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Original

Effect of endurance and resistance training on regional fat mass and lipid profile

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Abstract

The purpose of this study was to investigate the effect of 10-week of endurance training or resistance training on regional and abdominal fat, and in the lipid profile, examining the associations among the changes in body composition, weight, waist circumference and lipid profile. Body composition, waist circumference and lipid profile were analyzed in 26 volunteers healthy young men (age 22.5 ± 1.9 yr), randomly assigned to: endurance group (EG), resistance group (RG) or control group (CG). The EG significantly decreased after training the body weight, body mass index, total body fat and percentage of fat, fat and percentage of fat at the trunk and at the abdominal region and High-Density Lipoprotein. The RG significantly increased total lean mass and decreased total cholesterol, High-Density and Low-Density Lipoprotein. Close relationship were found among changes in weight, total lean mass, regional fat mass, waist circumference and changes in lipid profile (all p < 0.05). We concluded that 10-week of endurance training decreased abdominal and body fat in young men, while 10-week of resistance training increased total lean mass. These types of training had also effects on lipid profile that seem to be to some extent associated to changes in body composition; however it requires additional investigation.

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Key words: *Fat abdominal. HDL. LDL. Strength training. Total cholesterol.*

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EFECTO DEL ENTRENAMIENTO DE RESISTENCIA Y FUERZA SOBRE LA MASA GRASA REGIONAL Y EL PERFIL LÍPIDO

Resumen

El objetivo de este estudio fue investigar el efecto de 10 semanas de entrenamiento de resistencia ó fuerza sobre la cantidad de grasa en la región abdominal y sobre el perfil lipídico, analizando las asociaciones entre los cambios en composición corporal, peso, circunferencia de la cintura y perfil lipídico. La composición corporal, la circunferencia de la cintura y el perfil lipídico fueron analizados en 26 jóvenes (edad 22.5 ± 1,9 años), que se asignaron aleatoriamente a un grupo de resistencia (EG), un grupo de fuerza (RG) o al grupo control (CG). El EG disminuye significativamente, después del entrenamiento, el peso corporal, el índice de masa corporal, la cantidad total de grasa y el porcentaje de grasa, la grasa y porcentaje de grasa en el tronco y en la región abdominal y la lipoproteina de alta densidad. El RG mejoró significativamente la masa muscular total y disminuyeron el colesterol total, HDL y LDL. Se observó una relación estrecha entre los cambios en el peso, la masa magra total, la masa grasa regional, la cintura de la cadera y los cambio lipídicos (p < 0,05). Concluimos que 10 semanas de entrenamiento de resistencia disminuyen la grasa abdominal y corporal en sujetos jóvenes, mientras que 10 semanas de entrenamiento de fuerza aumentan la masa muscular total. Estos entrenamientos tienen un efecto sobre el perfil lipídico que parecen estar asociado a cambios en la composición corporal, no obstante, son necesarios más estudios.

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Palabras clave: *Grasa abdominal. HDL. LDL. Entrenamiento de fuerza. Colesterol total.*

Abreviaturas

BMI: Body mass index.
LDL: Low density lipoprotein.
HDL: High density lipoprotein.
CHD: Coronary heart disease.
CHOL: Total cholesterol.
EG: Endurance group.
RG: Resistance group.
CG: Control group.
DXA: Dual-energy X-ray absorptiometry.
ROI: Region of interest.
ISAK: International Society for the Advancement of Kinanthropometry.
VT1: Ventilatory threshold 1.
VT2: Ventilatory threshold 2.
1RM: One repetition maximum.

Introduction

Obesity is characterized by excess fat storage in adipose tissue is a major risk factor for chronic disease, specifically cardiovascular disease and diabetes. Obesity is defined by the use of body mass index (BMI), which is calculated as weight (kg) divided by height squared (m^2). Despite the benefits of using BMI as it is simple measure to characterize individual's body composition it does not provide a good indication of the location of fat deposition, which has been found to be more closely related to cardiovascular health risk than total fat mass;[1] specifically, excess accumulation of adipose tissue within the abdominal cavity.[2]

Dyslipidemia characterize by elevated levels blood lipid (Low density lipoprotein (LDL), total cholesterol (CHOL), triglycerides) is also another major risk factor for coronary heart disease (CHD).[3] Previous research have demonstrated that high level of cholesterol in blood can lead to secondary cardiovascular disease,[4] while high level of High density lipoprotein (HDL) can prevent atherosclerosis and CHD,[5] elevated concentration of LDL has shown to be associated with CHD.[6]

Positive associations have been found between body fat and lipid profile,[7] even it has been suggested that an increased percent body fat can predict an increase LDL.[8] However, it is not clear how changes in soft tissues body composition affect lipid profile in healthy young men.

One of the main recommendations in preventing obesity is engaging in regular physical activity, which is important in maintaining and improving health[9] and have been associated with lower visceral and abdominal subcutaneous adipose tissue.[10] Specific training programs have shown to change body composition; endurance training can improve body composition by decreasing fat mass,[11] and resistance training can also decrease fat mass and increase total lean mass;[12] however it remains unclear which kind of specific training is more appropriate to reduce regional and specifically abdominal adiposity.

In addition to changing body composition, exercise training has been associated with changes in lipid profile, mainly when concomitant dietary interventions and/or weight loss were presented.[13,14] However, the effect and mechanism around on changes in body composition on lipid profile due to exercise per se requires additional investigation.

The purpose of this study was to investigate the effect of two different trainings (endurance or resistance) on regional, and specifically, abdominal adipose tissue, as well as in the lipid profile in young men. Secondly, to examine the associations among the changes produced in body composition, weight, waist circumference and lipid profile after the training period.

Methods

A total of 26 healthy young men (age 22.5 ± 1.9 yr) participated in this study. The participants were randomly assigned to three groups: endurance (EG, n = 7), resistance (RG, n = 8) or control (CG, n = 11). Their physical characteristics are presented in table I. The participants were healthy and physically active. All participants answered a questionnaire, which included information about personal data, sports participation, and medical history. Participants were asked to keep their dietary habits during the study and were classified as normal-weight participants according to their BMI values. All participants provided written after they had received a full explanation of the study procedures. The study was performed in accordance with the Helsinki Declaration 1975 and was approved by the Research Ethics Committee of the Government of Aragón (CEICA; Spain).

Baseline data was collected in one week; it consisted of 6 tests sessions. In the first session cardiorespiratory fitness was assessed, in the second session body composition was determined by dual-energy X-ray absorptiometry (DXA), and in the third session blood sample was taken.

The DXA measurements were taken to calculate total and regional lean (body mass – [fat mass + bone mass]) and fat masses. The DXA (QDR-Explorer, Hologic Corp., Software version 12.4, Waltham, MA) was calibrated using a lumbar spine phantom as recommended by the manufacturer. Participants were scanned in supine position and the scans were performed at high resolution. Lean and fat mass were calculated from total and regional analysis of the whole body scan [15]. In order to obtain abdominal fat mass, a region of interest (ROI) was established from the lower costal margin to above the iliac crest was also analyzed with a variation coefficient lower than 4%.

In additional to abdominal fat mass anthropometrics were also obtained to determine body composition. Height, body mass and waist circumference were obtained by the same anthropometrics (Level 3 ISAK

Table I
Participant's characteristics by groups

	Control					*Endurance training*					*Resistance training*				
	Baseline		*Post-intervention*		*% Change*	*Baseline*		*Post-intervention*		*% Change*	*Baseline*		*Post-intervention*		*% Change*
	Mean	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*	
Weight (kg)	72.8	8.9	73.2	8.4	0.5	75.1	6.6	73.1*	6.4	-2.7	70.4	10.1	70.6	9.4	0.3
Height (cm)	177.4	7.2	177.3	7.7	-0.1	178.9	6.9	178.7	6.9	-0.1	175.2	5.6	175.1	5.9	0.0
Age (yr)	23.3	2.5				21.8	1.0				22.0	1.2			
BMI (kg/m²)	23.1	1.7	23.2	1.1	0.7	23.5	1.5	22.9*	1.3	-2.6	22.9	2.0	22.9	1.7	0.4
Waist C. (cm)	76.9	5.1	76.5	3.2	-0.6	77.9	4.4	76.6	3.5	-1.7	77.0	3.4	76.5	3.1	-0.6

SD: Standard deviation; BMI: Body mass index; Waist C: Waist circumference.
*P < 0.05.

accreditation), according to the procedures of the International Society for the Advancement in Kinanthropometry.[16] The intratester Technical Error of Measurements was lower than 1% for the measurements (within the limits set by ISAK). The anthropometric instruments used included a stadiometer, balance, and an anthropometric tape (GPM Siber-Hegner Maschinen, Switzerland). BMI was also calculated.

Blood samples were collecting at baseline and at the end of the study, 48-72 hours after the last training session. Venous blood samples were taken between 7.00-8.00 hours, after 12 hours overnight fasting. The blood samples were allowed to clot at 4º C and then centrifuged at the same temperature (Allegra 21R, Beckman Instruments Inc, Fullerton, CA, USA). The lipid profile was determined using blood serum using an Analyzer Synchron DX 800 by means of well-proportioned enzymatic reagents by Beckman Instruments.

The intervention was a 10-week period of supervised training. The EG performed running and cycling sessions with a load intensities ranging between the ventilatory threshold 1 (VT1) and 2 (VT2), during 90 minutes per session. The VT were calculated from the cardiorespiratory tests that were performed at the same time of the day (16:00-19:00 h) under similar environmental conditions (20º C; relative humidity, 45-55%, 720 mmHg) on an electrically braked cycle-ergometer (Germany Ergometrics 900; Ergo-line; Bitz, Germany).[17]

The one repetition maximum (1RM) was assessed, and training protocol for the RG is described elsewhere.[18] Briefly, RG trained with 5 different exercises (parallel squat, leg extension, inclined leg press, leg curl and hip flexors), for which 1RM was assessed before and after 10-week training. The ranged between 50-90% of 1RM values obtained were used for the training. A 90-s rest period was taken between exercise sets.

Data analysis was done using R software v2.7.0. Nonparametric statistics were used as the Kolmogorov-Smirnov tests showed non-normally distribution of the variables. Wilcoxon test was applied to study differences between the baseline and the post-intervention results within each group. Differences between groups either, at baseline, for post-intervention or changes were studied by Kruskal-Wallis test. Relationship among body composition, weight, waist circumference and lipid profile variables were studied by Spearman bivariate correlations. The probability for significance was fixed at 0.05.

Results

The characteristics of the participants are shown in table I. Among the three training groups, no significant differences were observed in anthropometrics (weight, height, age, BMI or waist circumference) and lipid profile (fig. 1) at baseline or after the intervention. The EG significantly decreased their body weight and BMI by 2.7% and 2.5% respectively after training period (table I, both $P < 0.05$). No other significant changes were observed in the RG and CG with regards to anthropometrics.

The CG significantly decreased total lean mass shown in table II. The EG significantly decreased body fat and percentage of fat, as well as fat and percentage of fat at the trunk and at the abdominal region and the RG significantly increased total lean mass; however, no significant changes were observed in fat mass, (all $P < 0.05$).

For EG the change in abdominal percentage of fat was significantly higher compared with CG. For the RG, only the total lean mass percentage of change was significantly higher compared with the CG (all $P < 0.05$).

There was no difference between baseline and post-intervention in the CG. For the EG the HDL (mg/dL) significantly decreased (57.7 ± 7.0 *vs.* 48.0 ± 4.2). For the RG, the CHOL (159.9 ± 17.9 *vs.* 149.4 ± 18.7), HDL (58.4 ± 8.7 *vs.* 51.3 ± 10.8) and LDL (90.8 ± 15.6 *vs.* 86.3 ± 15.7) significantly decreased with training (all $P < 0.05$).

For EG, the percentage change in HDL was significantly greater compared with the changes of the CG; while the percentage change of LDL was significantly different compared with the RG. For EG, the

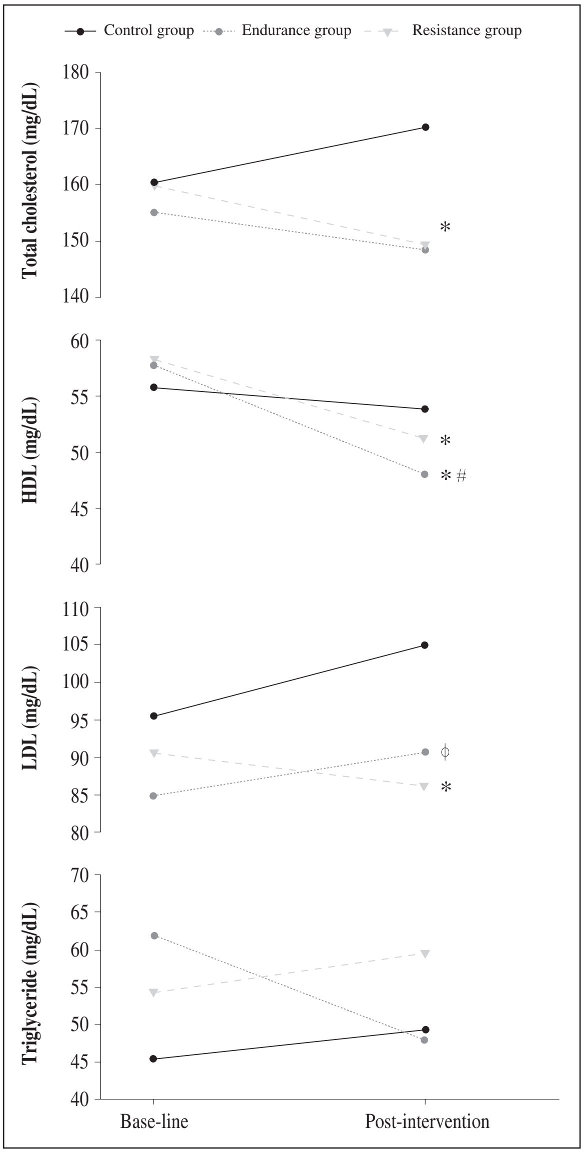

*Fig. 1.—Changes between Base-line and Post-intervention in lipid profile for the control, endurance training and resistance training groups. *P <0.05 between baseline and post-intervention value by Wilcoxon test within each group. #P < 0.05 for changes in % between endurance and control groups by Kruskal Wallis test for K samples. ϕ P < 0.05 for changes in % between endurance and resistance groups by Kruskal Wallis test for K samples.*

percentage change in CHOL, HDL and LDL were significantly different compared to changes of the CG (all $P < 0.05$).

The table III shows the correlation among total body soft tissue composition, regional fat, waist circumference and lipid profile. In the CG changes in HDL showed a close correlation with changes in trunk fat. In the EG, changes in CHOL strongly correlated with changes in total body weight; changes in HDL with changes in total lean mass and weight and changes in LDL with changes in waist circumference. In the RG, changes in CHOL strongly correlated with changes in weight and in trunk and abdominal fat; and changes in HDL with changes in weight and in total body and trunk fat mass, (all $P < 0.05$).

Discussion

The main findings are that the EG had significant decreases in body fat, the percentage of fat, fat and percentage of fat at the trunk and at the abdominal region. The results of this study supports findings of early studies in which showed that significant decrease in fat mass after regular physical exercise.[19,20].

Research have shown that abdominal fat has close correlation with visceral fat[21] therefore, by direct measuring fat in fat the abdominal area provides a more direct understanding of different training programmes which can reduces visceral fat. Thereby providing closer to measure the results from this study suggest that visceral fat can decrease with just 10-week of endurance training; this could have important implications for addressing cardiovascular disease prevention, because visceral fat is a determinant of cardiovascular disease.[2] The RG increased total lean mass as happened in most of the previous studies[22] after resistance training. However, no effect has been observed on total or regional fat in the RG, which could be the result of internal aspects of this training program such as intensity or training volume.

Research studies designed to measure the effects of exercise training on the lipid profile are usually carried out in overweight and/or obese participants and have often been confounded by concomitant dietary changes and/or weight loss.[14] Few studies have examined the effect of different training regimens on serum lipid changes in normal-weight participants with healthy lipid profile. Weight loss has been associated with variable changes in lipid profile in obese individuals,[13] specifically reductions in triglycerides, CHOL, and LDL.[14] There are also changes in HDL, usually after significant weight reduction and a stabilization but this is often no change or decrease in HDL during active weight loss period increases.[14] It is unclear whether changes in the lipid profile after training programs can be a consequence of elevated initial values and/or weight loss is still unknown in the current literature available more research is need to clarify the exact mechanism.

A meta-analysis that investigated the effect of moderate- to hard-intensity endurance training showed inconsistent results in improvements in the blood lipid profile.[23] Twelve weeks of moderate endurance training alone, without weight loss, was insufficient to stimulate changes in any lipid or lipoprotein measured in obese participants.[24] However, the same exercise program including a diet intervention (weight loss of 4 kg) resulted in an improved lipid profile. This data seems to indicate that no effect of the training intervention per se can be found on the lipid profile unless weight loss is present in obese participants. In this

Table II
Baseline, post-intervention and changes for whole body composition variables and regional fat and percentage of fat for the control, endurance training and resistance training groups

	Control					*Endurance training*					*Resistance training*				
	Baseline		*Post-intervention*			*Baseline*		*Post-intervention*			*Baseline*		*Post-intervention*		
	Mean	*SD*	*Mean*	*SD*	*Change^*	*Mean*	*SD*	*Mean*	*SD*	*Change^*	*Mean*	*SD*	*Mean*	*SD*	*Change^*
Fat mass (kg)	12.84	4.93	12.75	4.34	-0.67	13.17	4.17	11.99*	3.27	-8.97	11.47	3.40	10.88	2.76	-5.11
Lean mass (kg)	58.39	6.46	57.26*	5.97	-1.94	60.30	4.64	60.23	5.07	-0.12	57.50	7.26	58.30*	7.07	1.39§
%BF	17.84	5.28	17.94	4.94	0.11	17.72	4.46	16.50*	3.73	-1.22	16.44	3.37	15.61	2.60	-0.83
Trunk fat mass (g)	5,159.02	2,086.68	5,122.01	1,872.44	-0.72	5,655.46	1,940.78	4,861.49*	1,515.09	-14.04	4,405.07	1,092.06	4,124.19	747.91	-6.38
Trunk %fat	15.76	5.19	15.77	4.77	0.01	16.55	4.57	14.83*	4.08	-1.72	14.07	2.61	13.14	1.89	-0.93
Abd. fat mass (g)	655.91	347.33	618.67	303.06	-5.68	641.08	321.81	507.33*	228.24	-20.86	518.47	234.36	463.90	179.74	-10.52
Abd. %fat	18.95	7.00	19.45	6.52	0.50	19.09	5.62	16.43*	3.93	-2.66#	16.74	3.74	15.23	3.05	-1.51
Mean arm fat (g)	725.67	300.08	777.74	321.84	7.17	761.76	243.03	704.23	147.52	-7.55	673.18	185.00	648.11	138.90	-3.72
Mean arm %fat	17.89	5.71	19.00	6.19	1.12	18.56	4.90	18.29	3.79	-0.27	16.72	3.75	16.40	2.51	-0.32
Mean leg fat (g)	2,612.45	1,138.73	2,539.88	938.36	-2.78	2,481.12	895.18	2,390.10	777.40	-3.67	2,363.94	1,014.75	2,253.03	912.87	-4.69
Mean leg %fat	20.06	6.39	20.02	5.89	-0.04	18.47	5.15	17.36	4.06	-1.11	18.53	5.28	17.53	4.55	-1.00

SD: Standard deviation; Abd: Abdominal.
^In percentage for absolute variables and in units for percentage of total and regional fat.
*P < 0.05 between baseline and post-intervention value by Wilcoxon test within each group.
#P < 0.05 for changes in % between endurance and control groups by Kruskal Wallis test for K samples.
§P < 0.05 for changes in % between strength and control groups by Kruskal Wallis test for K samples.

Table III
Relationship among percentage changes in body composition, regional fat and lipid profile

Group	*% change*	*Fat mass*	*Lean mass*	*Trunk fat*	*Abdominal fat*	*Weight*	*Waist C*
Control	CHOL	0.23	0.25	0.60	0.58	0.43	-0.26
	HDL	0.41	0.31	0.72*	0.64	0.77	-0.03
	LDL	0.19	0.02	0.69	0.67	0.54	-0.20
	Triglycerides	-0.50	-0.01	-0.24	0.19	-0.03	-0.03
Endurance training	CHOL	0.54	0.64	0.54	0.21	1.00*	0.57
	HDL	0.54	0.82*	0.46	0.43	0.82*	0.46
	LDL	0.54	0.57	0.39	0.00	0.75	0.89*
	Triglycerides	0.57	0.36	0.46	0.54	0.54	0.46
Resistance training	CHOL	0.67	0.24	0.81*	0.81*	0.83*	0.28
	HDL	0.83*	0.43	0.86*	0.41	0.79*	0.64
	LDL	0.25	0.36	-0.01	-0.18	0.28	0.17
	Triglycerides	-0.47	-0.45	-0.38	-0.05	-0.45	-0.02

CHOL: Total cholesterol; HDL: High density lipoprotein; LDL: Low density lipoprotein.
*P < 0.05 for Spearman bivariate correlation.

current study, the EG, with a similar training regimen and duration as the study of Nieman et al. (2002), had no changes in CHOL, and triglycerides levels despite a significant reduction in body weight and body fat, illustrating that in normal-weight participants changes in body weight after an endurance training does not necessary implies positive changes in the lipid profile. These results, support the findings of another meta-analysis which concluded that aerobic training influence on lipid profile were more effective in participants with initially high CHOL levels or low BMI (< 28 kg/m^2), proving that both variables seems to be highly relevant.[25]

There are few data related to the effects of resistance training on blood lipid levels. In healthy, pre-menopausal women, with normal baseline lipid profile, five months of resistance training was associated with significant decreases in CHOL and LDL concentrations.[26] Moreover, a 14-week resistance training had a favourable effect on lipid profile and body fat percentage in a similar type of population.[27] These findings suggest that resistance training could have a favourable effect on lipid profile and body fat percentage. On the contrary, eight weeks of low intensity resistance training was not enough to produce significant alterations in blood lipid concentrations in postmenopausal women.[28] Thus, it seems that when the stimulus is sufficient, the resistance training could positively influence the lipid profile. Accordingly, data from the present investigation indicates that although body weight remained stable and fat mass did not decrease substantially, a marked reduction in all lipid variables was found in the RG. This could be partly explained by the increase in the total lean mass occurred in this group, however since no significant correlations between lipid and total lean mass changes have been observed, it seems that intensity and duration of the exercise program might be more influential than body composition changes in normal-weight participants with optimal baseline lipid values.

The fact that both, EG and RG, had a reduction in the HDL levels after the training period is in agreement with other studies that previously showed that especially when negative caloric balance is present and/or a stabilization period is missed a decrease in HDL can be found.[14] Moreover, data from the Heritage Study concluded that as a consequence of a short-term endurance training, 20-week, there were more participants who experienced a decrease in HDL among those with high baseline HDL levels compared to those with initial low HDL levels, proving to some extent the importance of initial values and the elevated heterogeneity of the HDL changes in response to a training period.[29]

The present data shows positive correlations between fat mass and CHOL in the EG and with HDL in the resistance training. There were also strong correlations between total lean mass with HDL in the EG. These results are of interest since traditionally, changes in lipid profile have been investigated in relation with fat, but total lean mass changes may be also important, at least when the endurance training is carried out. Previous studies have also shown that 12-week of aerobic or strength training significant decreased body fat composition, triglyceride, and CHOL levels.[30] Conversely there are several studies that showed changes in body mass did not improve lipid profile for type 1 mellitus participants, while in healthy participants, only HDL increased significantly after training.[31] A 6-week study of endurance training showed that improvement of body composition by reducing fat mass and waist circumference did not change CHOL, HDL, LDL, and triglyceride levels in young female.[32] However, in the present study changes in waist circumference are correlated with changes in LDL in the EG. It is possible that the variance in results from this research and previous findings might be related to the differences in regional fat distribution between male and female.

A study with middle-aged men demonstrated that fat mass distributions were associated with blood lipid profile.[33] Waist circumference is correlated with abdominal fat mass and is associated with increased metabolic diseases risk,[34] waist circumference is also a better predictor of changes in HDL than the BMI,[35] therefore it is important to highlight that the present research observed a close relationship between waist circumference and lipid profile. Since changes in abdominal fat did not show relationship with changes in lipid profile, more studies are needed to clarify the relationship between changes in waist circumference and lipid profile.

Conclusion

We concluded that ten weeks of endurance training decreased abdominal and body fat in young men, while 10-week of resistance training increased total lean mass. There were no observed changes in the endurance training group for lipid profile components; however in statistical testing it was shown that changes in CHOL was associated with changes in weight, in HDL with total lean mass and weight, and LDL with waist circumference.

The resistance training group showed a significant decrease in CHOL, HDL and LDL without significant changes in body weight. The observed changes are associated with changes in weight, and trunk and abdominal fat. The changes in LDL and HDL may require addition investigation in order to better understand the associations and interactions between endurance and strength training on lipid profile.

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