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Effects of Resistance Exercise on Total and Regional Body Composition in Overweight Sedentary Males

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Abstract

The purpose of this study was to examine the effects of 12 weeks of resistance exercise training on body weight (BW), body mass index (BMI), total fat mass (FM), trunk, arm, and leg fat mass, and total lean body mass (LBM), arm, and leg lean mass of sedentary overweight healthy males. Twenty-nine sedentary overweight healthy males, aged 18-30 years, with a BMI ≥ 25, were enrolled in the study. The subjects were randomly assigned to either a resistance exercise group (REG, n=15) or an aerobic exercise group (AEG, n=14). Randomized subjects followed resistance (3 sessions/wk 60 min 2 sets × 12 repetitions of 5–7 exercises at 65% 1 repetition maximum in 1-4 weeks, 3 sets × 10 repetitions of 5–7 exercises at 75% 1 repetition maximum in 5-8 weeks, and 4 sets × 8 repetitions of 5–7 exercises at 85% 1 repetition maximum in 9-12 weeks,) and aerobic exercise programs (3 sessions/wk 60 min aerobic exercises at 40-50% heart rate reserve in 1-6 weeks and 70%–75% maximal heart rate in 5-8 weeks). At baseline and after the intervention session, total and regional body composition measurements were assessed using the Jawon make body composition analyzer (model IOI-353 Yuseong, South Korea). After the intervention study, there were significant differences observed between the groups regarding the investigated variables (BW, BMI, LBM, trunk, arm, leg lean mass, and arm fat mass $p < .05$). Both REG and AEG were significantly decreased the amount of total FM, BF, trunk fat mass, arm fat mass, and leg fat mass ($p < .05$). Trunk and arm lean mass were significantly improved only in the REG ($p < .05$). In conclusion, resistance exercise training is an efficient training protocol, which produced a better improvement in regional lean mass.
Keywords: Fat mass, Lean mass, Hypertrophy, Obesity

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INTRODUCTION

Today, it is widely accepted by everyone that obesity is a global public health issue and has reached pandemic proportions. Besides being a significant global health issue, obesity serves as a risk factor for numerous chronic and life-threatening conditions (Williams et al., 2015). It has been recently reported that excessive weight and obesity, a disease that affects most body systems, are associated with more than 50 medical conditions, including metabolic, cardiovascular, respiratory, neurological, gastrointestinal, renal, rheumatological, cancer, musculoskeletal, skin, infection, mental, and pregnancy-related conditions (Lam et al., 2023) at every stage of life (Phelps et al., 2024). According to the World Health Organization (WHO), more than 1 billion people worldwide are obese, and by the year 2035, the number of people living with obesity globally is expected to reach 1.9 billion (WHO, 2022). The recent rise in obesity is mainly attributed to the increased consumption of high-fat and high-sugar foods, as well as the growing prevalence of physical inactivity and sedentary lifestyles (WHO, 2024). Therefore, the relationship between an increase in physical activity levels and the management of overweight and obesity is considered an important factor for public health worldwide (Bull et al., 2020).

Previous research has demonstrated that regular physical activity effectively manages and treats obesity by promoting weight loss (Alexander et al., 2022; Chin et al., 2016; Oppert et al., 2023; Wiklund, 2016). Overweight and obese individuals typically prefer aerobic exercises to reduce fat mass and improve body composition (Davis et al., 2022; Oppert et al., 2023). However, recent findings from studies have shown that resistance exercises can be included in weight management programs due to the positive effects they have on body composition (Lopez et al., 2022; Ribeiro et al., 2023; Tan et al., 2023; Zouita et al., 2023). Resistance exercise training, also known as strength or weight training have the potential to improve body composition by increasing muscle mass (Sharma et al., 2022) and reducing fat mass (Lopez et al., 2022; Orange et al., 2020; Wewege et al., 2022). This effect is explained as a decrease in total body fat tissue due to the increase in resting metabolic rate and 24-hour energy expenditure, which are results of the development of muscle mass (Donnelly et al., 2009; Roh et al., 2020). In a recent study providing a systematic review and meta-analysis of randomized controlled trials (Lopez et al., 2022), it has been reported that resistance exercises applied to overweight and obese individuals in different age groups led to positive changes in body fat percentage and body fat mass. In another study, it has been reported that resistance exercises alone can be included in exercise prescriptions aimed at promoting fat loss in overweight and obese individuals (Rodriguez-Lopez et al., 2022). In addition, it has been reported that determining the effect of resistance exercises on overweight and obese individuals is challenging due to the emphasis on body weight rather than body composition (Lopez et al., 2022).

In the literature, there are studies on the impact of resistance exercises on body composition in obese individuals conducted in various ways: alone (without caloric restriction) (Khalafi et al., 2021; Miller et al., 2018), in different exercise modalities (resistance + aerobic exercise) (Pieczynska et al., 2023; Rejeki et al., 2023), and in combination with both resistance and aerobic exercise + calorie restriction (Aneis et al., 2023; Oh et al., 2018). Although research on resistance exercises is increasing, the isolated effect of resistance exercises alone and in different exercise modalities on body fat is still debated (Wewege et al., 2022). Therefore, it has been reported that more research is needed to investigate the effectiveness of the most suitable exercise for obese individuals (Davis et al., 2022).

This study aimed to determine the effects of a 12-week resistance exercise training on body weight (BW), body mass index (BMI), total fat mass (FM), trunk, arm, and leg fat mass, and total lean body mass (LBM), arm, and leg lean mass of sedentary overweight healthy males. We hypothesized that resistance exercise training would result in more effective reductions on both total and regional fat mass.

METHODS

Research Model

In this research, a pretest-posttest experimental design was used.

Participants

This was a parallel-group study with the non-probabilistic sample, conducted in a private fitness center in the city of Uşak, Turkey. The study lasted 12 weeks, and participants were assessed at baseline and after 12 weeks. The primary outcomes were body composition variables (BW, BMI, FM, BF, LBM, trunk, leg, and arm fat and lean mass). The evaluators were not blind to the intervention assignment. From the 44 potential participants assessed for eligibility, 5 refused to participate, and 39 were randomly assigned for one of the two study arms (REG: n=15; age=25.4±3.44; height=1.77±5.15; AEG: n=14; age=24±4.73; height=1.84±9.08). During the study protocol, 10 participants (REG: 4; AEG: 6) dropped out because of injuries (3 from the REG and 1 from AEG) and non-compliance with 80% of the exercise sessions (1 from REG and 5 from the AEG). In the end, 29 overweight males, aged 18-30 years, were enrolled in the study.

In this study, 29 participants (from a total of 44 assessed for eligibility) with new registrations at fitness center, male sex, body mass index (BMI) ≥25, physically inactive (within the last 6 months), not currently undergoing any pharmacological intervention, adhering to a standard dietary regimen, abstaining from smoking, and not experiencing any major illnesses were able to participate. All subjects provided written informed consent and were informed about the purpose and experimental procedures before being involved in the study. After invitation, verification of eligibility criteria, and signature of the informed consent, participants underwent the baseline assessment. In this assessment, sociodemographic and body composition variables were gathered. Thereafter, participants were randomly allocated to either the resistance exercise (REG; n=15) or aerobic exercise (AEG; n=14) group (Figure 1).

Procedures

Dietary regimen: For both groups, a dietitian provided all participants with a 1-hour individual nutrition session on appropriate food selection and preparation. All participants were asked to follow a weight maintenance diet (55-60% carbohydrate, 15-20% protein, and 20-25% fat) for the duration of the exercise interventions to allow for the assumption that any changes in anthropometrics and body composition were the result of the effects of regular exercise alone without caloric restriction. Whether this regimen was adhered to was determined by examining body weight before each exercise session. For body weights that deviated significantly (0.4% of baseline weight in two consecutive weeks), nutritional counseling was given to determine the deviation (Lee et al., 2012).

Aerobic exercise training: Participants underwent a continuous aerobic exercise program, lasting 60-minutes per day, 3 days a week for 12 weeks. Intensity was gradually increasing (Table I). In each exercise session, warm-up, cool-down, and flexibility exercises were included. Loading was performed at 40-50% of heart rate reserve (HRR: maximal heart rate - resting heart rate) for the first 6 weeks (weeks 1- 6) and 70-80% for weeks 7-12. A polar watch (Polar RS300X, Finland) was used to determine the target heart rate (Chih-Hui Chiu et al., 2017; Gert-Jan van der Heijden et al., 2010; Saremi et al., 2010).

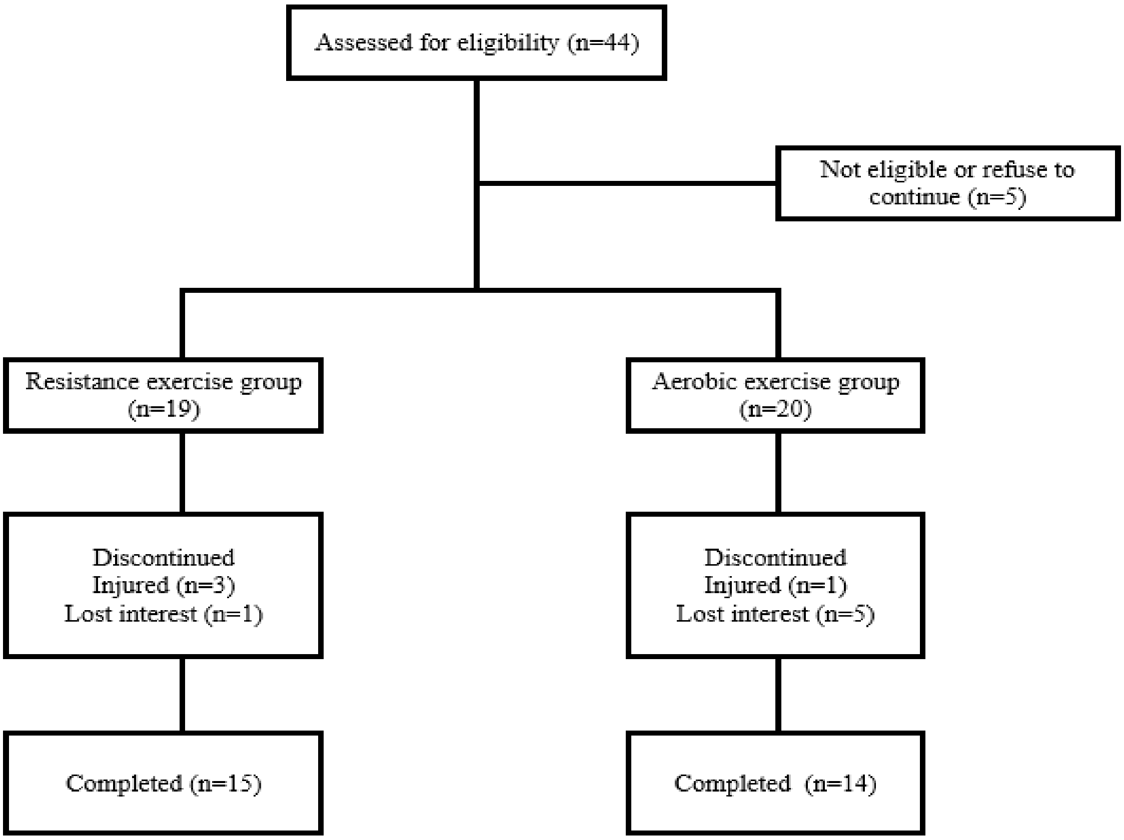

Figure 1. Study flowchart

Table 1. Aerobic exercise program

1-6 weeks	5-8 weeks
Frequency: 3 sessions/wk 60 min/session	**Frequency:** 3 sessions/wk 60 min/session
Intensity: 40-50% of HRR	**Intensity:** 70-80% of HRR
Type of exercise	
Treadmill Elliptical Biking Walking Climbing steps	Treadmill Elliptical Biking Rower X-c skiing Stair-climber

wk: week; HRR: maximal heart rate - resting heart rate

Resistance exercise training: Resistance exercise training was performed 3 days a week, with sessions lasting 60-minute each, for 12 weeks. Sessions include a 10-minute warm-up, 45-minute of resistance exercises, 5-minute of flexibility, followed by cool-down exercises. Resistance exercises were performed using resistance machines and free weights, and sessions were grouped in 3 mesocycles. The first one (weeks 1 to 4) started with 2 sets of 12 repetitions at a load of 65% one-repetition maximum (1-RM). The second cycle (weeks 5 to 8) was made of 3 sets of 10 repetitions at 75%, and the last one (weeks 9 to 12) was of 4 sets of 8 repetitions at 85 of 1-RM. Regardless the mesocycles, resting interval was 3 minutes between exercises and 90 seconds between sets (Table 2) (Akbarpour-Beni and Alishirazi, 2021; Guelfi et al., 2013). The 1-RM in kilograms was estimated by considering the maximum number of repetitions completed with a specific load, employing the formula as follows (Bryzicki, 1998):

$$1RM = load / [1.0278 - (0.0278 \times repetitions)]$$

Following this, each exercise session was conducted using the estimated 1-RM until only one repetition could be completed, at which point the load was identified as the 1-RM. Adequate rest was given between each attempt to determine the 1-RM.

Table 2. The 12 weeks resistance exercise program

1-4 weeks	5-8 weeks	9-12 weeks
Frequency: 3 sessions/wk 60 min/session	**Frequency:** 3 sessions/wk 60 min/session	**Frequency:** 3 sessions/wk 60 min/session
Intensity: 65% of 1-RM	**Intensity:** 75% of 1-RM	**Intensity:** 85% of 1-RM
Sets × Duration: 2 sets x 12 reps	**Sets × Duration:** 3 sets x 10 reps	**Sets × Duration:** 4 sets x 8 reps
The rest interval was 3 minutes between each exercise and 90 seconds between each set	The rest interval was 3 minutes between each exercise and 90 seconds between each set	The rest interval was 3 minutes between each exercise and 90 seconds between each set
Type of exercise		
Power clean Bench press Incline bench press Incline fly Hang pulls (Clean grip) Push press High pulls (Snatch grip) Seated shoulder press Power dumbbell shrugs Dumbbell front raise Triceps pushdowns Trunk and abdominal routine	Squat Power snatch Dead lift Leg extensions Leg curls Standing calf raises Lat pulldown Seated row Hammer curls Dumbbell biceps curls Triceps dumbbell extensions Trunk and abdominal routine	Barbell Back Squat Fixed Barbell Walking Lunge Plank Pull-Up / Pulldown Dumbbell Chest Press Barbell Incline Bench Press Cable Row Barbell Reverse Lunge Barbell Hip Thrust Machine Seated Leg Curl Machine Standing Calf Raise Dumbbell Incline Chest Press Cable Pulldown (close grip) Hanging Knees Raise

wk: week; 1-RM: one-repetition maximum

Data Collection Tools

Body mass and Body mass index: Both body mass (kg) was assessed with bioelectrical impedance scale (Jawon, model IOI-353, Yuseong, South Korea). Measurements were taken in the morning, three hours after waking up, and after the last meal and drink. Height (m) was measured to the nearest 0.1 cm using a wall-mounted stadiometer (Model S100, Ayrton Corp., Prior Lake, MN, USA) with participants wearing surgical scrubs and bare feet. Therafter, body mass index (BMI) was computed as kg/cm^2.

Body composition: Body composition variables were assessed with bioelectrical impedance sclale (Jawon, model IOI-353, Yuseong, South Korea), following recommendations for bioelectrical impedance analysis REF, and immediately after body mass measurement. The subjects then stood on the scales with their bare feet and hands at the marked locations. Based on differences in the ability of body tissues to conduct electric current (different resistance) due to different water content, the device analyzes body composition. BW, BMI, FM, BF, LBM, trunk, leg, and arm fat and lean mass were used in the study analysis.

Ethical Approval

The study was approved by the Uşak University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (21.09.2023/171-171-04) and all procedures were conducted according to the Helsinki declaration.

Analysis of Data

Data analysis was perfomed including only the participants who fully accomplished the interventions and who undertook all the evaluations over the 2 assessment periods. The data were presented as median and interquartile range. For comparisons between groups at baseline (REG vs. AEG), Wilcoxon test was used. Mann Whitney U test was carried out to analyze statistically significant differences within groups. The data were processed using SPSS Statistics 23.0 (IBM, 2015). Significance level was set as $p < .05$.

FINDINGS

Baseline characteristics: The two groups of participants were similar with respect to baseline variables investigated (p> .05) (Table 3).

Table 3. Parameters [median (interquartile range)] at baseline and after intervention

Parameters	Groups	Pre test	Post test
		Median (IQR)	Median (IQR)
BW (kg)	AEG	85.1 (2.6)	82 (3.4)*
	REG	84.6 (15.1)	85.9 (14.35)* #
BMI (kg/m²)	AEG	25.2 (5.7)	24.4 (4.5)*
	REG	25.8 (3.52)	27.1 (3.3)* #
Trunk Fat Mass (kg)	AEG	9.3 (3.7)	8.7 (2)*
	REG	11.4 (8.4)	10 (7.5)*
Leg Fat Mass (kg)	AEG	2.45 (1.6)	1.95 (1.7)*
	REG	2.7 (1.65)	2.2 (1.85)*
Arm Fat Mass (kg)	AEG	0.85 (0.4)	0.75 (0.3)*
	REG	0.9 (0.9)	0.75 (0.8)* #
FM (kg)	AEG	17.3 (5.6)	14.9 (4.4)*
	REG	26.78 (13.25)	15.9 (12.8)*
BF (%)	AEG	20.3 (6)	18.1 (4.7)*
	REG	21.5 (11.95)	18.5 (12.15)*
Trunk Lean Mass (kg)	AEG	35.6 (2.9)	35.8 (2.7)
	REG	34.9 (5.2)	36.8 (4.65)* #
Arm Lean Mass (kg)	AEG	3.65 (0.55)	3.55 (0.3)
	REG	4.09 (1.03)	4.1 (1.13)* #
Leg Lean Mass (kg)	AEG	11.15 (1.3)	11.4 (0.8)*
	REG	11.05 (1.75)	11.85 (2.15)* #
LBM (kg)	AEG	64.4 (2.8)	65.6 (2.8)*
	REG	63.4 (10.3)	67 (10.35)* #

** Difference within groups; # Difference between groups*
Data presented are median (IQR), median change (IQR), and overall effect
BW: Body Weight; BMI: Body Mass Index; FM: Fat Mass; BF: Body Fat; LBM: Lean Body Mass

Changes in anthropometry and body composition: Anthropometrics and body composition at baseline and following the interventions are demonstrated in Table 3. After the 12 weeks intervention period, REG and AEG groups showed significant differences in anthropometry and body composition variables, which included BW, BMI, FM, BF, LBM, trunk, leg, and arm fat and leg lean mass between pre- and post-test (p< .05). Trunk and arm lean mass were significantly improved only in REG (p< .05).

Changes in body weight and BMI: Figure 2 shows changes in BW and BMI after the intervention among the 2 groups. BW increased significantly in REG by 2% (p< .05) and decreased significantly by **%=** -3% (p< .05) in AEG. The total weight gain for the REG was 1.3 kg and the weight loss for the AEG was -3.1 kg. Similarly, BMI decreased significantly in AEG by **%=** -3% (p< .05) and increased significantly by **%=** 3% (p< .05) in REG. Furthermore, there were statistical differences in BW and BMI between groups (p< .05).

Changes in lean mass: Total LBM, trunk, leg, and arm lean mass increased significantly in REG by 8%, 6%, 8%, and 15% (p< .05) respectively. In the AEG, LBM, and leg lean mass increased significantly by 1% and 4% (p< .05), whereas arm lean mass was unchanged (p> .05). Trunk lean mass decreased by -1% in AEG (p> .05; Fig 2).

Changes in fat mass: Total FM reduced significantly (-25% vs. -21%, for REG and AEG, respectively, p< .05). In regard to regional adiposity, trunk, leg, and arm fat mass decreased significantly in REG and AEG by -6%, -35% and -35%, and -1%, -32% and -18%, respectively, (p< .05; Figure 2). Total BF decreased more in REG than in AEG (-28% vs. -18%, respectively, p< .05; Figure 2).

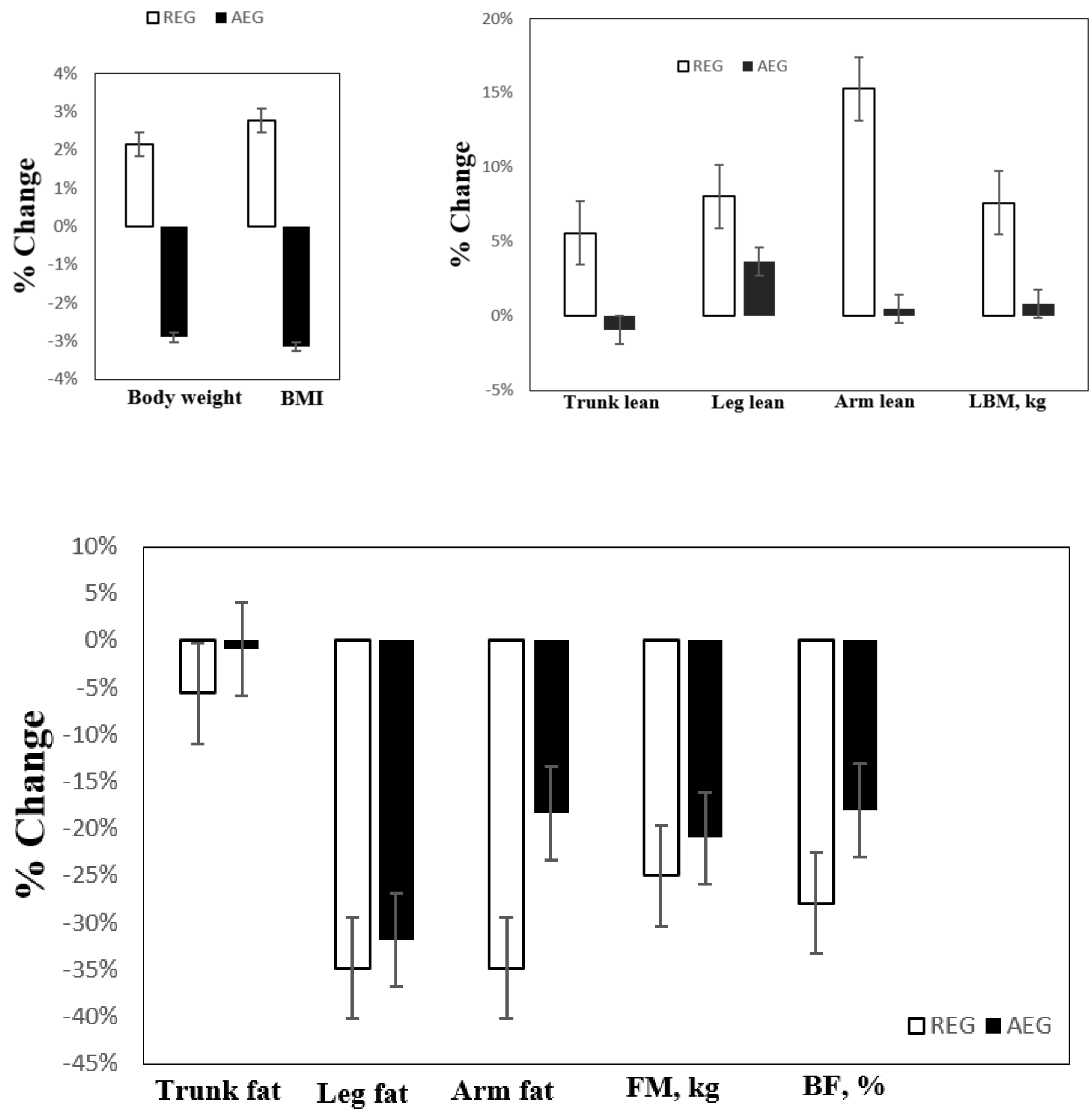

Figure 2. Changes in total and regional change in the resistance exercise group (REG) and aerobic exercise group (AEG). *p< .05 significant difference between groups.

DISCUSSION and CONCLUSION

The current study indicated that 12 weeks of resistance exercise training without caloric restriction increases body weight, BMI, and total and regional lean and decreases fat mass in healthy sedentary overweight males. The outcomes for this current study were body weight and BMI, lean body mass, and fat mass. As a result of this current study, we found that: (ı) BW and BMI increased significantly in REG, but decreased significantly in AEG; (ıı) significant decreases in the amount of FM, BF, trunk, arm, and leg fat mass were detected in both REG and AEG; (ııı) significant increases in the amount of trunk and arm lean mass were observed only in REG; and (ıv) the results indicated that the changes in the amount of BW, BMI, LBM, trunk, leg, and arm lean mass, and arm fat mass significantly differed within 2 groups. For this reason, it can be said that resistance exercise training performed without calorie restriction in overweight individuals causes an increase in muscle mass and has positive effects on general health by causing a decrease in fat mass. This provides evidence for the concept of body recombination and supports previous research demonstrating the benefits of resistance exercise training.

BW and BMI: Resistance exercise trainings induced significant gains in the amount of BW and BMI, whereas the participants in AEG decreased both BW and BMI values significantly from pre-to post-test. The amount of change in BW and BMI demonstrated by the REG in the current study is in parallel with previous findings (Donges and Duffield, 2012; Mohammadi et al., 2018). It may be said that the change in BW and BMI means in REG was driven by the increase in total and regional lean body mass induced by resistance exercise. It has also been stated before that there is a positive relationship between the amount of upper extremity muscle and body weight detected. In a study, Donges and Duffield (2012) conducted with sedentary overweight middle-aged adults for 10-week, showed that the resistance exercise training group (2-4 sets × 8-10 repetitions of 5-7 exercises at 70%-75% 1 repetition maximum) increased the amount of body mass, whereas aerobic endurance training group (30-50 min cycling at 70%-75% maximal heart rate) reduced the amount of body mass. Considering that BMI value is affected by both body fat percentage and lean body mass (Mohammadi et al., 2018), it can be said that the difference between the two groups obtained in this current study is due to the difference in muscle mass at the end of the study.

Lean Mass: Measures of LBM, trunk, leg, and arm lean mass were significantly increased in REG, but not in AEG. When analyzing the changes in the percentage values between groups, the total and regional lean mass in REG were significantly greater than that in AEG. These significant increases in total and regional lean mass in the REG mostly be explained by the growth of the contractile proteins actin and myosin within the skeletal muscle which results in induced muscle hypertrophy (Versic et al., 2021). Our results are supported by previous findings from this trial that indicate resistance training without calorie restriction significantly induces muscle mass increase more than aerobic exercises in sedentary men (Mohammadi et al., 2018; Shepherd et al., 2012; Willis et al., 2012).

In their study, Adıgüzel and Canlı (2019) reported that resistance exercises program without a calorie restriction for 12 weeks increased LBM in sedentary men without a calorie restriction. Furthermore we found 2 recent meta-analyses that examined the resistance training effects on body composition. Benito et al., (2020) concluded that resistance training programs increase muscle mass in avarege 1.53 kg with a wide range of heterogeneity (from 0 to 7.2 kg) in healthy males. Another study by Lopez et al. (2022) examined one-hundred-sixteen articles describing 114 trials (n=4184 individuals with overweight/obesity). They stated that resistance training alone was the most effective for increasing lean mass with changes of 0.8 kg, consistently observed across age and sex groups. Willis et al., (2012) also compared 8-month of resistance training vs. aerobic training in overweight adults, showing resistance training group increased lean body mass more than the aerobic training group. Thus based on this current data we may say that resistance training was the more efficient method for favorable changes in muscle mass.

Fat Mass: Total and regional body fat adiposity significantly decreased after 12 weeks of intervention in both groups. However, there were no significant differences found in changes in the percentage values of FM, BF, trunk, leg, and arm fat mass percentage between the groups. This provides evidence for the notion of body recomposition and adds to the previous literature demonstrating the benefits of RT. Willis et al., (2012) stated that there are conflicting reports in the literature about whether resistance training induces fat mass loss, and in their study without the calorie restriction they indicated that aerobic exercises were more effective for optimal fat mass loss. However, more recent studies (Benito et al., 2020; Lopez et al., 2022) have shown that resistance-based exercise training decreased body fat percentage, total body fat mass, and regional body fat mass, regardless of age and gender, in overweight and obese participants found that adiposity measures significantly decreased after exercise programs.

Wewege et al., (2022) indicated that resistance training, without caloric restriction, dietary alteration, and supplementation reduces body fat percentage and body fat mass in healthy adults. Furthermore, Shepherd et al., (2012) examined resistance training (three training sessions per week for 6 weeks) without calorie restriction in healthy sedentary men (BMI= 24.8 kg/cm^2). They observed a significant reduction in absolute fat mass and relative fat mass. In another study, Mohammadi et al., (2018) examined strength vs. aerobic training for 12 weeks without calorie restriction in sedentary middle-aged men, where both strength and aerobic training groups showed a significant reduction in fat percentage. Our results agree with later studies, which showed a positive effect of a resistance exercise program without calorie restriction on total and regional body fat in sedentary overweight males. The increased metabolism for hours following a resistance exercise may require additional calories, providing significant cumulative energy expenditure (Schuenke and Mikat, 2002; Westcott, 2012). Possible explanations for total and regional body fat loss in our study may include the increased resting metabolic rate after the resistance exercise. Increased body fat is associated with several health-related risk factors including type 2 diabetes and cardiovascular disease (Westcott, 2012). For this reason, a significant decrease in total and regional body fat loss in the REG supports the efficiency of resistance exercise programs for total and regional adiposity of overweight/obese males.

There are also some methodological limitations that exist in our study, including inadequate measurement parameters (i.e., strength and waist circumference). The current study did not quantify the 1-RM muscular strength and circumference measurements changes after resistance vs. aerobic exercise. Waist circumference and waist-to-hip ratio which are indicators of central obesity are correlated with the cardiovascular disease more than measures of BMI (Savva et al., 2000). Furthermore, another limitation of our study was not using DXA, which provides information on fat mass, lean mass or fat-free soft tissue, and bone mineral content (Nana et al., 2015).

The current research would be that resistance exercise without calorie restriction leads to greater improvements in anthropometric and body composition which include BW, BMI, total and regional fat loss, and muscle gain in sedentary overweight males. Such improvements can be beneficial in enhancing several important aspects of physical and mental health. Therefore, if fat loss is the goal with muscle mass gain of the exercise program, individuals must be aware of the specificity of resistance exercise traning.

Practical Application

Based on the results obtained in this study, sedentary overweight males aiming to lose weight under the supervision of a trainer or individually can increase muscle mass and reduce body fat over 12 weeks of resistance training without caloric restriction. In future studies, the effects of 12 weeks of resistance training on body composition can be investigated in sedentary overweight males with different BMI values or in sedentary overweight females. Additionally, similar approaches can be applied in scientific studies involving athletes.

Conflicts of Interest: There is no financial or personal conflict of interest among the authors of the article within the scope of the study.

Authors' Contribution: Study Design - Bahar Ateş, Halil Tanır & Jorge Mota Data Collection - Bahar Ateş & Halil Tanır Statistical Analysis - Bahar Ateş & Lucimere Bohn Manuscript Preparation - Bahar Ateş, Halil Tanır, Jorge Mota & Lucimere Bohn. All authors read and approved the final manuscript.

Ethical Approval

Ethics Committee: Uşak University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee

Date / Protocol number: 21.09.2023 / 171-171-04

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