Original article

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

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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).

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

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).

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Introduction

High lipid concentrations are a significant risk factor for the development of cardiovascular diseases (CVD), given that they commonly precede endothelial dysfunction, playing a key role in the formation of atherosclerotic plaque and the subsequent inflammatory response[1]. These phenomena are associated with an increase in the secretion of cytokines, the precursors of inflammation, the expression of adhesion molecules (ICAM, VCAM-1), fibrinogen and the activity of oxidation-promoting substances[2].

Physical exercise has been shown to have beneficial effects on the regulation of lipemia markers in different populations, associating the total energy expenditure during exercise as the main determinant of the subsequent metabolic phenomena[3,4]. The performance of an aerobic exercise session can reduce the lipid plasma concentrations associated with atherosclerosis pathogenesis, such as low-density lipoproteins (LDL) and very low-density lipoproteins (VLDL)[5], as well as increasing the activity of high-density lipoproteins (HDL) which play a significant role in the systemic regulation of excess cholesterol[6]. More recent studies have reported favourable changes in the lipid profile after a single aerobic exercise session[7,8].

On the other hand, muscle strengthening exercises with external resistances or resistance exercises (RE) are primarily associated with responses in the functional sense of anaerobic resistance and strength[9]. RE are classed as a means for the prevention of chronic diseases and acute catastrophic events, such as infarcts or cerebrovascular ischemia[10]. The preventive role of RE could be due to their impact on the assimilation of lipids and the regulation of the pro- and anti-inflammatory markers on the organism, during, and primarily after exercising[11,12]. Only a few studies have assessed how an RE session modifies the lipid markers in the blood stream.

The combination of RE and aerobic exercises, currently known as concurrent exercises (CE), has been shown to have beneficial effects on the state of health and general physical condition if performed regularly[13]. However, benefits have been observed, as well as improvements in the lipid profile and general physical fitness in vulnerable populations, such as persons with obesity and postmenopausal women[14].

After the menopause, the risk of women developing CVD increases[4]. This increased vulnerability is related to the reduction in oestrogen levels, a hormone that appears to exercise a protective role against CVD in women, by promoting an atherogenic lipid profile, an anti-inflammatory immunological profile and by direct action on the blood vessel walls, thereby avoiding the dysfunction of the vascular endothelium[15]. The associated physiological, metabolic and morphological changes are characterised by a fall in the level of physical activity, increased body mass index (BMI), a decrease in muscle mass (sarcopenia), a decrease in the basal metabolic rate, an increase in triglyceride concentrations (TG) and LDL[12]. The inclusion of physical exercise in the life style of this population, may have a positive effect on a number of cardiovascular risk factors, such as a reduction in body fat and the acute regulation of some of the lipemia markers[6].

This study is directed at determining the acute effect of an RE session and a CE session on the lipid profile of postmenopausal women, compared to a control group.

Material and method

This investigation corresponds to a quasi-experimental study with single blind randomisation, exposure-response based on the acute changes provided in two experimental groups, two types of physical exercise with specific biochemical blood markers, compared to a control group.

Subjects

The sample comprised a total of 32 postmenopausal women volunteers, workers from the Fundación Hospital Universitario Metropolitano in the city of Barranquilla, with an average age of 54.66 ± 4.04 years, recruited through the occupational welfare office. The inclusion criteria were postmenopausal women with no hormone replacement treatment. Excluded from the study were those women who had taken part in some type of resistance training during the 6 months prior to the study and those with a medical history of serious endocrine, metabolic and/or neuromuscular disorders, determined during screening by a doctor specialising in internal medicine. Before taking part, each of the subjects of the study was carefully informed of the study design, particularly the possible risks and discomforts related to the procedures, subsequently giving their written informed consent.

Ethical considerations

This study was conducted in accordance with the ethical standards of exercise sciences[16], of the World Medical Association and of the Declaration of Helsinki. The protocol was approved by the Institutional Investigation and Ethics Committee of the Universidad Metropolitana de Barranquilla, Colombia.

Experimental design

The total number of study subjects (n=32) were randomly divided into 3 groups, two experimental groups who performed a session of resistance exercises (RE, n=11) and a session of concurrent exercises (CE, n=11), respectively; and a control group with no exercises with significant energy expenditure (CG, n=10).

Prior to the experimental protocol, an appointment was made for the women for an initial assessment of the musculoskeletal variables (maximum dynamic force and lower-limb functional capacity), body composition (% of fat and lean mass), anthropometric assessment (height, weight, waist circumference), basal metabolic rate and monitoring of dietary behaviour based on the protocols described below.

Maximum dynamic force

In order to determine the maximum dynamic force of the women's different body segments, maximum repetition tests (1RM) were used for the muscle groups performing the resistance exercises on which the experimental groups were based. The maximum load for each subject was determined with no more than 5 tries with a 4-minute recovery between tries.

Maximum dynamic force

In order to determine the maximum dynamic force of the different body segments of the women, tests of a maximum repetition (1RM) were used for the muscular groups that perform the resisted exercises on which the experimental groups are based. The maximum load of each subject was determined with no more than 5 attempts with a recovery of 4 minutes between attempts.

Assessment of the lower-limb functional capacity

The 30 second sit-to-stand test measures the functional capacity of the lower limbs. The test was performed as follows: the initial position was seated in the centre of a chair (height 43 cm), with the back straight and the feet placed flat on the floor, shoulder width apart, the arms crossed at chest height, with an approximate angle of 90º flexion of the hip and knee. At a verbal signal, the participants stand up and then return to the initial seated position. Participants were encouraged to repeat this as many times as possible within a 30 second period.

Anthropometric assessment, body composition and basal metabolic rate

The anthropometric assessment was made of the women, determining height, weight, waist circumference, using a digital scale, stadiometer and tape measure, SECA brand, according to the instructions set out in resolution 2465 of the Ministry of Health of Colombia[17]. The data were used to calculate the BMI. Using the bioelectrical middle ear analyser, Tanita brand (TBF-300WA Wrestling Body Composition Analyzer) the body composition was determined, calculating the percentage of body fat and lean mass. The Basal Metabolic Rate (BMR) was calculated with the Harris-Benedict formula, modified with the physical activity factor (+20%). BMR = [655.0955 + (9.5634 x weight in kg) + (1.8449 x height in cm) - (4.6756 x age in years)].

Monitoring and guiding nutritional behaviour

On the day of the initial assessment, the study subjects were given a printed document and, prior to a detailed explanation by a nutritionist, they recorded their nutritional behaviour during the 3 days prior to performing the experimental protocol. This was for the purpose of compensating for any improbable lipid profile results, derived from consuming excessively high fat food. The aim was to reduce alterations in the results obtained, derived from atypical dietary behaviour.

On the day of the experimental protocol, the food intake was monitored, standardising the calorie consumption prior to doing the exercises to 60% of the BMR with a physical activity factor for each case. The strategy included breakfast (cereals and fruit), snack (cereals) and lunch (chicken, potatoes and vegetables). All the food was prepared, proportioned and monitored by a nutritionist. The aim of this procedure was to guarantee that, when performing the exercise session, the lipid concentrations were influenced by similar nutritional conducts and in specific quantities for each individual case. The last food intake for each case was programmed at least 3 hours prior to the exercises, encouraging participants to keep hydrated just by drinking water.

Baseline lipid profile

All subjects underwent this procedure one day prior to doing the exercises and after at least a 12-hour fast. The women in the groups went to the facilities of the Fundación Hospital Universitario Metropolitano in the morning, to have 5ml of blood drawn in order to determine the baseline lipid profile, which includes the analysis of the serum concentrations of Total Cholesterol (TC), HDL, LDL, VLDL and TG.

Experimental protocol

In a maximum period of one week following the muscular fitness assessment, another appointment was scheduled with the study subjects, at 5:00 pm at the gym facilities of the Physiotherapy Department of the Fundación Hospital Universitario Metropolitano. On the subjects' arrival, the nutritionist initially authorised the exercise session for those women with no atypical eating disorders that could interfere with the results and who correctly followed the dietary procedures, based on the review of the nutrition monitoring document.

Blood samples were drawn from the women by a bacteriological expert, for the assessment of the lipid profile before the exercise session, and then immediately after it ended and 12 hours later, the following morning (under fasting conditions). Immediately after being drawn, the blood samples were taken to the laboratory for analysis. The exercise sessions for each experimental group and the control group are described below:

Exercise protocol

The subjects of the RE group did a 10 minute warm-up consisting in walking (5 min) and general joint mobilization (5 min). Following this, they performed a total of 8 resistance exercises (1. *Leg Press*; 2. Machine knee extension; 3 Machine knee flexion; 4 Elbow flexion with dumbbells; 5 Elbow extension with dumbbells; 6 Shoulder adduction with dumbbells from abduction in a supine position; 7. Unilateral dumbbell row; and 8. Push-ups with free weight), each one with 3 sets and each set with 15 reps, with an intensity of 75% of MR1. The approximate total duration of this session was 40 minutes.

The CE group initially performed a 10 minute warm-up consisting in walking (5 min) and general joint mobilization (5 min), followed by the same exercises as for the RE group, except for the fact that each exercise was only performed for a set with 15 reps, at 75% of MR1. Subsequently, the subjects performed 20 minutes of continuous pedalling on a cycle ergometer at a frequency of between 70 to 80% of the maximum heart rate. The approximate total duration of this exercise session was 40 minutes.

On the implicit instructions of the ethics and scientific committee of the Universidad Metropolitana de Barranquilla, those subjects forming part of the Control Group (CG) ought to do some exercises to promote their physical health, from any point of view. It was therefore decided to get the members of this group to perform a set of passive stretching exercises, which were shown to have no metabolic implications on the lipid metabolism[18]. The session comprised a 10 minute warm-up (5 minutes free walk and 5 minutes of joint mobilization) and 30 minutes of directed stretching. The average duration of this session was 40 minutes.

At the end of each exercise session, the subjects were instructed to drink only water with no calorie content, until the following morning when, under fasting conditions, a blood sample was taken corresponding to 12 hours after the exercise session.

Statistical analysis

A descriptive and comparative statistical analysis was performed with measurements of averages with respective standard deviations. The Shapiro-Wilk test of normality was used and the Levene test of homogeneity. Subsequently, the Analysis of Variance Test (ANOVA) was used two-way, intra-group and inter-group. Whenever relevant, the Bonferroni post-hoc test was considered. The significance level was $p < 0.05$, considering this for all analyses.

Results

The results of the initial assessment of the women showed that the randomisation did not lead to any significant difference between any of the groups and for none of the performance variables before executing the experimental protocol (Table 1). For the total number of women, the BMI ranged from 25.02 to 37.58, ranging from 25 to 30 in 23 women, greater than 30 for 8 women considered to have type I obesity and only one woman had a BMI of more than 35, considered to have type II obesity. The distribution of women with obesity was balanced in the three groups. The waist circumference value ranged between 84 to 110 cm, with all the women with abdominal obesity coming within the criteria established by resolution 2465 of 201617. The average values of the variables analysed in the initial evaluation of the women for the total population and for each of the experimental and control groups are set out in Table 1.

The statistical comparison of the average values between the experimental groups, of the variables of the baseline lipid profile under fasting conditions and at each of the times established in the experimental protocol (before, immediately after and 12 hours after exercise), showed no significant variations ($p>0.05$) in the exercise sessions performed by the RE and CE groups in relation to total cholesterol, triglycerides and LDL. The assessment of the VLDL levels was statistically significant and was lower for the women in the CE group 12 hours after the exercise session, compared to the RE and CG groups. After 12 hours post-exercise, the HDL levels were also seen to be statistically higher in the CE group in relation to the RE group (Table 2).

Table 3 shows the within-group variations for each lipid profile component, under fasting conditions, comparing the baseline analysis with that collected 12 hours after the corresponding exercise session. No statistical differences were found for any of the variables in the comparison of averages in relation to times ($p>0.05$). The average with the greatest variation in the CT analysis was that of the CG, dropping 10.1%, followed by the RE group and CE with drops of 9.8% and 3.5% respectively. The CE group showed a greater variation in the TG analy-

Table 1. Characteristics of the subjects, members of the different groups.

Variable	Total population (n=32)	Experimental groups			P^3 value
		RE (n=11)	CE (n=11)	CG (n=10)	
Age (years)	54.65±4.04	54.82±3.46	54.63±4.59	54.50±4.43	0.98
Anthropometric characteristics					
Weight (kg)	71.31±9.29	70.31±9.44	71.88±10.32	71.80±8.85	0.91
BMI (kg/m²)	28.52±3.33	27.76±3.28	29.03±3.70	28.82±3.16	0.64
Body fat (%)	36.73±4.68	36.79±4.05	37.04±4.39	36.34±5.97	0.94
Lean mass (%)	44.20±5.69	44.48±3.58	42.66±8.45	45.60±3.58	0.50
Waist circumference	96.23±7.61	94.88±7.56	97.09±8.63	96.78±7.28	0.77
Strength and functional capacity					
1RM knee extension (kg)	22.78± 4.57	22.36±4.57	23.45±4.20	22.50±5.34	0.84
1RM elbow flexion (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
Energy requirements (Kcal)					
BMR	1374.4±104.26	1364.32±94.76	1374.95±116.11	1384.98±110.61	0.90
BMRAF	1649.3±125.11	1637.19±113.71	1649.92±139.33	1661.97±132.73	0.90

Average values of the variables analysed in the initial evaluation of the women for the total population and for each of the experimental groups. Value P^3 shows the statistical significance when comparing the average values of the variables in the three experimental groups. BMR: basal metabolic rate; BMRAF: basal metabolic rate with physical activity factor.

Table 2. Inter-group comparison of the lipid profile for fasting baseline, before, immediately after and 12 hours fasting after the exercise sessions.

Lipid profile (mg/dL)	Experimental groups			P^3 value
	RE (n=11)	CE (n=11)	CG (n=10)	
TC				
12 hours fasting basal	214.36±21.86	217.52±33.05	217.10±38.09	0.93
Pre exercise	228.45±73.34	220.18±68.08	222.00±70.16	0.95
Immediately post-exercise	244.09±66.86	249.27±67.39	213.10±59.38	0.40
12 hours fasting post-exercise	193.18±28.18	209.81±33.80	195.20±35.61	0.43
TG				
12 hours fasting basal	171.09±71.73	167.36±44.12	172.00±51.76	0.98
Pre exercise	226.27±96.56	204.63±87.56	222.80±87.21	0.41
Immediately post-exercise	252.21±102.21	198.09±82.62	250.81±104.09	0.54
12 hours fasting post-exercise	166.18±63.93	144.00±29.50	175.50±54.90	0.36
LDL				
12 hours fasting basal	135.95±15.59	140.63±18.60	137.35±32.48	0.88
Pre exercise	131.50±54.36	126.87±49.33	119.05±52.36	0.85
Immediately post-exercise	137.61±49.15	148.65±50.12	105.00±48.63	0.12
12 hours fasting post-exercise	140.46±39.22	155.94±47.84	130.40±23.06	0.32
LDL				
12 hours fasting basal	31.05±13.84	30.04±9.55	32.02±14.26	0.92
Pre exercise	45.25±19.31	40.92±15.38	44.56±20.72	0.84
Immediately post-exercise	50.45±29.74	39.61±16.45	50.16±29.86	0.54
12 hours fasting post-exercise	33.23±12.78[a]	23.34±5.50[b]	37.10±20.80[a]	<0.05
HDL				
12 hours fasting basal	42.59±7.19	48.76±6.53	46.13±8.24	0.15
Pre exercise	51.70±11.30	52.38±10.36	58.39±21.18	0.53
Immediately post-exercise	56.02±9.12	61.05±7.99	57.94±16.03	0.59
12 hours fasting post-exercise	48.42±9.05[a]	56.90±7.40[b]	52.71±8.43[ab]	<0.05

Average values by group for TC: total cholesterol; TG: triglycerides; HDL: high density lipoproteins; LDL: low density lipoproteins; VLDL: very low density lipoproteins; baseline, before, immediately after and 12 hours after exercise. The comparison of the averages is significant between the three groups when P^3<0,05. The averages in the lines that do not share the same superscript letter (a, b) are statistically different.

Table 3. Intra-group variations of the lipid profile components when fasting compared to physical exercise.

Variable	Basal	Post exercise	Δ%	P-value
Total cholesterol (mg/dL)				
RE	214.36±21.86	193.18±28.18	-9.8	0.06
CE	217.52±33.05	209.81±33.80	-3.5	0.59
CG	217.10±38.09	195.20±35.61	-10.1	0.16
Triglycerides (mg/dL)				
RE	171.09±71.73	166.18±63.93	-2.9	0.86
CE	167.36±44.12	144.00±29.50	-13.9	0.15
CG	172.00±51.76	175.50±54.90	+2.0	0.87
LDL (mg/dL)				
RE	135.95±15.59	140.46±39.22	+3.3	0.72
CE	140.63±18.60	155.94±47.84	+10.9	0.19
CG	137.35±32.48	130.40±23.06	-5.0	0.58
VLDL (mg/dL)				
RE	31.05±13.84	33.23±12.78	+7.0	0.70
CE	30.04±9.55	23.34±5.50	-22.3	0.39
CG	32.02±14.26	37.10±20.80	+15.8	0.53
HDL (mg/dL)				
RE	42.59±7.19	48.42±9.05	+13.6	0.13
CE	48.76±6.53	56.90±7.40	+16.7	0.13
CG	46.13±8.24	52.71±8.43	+14.26	0.06

Average values and proportion of variation of the lipid profile by groups. HDL: high density lipoproteins; LDL: low density lipoproteins; VLDL: very low density lipoproteins; baseline, before, immediately after and 12 hours after exercise.

ses, dropping 13.9% compared to 2.9% for the RE group while the CG increased 2.0%. For the RE and CE groups, the LDL showed a tendency to increase, while it dropped in the CG by 5.0%. Only the CE group showed lower VLDL plasma levels in the post-exercise period (22.3%), with the levels for this variable increasing in the RE group /7.0%) and CG (15.8%). The HDL trend in the post-exercise analysis was to increase for all groups.

Discussion

For each individual, the lipid metabolism at the systemic level is dependent on many factors, including diet, the physical health condition and the daily energy expenditure. This study aimed to demonstrate the influence of the different types of physical exercise considered, in a population of postmenopausal women with similar characteristics by comparing the results of the assessment times (baseline, pre-exercise, immediately post-exercise and 12 hours post-exercise) between the experimental groups. In addition, it attempted to show the possible influence of physical exercise on the variation in the lipid profile under fasting conditions within each group. Although it is clear that the influence of physical exercise is not the only determining factor in the lipid profile variations, given that, depending on time, the general energy shortage and the physiological replenishment mechanisms vary from subject to subject. However, it is extremely important to clarify that, although there are limitations with regard to the control of the biological and behavioural factors that influence the lipid profile, additional energy expenditure involved in exercising, influences the magnitude of the physiological responses regulating the lipid metabolism and other energy substrates.

The analyses of the results of this study are based on the acute responses of the types, levels and intensities of physical exercise considered on the lipids found in the blood plasma. These responses have not been fully clarified for postmenopausal women, a population that is relatively prone to suffering CVD. The interpretation of responses at times that are subsequent to the scheduled performance of physical exercise is extremely important given that it makes it possible to build a useful description of the physiology of the human body, endeavouring to support the notion that argues the benefits of physical exercise not only when it is being performed but also subsequently, during a period of physiological recovery and reorganisation.

Findings in the literature associate regular physical exercise with changes in the metabolic and functional variables, primarily in combinations of resistance exercises with aerobic exercises[9,19]. In order to bring about changes in the BMI, weight and percentage of body fat, it is necessary to implement long-term exercise programs. This is a limiting factor in this study, given that a single exercise session does not produce changes in body composition. However, it has been observed that a single exercise session con modify the lipid profile of young people, adults and subjects with various disorders.

The systematic implementation of RE for more than 8 weeks, has shown findings associated with the reduction in serum concentrations of TC, TG and LDL, as well as increased concentrations of HDL[20], although results from other studies differ, such as the study by Kelley *et al.*[21], in which it is alleged that in different RE periods (for example, between 8 to 20 weeks) there are no changes in the lipoprotein concentrations in the blood plasma.

With regard to the acute effects of one exercise session, these effects are primarily associated with increased HDL concentrations. In a study on healthy adult men, Wallace *et al.*[22] reported a 12% increase in HDL plasma concentrations within the first 24 hours following a high volume and moderate intensity session of RE (7 exercises of 3 sets and 12 reps at 80% of the maximum strength), as well finding a 20% reduction in TG concentrations for the same period. Very similar results were found in this present study, a 13.6% increase in HDL was recorded for the RE group in relation to its baseline records, not finding any great changes in the TG levels 12 hours after exercise.

Compared to the control group, the RE group subjects showed no differences in modifications of LDL and HDL, refuting the findings of the study made by Correa *et al.*[23] in which high or low volume resistance exercises did not reduce the TC concentrations in postmenopausal women, neither did they affect the LDL and VLDL levels, both with regard to baseline values and the postprandial analysis. In the population studied, these results would associate resistance exercises with weak acute responses with regard to the lipid metabolism. However, more evidence is needed to support this claim, particularly taking account of the fact that the variability in the prescription of resistance exercises with regard to volume, intensity, number of exercises, groups of muscles, recovery intervals and speed of contraction, may show divergent results for alternative combinations to those considered in this study.

A marked trend in the lipid profile results before and immediately after the exercise session was that none of the variables showed an intragroup statistical difference. However, 12 hours after exercise, the group that combined aerobic and resistance exercises showed differences with the RE group and control group, with a significant reduction in VLDL of approximately 22% in relation to the baseline records during fasting for the same group. It appears that aerobic exercises have a better impact on the energy metabolism of postmenopausal than just doing resistance exercises. For this population, Weise *et al.*[5] reported that 12 hours after performing a session of aerobic exercises, the TG concentrations could be reduced by 8.5% while the HDL concentrations could be increased by 5%. In this study, the scope of the variation in TG and HDL within the CE group showed better results than in the aforementioned study, with a 13% reduction in TG and an increase in HDL up to 16.7%, 12 hours after performing the exercises. This finding may be an indicator that the combination of aerobic and anaerobic exercises have a better impact on the acute lipid metabolism of postmenopausal women.

The above results may suggest that high levels of resistance exercises do not stimulate the formation of HDL, due to the fact that the reverse mobilisation of lipids (towards the liver) is reduced by the energy demands of the exercised skeletal muscle, which requires the typical mobilisation of fatty acids. These are very similar results to those reported in the studies by Wooten *et al.*[24] and Zotou *et al.*[25], where they demonstrated that, although resistance exercises exert a positive influence on the acute mitigation of the baseline and postprandial lipid markers for postmenopausal women, the high volumes of these exercises did not show positive modifications in the HDL blood concentrations.

There are many authors who have not only mentioned a reduction in the levels of physical activity as a crucial factor in increasing the cardiovascular risk in postmenopausal women, but also find physiological aggravating factors that can be controlled with periodical physical exercise, particularly in overweight women. According to the American College of Sports Medicine, the regular performance of resistance exercises may improve the overall physical health of women, and help prevent and treat cardiovascular risk related disorders, such as diabetes or high blood pressure. Therefore, these exercises, monitored by a specialist, are currently part of rehabilitation and physical fitness programs, directed at this population[26]. There is little evidence-based literature that describes the acute metabolic implications of concurrent exercises on the lipid profile of postmenopausal women, although studies such as Figueroa *et al*.[19] and Libardi *et al*.[27] show positive effects on the control of cardiovascular risk factors when this type of exercise is performed in the long term. Based on the most important findings of this study, it is possible to start to consider the idea of the combined performance of resistance and aerobic exercises, in order to guarantee positive acute influences on the blood lipid profile of postmenopausal women, which, in the long term, could become a protective factor against suffering CVD.

Based on the analysis of the results of this study, we can conclude that, in comparison to the performance of a session of resistance exercises, a session of concurrent exercises could positively affect the lipid profile of overweight postmenopausal women, principally 12 hours after doing the exercises, reducing the VLDL plasma concentrations and increasing the HDL concentration.

Conflict of interest

The authors do not declare a conflict of interest.

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