/12/2015 A 15/12/2016) CON 10,18 CRÉDITOS

Curso dirigido a facilitar a los Diplomados y Graduados en Enfermería la formación precisa para conocer los elementos necesarios para la obtención de los elementos energéticos necesarios para el esfuerzo físico y para conocer la adecuada alimentación del deportista.

Curso "CINEANTROPOMETRÍA PARA SANITARIOS"

Curso dirigido a sanitarios destinado a adquirir los conocimientos necesarios para conocer los fundamentos de la cineantropometría (puntos anatómicos de referencia, material antropométrico, protocolo de medición, error de medición, composición corporal, somatotipo, proporcionalidad) y la relación entre la antropometría y el rendimiento deportivo.

Curso "CINEANTROPOMETRÍA"

Curso dirigido a todas aquellas personas interesadas en este campo en las Ciencias del Deporte y alumnos de último año de grado, destinado a adquirir los conocimientos necesarios para conocer los fundamentos de la cineantropometría (puntos anatómicos de referencia, material antropométrico, protocolo de medición, error de medición, composición corporal, somatotipo, proporcionalidad) y la relación entre la antropometría y el rendimiento deportivo.

Más información:
www.femede.es

Normas de publicación de Archivos de Medicina del Deporte

La Revista ARCHIVOS DE MEDICINA DEL DEPORTE (A.M.D.) con ISSN 0212-8799 es la publicación oficial de la Federación Española de Medicina del Deporte. Edita trabajos originales sobre todos los aspectos relacionados con la Medicina y las Ciencias del Deporte desde 1984 de forma ininterrumpida con una periodicidad trimestral hasta 1995 y bimestral a partir de esa fecha. Se trata de una revista que utiliza fundamentalmente el sistema de revisión externa por dos expertos (peer-review). Incluye de forma regular artículos sobre investigación clínica o básica, revisiones, artículos o comentarios editoriales, y cartas al editor. Los trabajos podrán ser publicados EN ESPAÑOL O EN INGLÉS. La remisión de trabajos en inglés será especialmente valorada.

En ocasiones se publicarán las comunicaciones aceptadas para presentación en los Congresos de la Federación.

Los artículos Editoriales se publicarán sólo previa solicitud por parte del Editor.

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1. Los trabajos deberán ser remitidos, a la atención del Editor Jefe, escritos a doble espacio en hoja DIN A4 y numerados en el ángulo superior derecho. Se recomienda usar formato Word, tipo de letra Times New Roman tamaño 12. Deberán enviarse por correo electrónico a la dirección de FEMEDE: femede@femede.es.
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3. En la segunda página figurará el resumen del trabajo en español e inglés, que tendrá una extensión de 250-300 palabras. Incluirá la intencionalidad del trabajo (motivo y objetivos de la investigación), la metodología empleada, los resultados más destacados y las principales conclusiones. Ha de estar redactado de tal modo que permita comprender la esencia del artículo sin leerlo total o parcialmente. Al pie de cada resumen se especificarán de tres a diez palabras clave en castellano e inglés (keyword), derivadas del *Medical Subject Headings* (MeSH) de la *National Library of Medicine* (disponible en: http://www.nlm.nih.gov/mesh/MBrowser.html).
4. La extensión del texto variará según la sección a la que vaya destinado:
   a. Originales: máximo de 5.000 palabras, 6 figuras y 6 tablas.
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   a. **ORIGINALES**: Constará de una introducción, que será breve y contendrá la intencionalidad del trabajo, redactada de tal forma que el lector pueda comprender el texto que le sigue. **Material y método**: Se expondrá el material utilizado en el trabajo, humano o de experimentación, sus características, criterios de selección y técnicas empleadas, facilitando los datos necesarios, bibliográficos o directos, para que la experiencia relatada pueda ser repetida por el lector. Se describirán los métodos estadísticos con detalle. **Resultados**: Relatan, no interpretan, las observaciones efectuadas con el material y método empleados. Estos datos pueden publicarse en detalle en el texto o bien en forma de tablas y figuras. No se debe repetir en el texto la información de las tablas o figuras. **Discusión**: Los autores expondrán sus opiniones sobre los resultados, posible interpretación de los mismos, relacionando las propias observaciones con los resultados obtenidos por otros autores en publicaciones similares, sugerencias para futuros trabajos sobre el tema, etc. Se enlazarán las conclusiones con los objetivos del estudio, evitando afirmaciones gratuitas y conclusiones no apoyadas por los datos del trabajo. Los agradecimientos figurarán al final del texto.

b. **REVISIONES DE CONJUNTO**: El texto se dividirá en todos aquellos apartados que el autor considere necesarios para una perfecta comprensión del tema tratado.
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   Las citas bibliográficas se expondrán del modo siguiente:
   - **Revista**: número de orden; apellidos e inicial del nombre de los autores del artículo sin puntuación y separados por una coma entre sí (si el número de autores es superior a seis, se incluirán los seis primeros añadiendo a continuación *et al.*); título del trabajo en la lengua original; título abreviado de la revista, según el World Medical Periodical; año de la publicación; número de volumen; página inicial y final del trabajo citado. Ejemplo: 1. Calbet JA, Radegran G, Boushel R, Saltin B. On the mechanisms that limit oxygen uptake during exercise in acute and chronic hypoxia: role of muscle mass. *J Physiol.* 2009;587:477-90.
   - **Capítulo en libro**: Autores, título del capítulo, editores, título del libro, ciudad, editorial, año y páginas. Ejemplo: Iselin E. Maladie de Kienbock et Syndrome du canal carpien. En: Simon L, Alieu Y. *Poignet et Medecine de Reeducation*. Londres: Collection de Pathologie Locomotrice Masson; 1981. p. 162-6.
   - **Libro**. Autores, título, ciudad, editorial, año de la edición, página de la cita. Ejemplo: Balius R. *Ecografía muscular de la extremidad inferior. Sistemática de exploración y lesiones en el deporte.* Barcelona. Editorial Masson; 2005. p. 34.
   - **Material eléctrónico, artículo de revista electrónica**: Ejemplo: Morse SS. Factors in the emergence of infectious diseases. *Emerg Infect Dis*. (revista electrónica) 1995 JanMar (consultado 0501/2004).
     Disponible en: http://www.cdc.gov/ncidod/EID/ eid.htm

7. **Tablas y Figuras**: Las tablas y figuras se enviarán en archivos independientes en formato JPEG. Las tablas también se enviarán en formato word.
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Cuando exista alguna relación entre los autores de un trabajo y cualquier entidad pública o privada de la que pudiera derivarse un conflicto de intereses, debe de ser comunicada al Editor. Los autores deberán cumplimentar un documento específico.

Ética

Los autores firmantes de los artículos aceptan la responsabilidad definida por el Comité Internacional de Editores de Revistas Médicas http://www.wame.org/ (*World Association of Medical Editors*).

Los trabajos que se envían a la Revista ARCHIVOS DE MEDICINA DEL DEPORTE para evaluación deben haberse elaborado respetando las recomendaciones internacionales sobre investigación clínica y con animales de laboratorio, ratificados en Helsinki y actualizadas en 2008 por la Sociedad Americana de Fisiología (http://www.wma.net/es/10home/index.html).

Para la elaboración de ensayos clínicos controlados deberá seguirse la normativa CONSORT, disponible en: http://www.consort-statement.org/.

Campaña de aptitud física, deporte y salud

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

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

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