



Trabajo Original

Circuit resistance training improved endothelial dysfunction in obese aged women

Mejora de la disfunción endotelial en mujeres mayores obesas mediante entrenamiento de fuerza

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Abstract

Introduction: It is widely accepted that obesity is associated with endothelial dysfunction. In a recent paper, we have also found circuit resistance training may reduce visceral fat in obese aged women. Accordingly, the current study was conducted to ascertain the effects of circuit resistance training on markers of endothelial dysfunction in this population group.

Methods: In the present interventional study, a total of 48 obese aged women were recruited from the community. Twenty-four of them were randomly assigned to perform a 12-week resistance circuit training programme, 3-days per week. This training was circularly performed in 6 stations: arm curl, leg extension, seated row, leg curl, triceps extension and leg press. The Jamar handgrip electronic dynamometer was used to assess maximal handgrip strength of the dominant hand. Lastly, serum samples were analysed using an immunoassay (ELISA) for endothelin-1, intercellular adhesion molecule-1 (ICAM-1) and vascular cell adhesion molecule-1 (VCAM-1).

Results: When compared to baseline, resistance training significantly reduced serum levels of endothelin-1 (2.28 ± 0.7 vs. 1.98 ± 1.1 pg/ml; $p = 0.019$; $d = 0.67$) and ICAM-1 (290 ± 69 vs. 255 ± 76 ng/ml; $p = 0.004$; $d = 0.92$) in the experimental group. No significant changes in any of the tested outcomes were found in the control group.

Conclusion: A short-term circuit resistance program improved endothelial dysfunction in aged obese women. Further studies on this topic are still required to consolidate this approach in clinical application.

Key words:

Aged. Resistance training. Endothelium disorder. Endothelin-1. Vascular cell adhesion molecule-1. Intercellular adhesion molecule-1.

Resumen

Introducción: recientes estudios han confirmado que el entrenamiento de fuerza en circuito podría reducir la masa grasa visceral en mujeres mayores obesas. Para seguir avanzando en esta línea de trabajo, nos propusimos determinar su impacto en marcadores de disfunción endotelial.

Material y método: participaron voluntariamente 48 mujeres (70-75 años) con obesidad procedentes de la comunidad. De ellas, 24 fueron asignadas aleatoriamente al grupo experimental para desarrollar un programa de entrenamiento de fuerza en circuito de 6 estaciones durante 12 semanas con 3 sesiones/semana. Los marcadores de disfunción endotelial ensayados fueron: endotelina-1, molécula de adhesión intercelular-1 (ICAM-1) y molécula de citoadhesión vascular-1 (VCAM-1). Asimismo se evaluó su influencia en un test funcional para población mayor como el de sentarse-levantarse en 30 segundos. Este protocolo fue aprobado por un comité de ética institucional.

Resultados: tras completar el programa de intervención se observó un descenso significativo de los niveles plasmáticos de endotelina-1 ($2,28 \pm 0,7$ vs. $1,98 \pm 1,1$ pg/ml; $p = 0,019$; $d = 0,67$) e ICAM-1 (290 ± 69 vs. 255 ± 76 ng/ml; $p = 0,004$; $d = 0,92$). También mejoró significativamente la puntuación del test funcional ($18,7 \pm 3,1$ vs. $23,0 \pm 3,6$ repeticiones; $p = 0,019$; $d = 0,98$). Por el contrario, no se observaron cambios en el grupo control.

Conclusión: el entrenamiento de fuerza en circuito mejora la disfunción endotelial presente en mujeres mayores obesas. Futuros estudios siguen siendo necesarios para consolidar su aplicación en clínica.

Palabras clave:

Mayores. Entrenamiento de fuerza. Disfunción endotelial. Endotelina-1. Molécula de adhesión intercelular-1. Molécula de citoadhesión vascular-1.

Received: 18/09/2015
Accepted: 27/10/2015

Rosety I, Pery MT, Rosety J, García N, Rodríguez-Pareja MA, Brenes-Martín F, Díaz A, Rosety-Rodríguez M, Ordóñez FJ, Rosety MA. Circuit resistance training improved endothelial dysfunction in obese aged women. Nutr Hosp 2016;33:131-134

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INTRODUCTION

Although there is unanimous agreement on the importance of resistance training to improve muscle strength in aged women (1), its impact on cardiovascular disease risk factors and outcomes in older adults has received less attention in this population group (2). Furthermore, the validity of these observations is limited by the fact that the proportion of elderly people who do resistance training is currently low (3). In this respect, Harada et al. have already described several perceived barriers to strength training among older adults (4).

Therefore, little information is available on the influence of resistance training on endothelial dysfunction. This finding would be of particular interest given that endothelial dysfunction may predict the incidence of adverse cardiovascular events (5). Furthermore, it is related not only to insulin resistance (6), but also to cognitive decline and dementia, in a complex interplay with vascular factors and aging (7). Similarly, endothelial function is abnormal in chronic obstructive pulmonary disease (8). Lastly, it should be also pointed out that obesity-related endothelial dysfunction was more prominent in women than in men (9).

For the reasons already mentioned, this study was conducted to ascertain the effects of resistance circuit training on markers of endothelial dysfunction in obese aged women. A secondary objective was to assess its influence on functional lower extremity strength after completing the intervention.

MATERIAL AND METHODS

STUDY POPULATION

In the present interventional study, a total of forty-eight obese aged women were recruited from the community (Table I). The statistical package GRANMO v7.12 (IMIM, BCN, Spain) was used for *sample size* calculation. Inclusion criteria were defined

Table I. Anthropometric and biochemical characteristics of obese aged women enrolled in the intervention and control groups at baseline

	Intervention	Control	p value
Age years	67.3 ± 2.1	68.1 ± 2.3	> 0.05
BMI (kg/m ²)	31.2 ± 1.0	31.6 ± 1.2	> 0.05
WC (cm)	101.8 ± 4.6	103.6 ± 4.9	> 0.05
c-LDL (mg/dl)	131.7 ± 12.1	133.1 ± 13.2	> 0.05
c-HDL (mg/dl)	47.7 ± 5.2	46.0 ± 6.1	> 0.05
Triglycerides (mg/dl)	166.2 ± 14.8	168.6 ± 17.9	> 0.05
Glycaemia (mg/dl)	113.8 ± 5.4	115.1 ± 4.2	> 0.05

WC: Waist circumference; c-LDL: Low density lipoprotein cholesterol; c-HDL: High density lipoprotein cholesterol.

as follows: woman, aged ≥ 65 years-old, obese, sedentary (< 20 minutes of aerobic exercise, twice per week, in the last six months (19). Obesity was defined according to the International *Obesity Task Force* (IOTF) standards (BMI ≥ 30 kg/m²). Furthermore, all of them had medical approval for physical activity participation. Exclusion criteria were defined as the coexistence of uncorrected thyroid diseases, due to their impact on the body composition of these patients, diabetes, ischemic heart disease, cardiac arrhythmia, congestive heart disease, rheumatoid arthritis and chronic obstructive pulmonary disease (COPD).

INTERVENTION PROGRAM

Twenty-four of them were randomly assigned to perform a 12-week resistance circuit training program, 3 days per week (Table II).

This training was circularly performed in 6 stations: arm curl, leg extension, seated row, leg curl, triceps extension and leg press. Each training session started and finished with a warming-up and cooling-down period of 5-10 minutes during which muscle stretching exercises were performed. Furthermore, training sessions were in small groups (6 participants) and were supervised by experienced physical therapists to ensure that participants used the correct technique and intensity (ratio 1 monitor/2 participants).

It should be pointed out that before starting the training program participants included in the intervention group underwent a pre-training session to be familiar with resistance exercises as well as to perform the 8-repetition-maximum (8RM) test per each exercise (11). Control group included 16 age-, sex- and BMI-matched adults with DS who did not take part in any training program.

NUTRITIONAL INTAKE RECORD

To control the potential confounding effect of diet, parents were carefully instructed to avoid quantitative or qualitative differences. Furthermore, they were asked to complete a food consumption frequency questionnaire for three days (2 weekdays and 1 weekend day). No significant difference was found between the intervention and control groups when assessing energy intake (1,792 ± 201 vs. 1,703 ± 196 kcal; p = 0.41).

OUTCOME MEASUREMENTS

All outcomes at individual level were assessed firstly at baseline and secondly 72-h after the end of the intervention. In this respect, blood samples were collected from the antecubital vein after a 12-h fast and drawn into tubes containing EDTA as anticoagulant. The whole blood was centrifuged at 3,000 rpm for 20 minutes in a clinical centrifuge. The plasma was separated and stored at -80 °C until further analysis. Serum samples were analyzed using an immunoassay (ELISA) for endothelin-1, intercellular adhesion molecule-1 (ICAM) and vascular cell adhesion molecule-1 (VCAM) (R&D Systems, Minneapolis, USA).

The 30-seconds chair stand test was chosen to assess functional performance given that it is commonly used both in clinical research and practice (12). According to Rikli and Jones (13), participants were encouraged to fully sit and stand as many times as possible in 30 seconds using a chair with a height of 43 cm. They were instructed to look straight forward with their arms folded across their chest. The score was the total number of stands executed correctly within 30 seconds. The highest value of two attempts was considered for further analysis. Lastly, all participants underwent a preliminary session to be familiar with the testing.

ETHICS AND STATISTICS

It should be pointed out that the current protocol complied with the Declaration of Helsinki (2008). Written informed consent was obtained from all participants. Further, the current protocol was approved by an Institutional Ethics Committee. The results were expressed as a mean (SD). The Shapiro-Wilk test was used to assess whether data were normally distributed. To compare the mean values, a one-way analysis of variance (ANOVA) with post-hoc Bonferroni correction to account for multiple tests was used. For all tests, statistical significance was set at an alpha level of 0.05. Finally, Cohen's *d* statistics were used for determining mean effect sizes as follows: small $d \geq 0.2$ and < 0.5 ; medium $d \geq 0.5$ and < 0.8 ; large $d \geq 0.8$.

RESULTS

Resistance training significantly reduced serum levels of both endothelin-1 (2.28 ± 0.7 vs. 1.98 ± 1.1 pg/ml; $p = 0.019$; $d =$

0.67) and ICAM-1 (290 ± 69 vs. 255 ± 76 ng/ml; $p = 0.004$; $d = 0.92$) in the experimental group. These results are summarized in table III. Regarding the work task performance, the chair stand test scores were also significantly increased (18.7 ± 3.1 vs. 23.0 ± 3.6 repetitions; $p = 0.019$; $d = 0.98$) after the completion of the intervention. On the other hand, neither sports-related injuries nor withdrawals from the program were reported during the entire study period.

Finally, no significant changes in any of the tested outcomes were found in the control group.

DISCUSSION

The most striking finding of this study was that short-term circuit resistance training may improve endothelial dysfunction in obese aged women. In a previous study, Miyaki et al. (14) found that a 12-week aerobic exercise intervention significantly reduced the concentrations of plasma endothelin-1 in overweight and obese adults. Similarly, Mavri et al. (15) found that weight reduction by low-calorie diet in obese adults might contribute to the improvement in endothelial function, as noted by a decrease in endothelin-1. Lastly, Cotie et al. (16) reported that endothelial function increases after a 16-week diet and exercise intervention in overweight and obese women.

All these findings may be explained, at least in part, by the fact that obesity is a major risk factor for the development of endothelial dysfunction (17). Mainly, if we take into consideration that endothelial dysfunction in obese people is prevalent even in the absence of hypertension and type 2 diabetes (18). In a more detailed way, during a lifestyle intervention, not weight loss or decrease

Table II. Characteristics of the resistance circuit training, comprised of 6 stations, performed by participants in the intervention group

	1°-2° wk	3°-4° wk	5°-6° wk	7°-8° wk	9°-10° wk	11°-12° wk
Load	40%	45%	50%	55%	60%	65%
Series	2	2	2	2	2	2
Rep.	10	10	8	8	6	6
Rest.	90	90	90	90	90	90

Load: Expressed as percentage of 8 repetition-maximum (8RM) test; Rep.: Number of repetitions; Rest: Resting periods between stations expressed in seconds.

Table III. Markers of endothelial dysfunction in obese adult women: influence of a short-term circuit resistance training program

	Intervention		Control		Cohen's <i>d</i>
	Pre-test	Post-test	Baseline	Final	
Endothelin-1	2.28 ± 0.7	$1.98 \pm 1.1^{a,b}$	2.41 ± 0.8	2.45 ± 0.7	0.67
ICAM-1	290 ± 69	$255 \pm 76^{a,b}$	302.0 ± 67	314 ± 64	0.92
VCAM-1	912 ± 286	898 ± 298	946 ± 281	951 ± 289	0.18

Endothelin-1 expressed as pg/ml. Intercellular adhesion molecule-1 (ICAM-1) and vascular cell adhesion molecule-1 (VCAM-1) expressed as ng/ml. *a*: $p < 0.05$ versus pre-test; *b*: $p < 0.05$ versus control at the end of the study.

in total adipose tissue but decrease in visceral adipose tissue was associated with improved endothelial function (19). Accordingly, visceral fat mass should be proposed as a therapeutic target in obese adults. In this line, our group had previously published that a circuit resistance program reduced visceral fat mass in obese aged women (20), thus contributing to a better understanding of the promising results reported in the current paper.

It is generally accepted that physical activity entails an inherent risk of musculoskeletal injury (21). Fortunately, in a recent study, the current supervised circuit resistance training did not increase markers of muscle damage in aged obese women (NH1). In addition, no sport-related injuries were reported in the intervention group. Similarly, the Cochrane review by Liu and Latham that included 121 trials with more than 6,700 older adults concluded that adverse events typically were not reported (22). Furthermore, adherence rates in aged women enrolled in two different exercise programs (endurance training vs. resistance training) showed it was significantly higher in the strength training group (23).

Strengths of the current study included the homogeneous and large sample size. Conversely, previous studies focused on the influence of regular exercise on elderly have recruited mixed (male and female) groups in order to increase sample size with the aim of strengthening research design (24). In addition, the presence of a control group consisting of age-, sex- and BMI-matched women may reduce the recruitment bias of healthy controls. Lastly, the excellent adherence rate suggested the training program was effective and easy to follow-up. In fact, it may finally give participants the confidence to continue exercising after the trial finishes. This was of particular interest given that in a previous study, Maeda et al. (25) reported that the decrease in ET-1 level lasted to the 4th week after the cessation of exercise training and these levels returned to the basal levels in the 8th week after the cessation of exercise training.

The present study had some limitations that should be considered too. The use of weight lifting machines may limit the reproducibility of this study in case exercise equipment is not available. Accordingly, future studies focused on well-designed resistance exercise workouts that use free weight are also required to facilitate its reproducibility elsewhere.

Finally, it was concluded that a short-term circuit resistance program reduced biomarkers of endothelial dysfunction in aged obese women. A secondary finding was that the training program also improved functional performance in this population group. While current results are promising, future studies are still required to consolidate this approach in clinical application given that endothelial dysfunction has been associated with several chronic diseases in the elderly.

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