EUR J PHYS REHABIL MED 2013;49:1-11

Effects of aerobic or combined aerobic resistance exercise on body composition in overweight and obese adults: gender differences. A randomized intervention study

E. SANAL [1], F. ARDIC [1], S. KIRAC [2]

[1]Department of Physical Medicine and Rehabilitation Faculty of Medicine, Pamukkale University Denizli, Turkey
[2]Department of Nuclear Medicine, Faculty of Medicine Pamukkale University, Denizli, Turkey

***Background*. In the literature, it is not yet clear whether sex may affect the outcomes of exercise training in obese adults.**
***Aim*. The aim of this study was to investigate gender difference in the effects of combined aerobic resistance exercise (ARE) *versus* aerobic exercise (AE) alone on body composition in overweight and obese adults.**
***Design*. Randomized clinical trial.**
***Setting*. University-based outpatient clinic.**
Population. Sixty-five healthy, untrained overweight and obese men and women
***Methods*. They were randomized into one of two intervention groups; AE group (N.=33) performed leg cycle exercises with increasing duration and frequency; ARE group (N.=32) performed additionally progressive weight-resistance exercises for the upper and lower parts of body. Both groups were asked not to change their diet. Body composition including percentage of fat (PF), fat mass (FM) and fat free mass (FFM) in regional and whole body was determined by dual-energy X-ray absorptiometry (DXA) at baseline and week 12.**
***Results*. ARE leads to more gains on regional and whole body FFM than AE. ARE was more effective in increasing the FFM of arms, trunk and whole body and decreasing PF of trunk in men and superior on reducing FM of legs in women when comparing with AE.**
***Conclusion*. In order to reduce the trunk fat in men and leg fat in women, resistance exercise can be added into an aerobic training program.**

Clinical rehabilitation impact. Dissimilar results of exercises on sex obtained in our study serves as a guide for prescribing exercises in overweight and obese men and women.

Key words: Obesity - Resistance training - Body composition - Gender identity.

Corresponding author: F. Ardic, MD, Department of Physical Medicine and Rehabilitation, Pamukkale University Faculty of Medicine, 20070, Kinikli/Denizli, Turkey. E-mail: fardic@pau.edu.tr

The World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that may impair health. Body Mass Index (BMI), which is calculated by dividing the weight by the square of the height (kg/m^2), is commonly used in classifying obesity in adults. A BMI of 25-29.9 and ≥30 defines overweight and obesity respectively.[1] Because obesity, especially abdominal obesity, is associated with an increased risk of multiple health problems, including cardiovascular diseases (mainly heart disease and stroke), diabetes, degenerative joint disease, and some cancers, it is an important public health issue.[1] Weight reduction is the common goal in the treatment of obesity. There is sufficient evidence supporting the role of exercise training in promoting weight loss.[2] Many studies investigated the effects of exercise types (aerobic and/or resistance) on weight loss; while in some studies it was demonstrated that both exercises were ineffective [3-5] in the others aerobic exercise [6-8] or both

[9, 10] were found to be effective. These differences may depend on methodology and variety of patient groups in the studies. Some studies implicated patients with chronic diseases[4], some applied different caloric restrictions [10] and some without dietary restriction during exercise training.[7, 8, 11] The most effective mode, duration, and intensity of exercise for successful body weight control are continually debated.[12] The recently published a systematic review and meta-analysis highlighted the need for more research examining the efficacy of combined AE and progressive resistance training modalities.[13]

An optimal weight reduction program should selectively deplete body fat while maintaining lean tissue. Exercise therapy is an integral component of obesity management, but the most potent exercise prescription for visceral adipose tissue benefit is unclear.[13] Several researchers have examined the effects of exercise on the reduction in total and/or visceral fat mass.[3, 10, 11, 14] Results vary regarding the effects of aerobic exercise (AE) and resistance exercise (RE) on the protection of the fat free mass (FFM). While some studies [3] have demonstrated that both aerobic and resistance exercises does not have any effect on FFM, others have shown that a combination of both exercise increase the lean body mass [14] and another study [10] has reported that additional RT is more helpful in protecting FFM than only AE. Although all these studies suggest positive effects of exercise on different systems, the evidence is not conclusive.

In the clinical setting, an accurate assessment of body composition remains a challenge. A major problem of the previous studies is the usage of indirect methodologies with limited accuracy such as bioelectrical impedance analysis or skinfold measurement.[15] Simple anthropometric measurements seemed to be useful in the cross-sectional analyses, but only dual-energy x-ray absorptiometry (DXA) was able to detect the group differences in training-induced changes in lean body mass.[16] DXA is an objective and reliable technique on predicting fat mass (FM) and FFM; also it is used in increasing interest for measuring body fat distribution and for searching its changes. [12, 14, 17]

In the literature, it is not yet clear whether sex may affect the outcomes of exercise training program in obese subjects.[18] The problem of determining differences in efficacy between the sexes is compromised by a lack of studies reporting the outcomes by gender.[19] Further evidence is needed to determine whether providing gender specific approaches to weight loss is more or less effective than a standardized approach.[20] There are few studies evaluating the effectiveness of exercise training on body composition and fat distribution in both genders.[12, 21-25] To the best of our knowledge, the present study is the first to compare the effects of two types exercise training in two sexes of non-dieting overweight and obese adults. Moreover, since the exercise intervention tends not to be monitored, the validity of some studies evaluating the effectiveness of exercise needs to be questioned. Therefore, an important feature of this intervention study – which differs from most others – is that the exercise was supervised.

The aim of this study was to assess effects of a 12-week combined aerobic resistance exercise (ARE) *versus* AE alone on anthropometric and body composition changes overweight and obese adults. Specifically, we aimed to evaluate the effect of 1) combined aerobic and resistance exercise vs. aerobic exercise alone on body composition change by DXA; 2) gender difference in the response to two types of exercise.

We hypothesized that, combined aerobic resistance exercise (ARE) would have a greater effect on body composition than either aerobic exercise only and men and women did different response to different types of exercise programs.

Materials and methods

Participants

One hundred and ten healthy sedentary overweight or obese men and women were evaluated for potential enrollment (Figure 1); 12 people did meet the exclusion criteria and 6 declined to participate in the study. Exclusion criteria were a history of chronic systemic or musculoskeletal diseases, involvement in regular strength or aerobic exercise program in the one year before commencement of the study, use of medications with known effects on musculoskeletal system, consumption of more than two alcoholic drinks daily and following regular energy-restricted diets. Ninety-two adults who met the eligibility criteria and agreed to participate were randomly assigned to aerobic exercise (group AE, N.=46) or combined aerobic resistance exercise (group ARE, N.=46). A simple randomization strategy (with a random numbers table) was used to

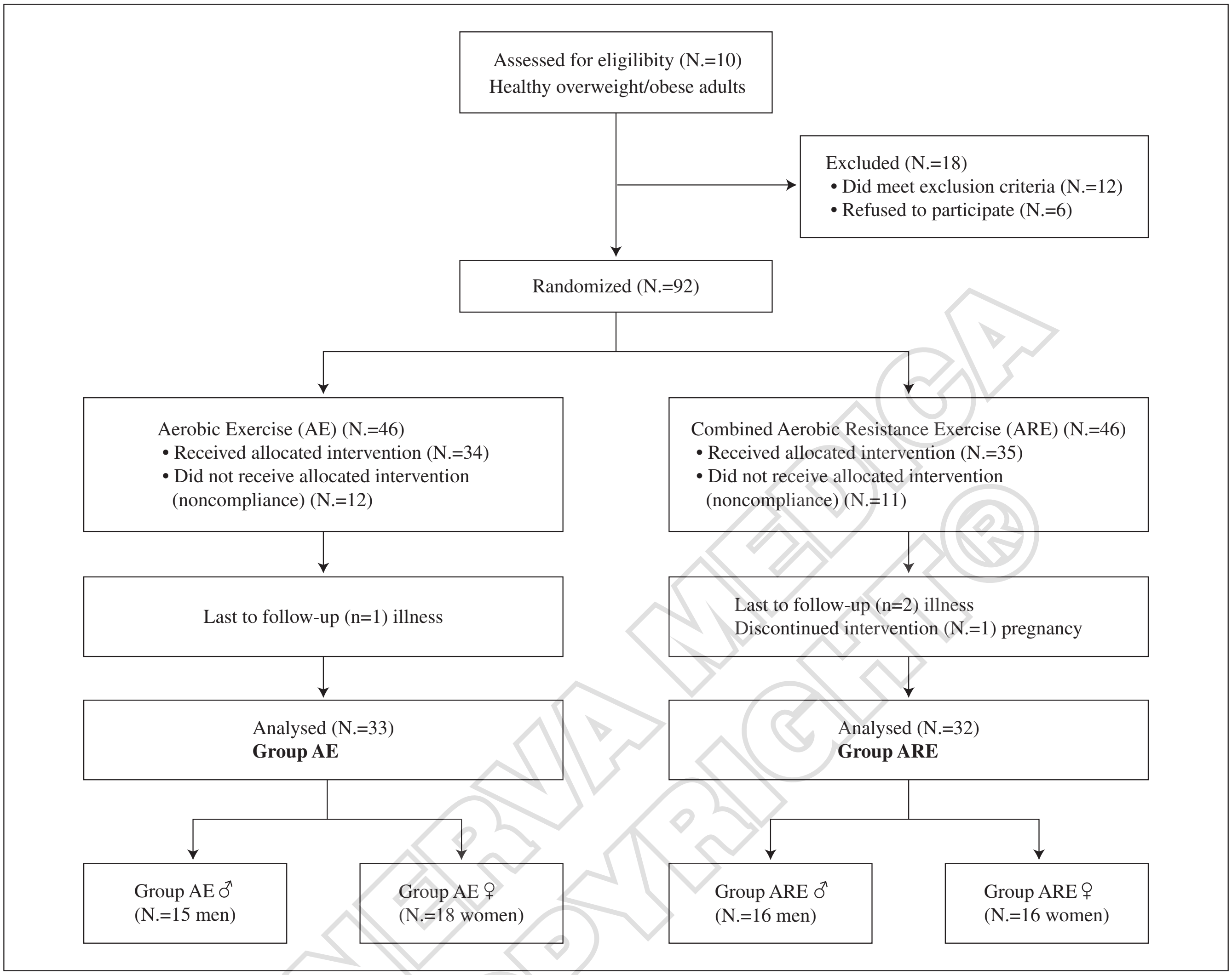

Figure 1.—Flow diagram of participant's progress through the phases of the randomized trial.

assign participants. 65 completed the training program (12 AE participants and 11 ARE participants did not receive training because of noncompliance, 3 participants were excluded because of illness and pregnancy). Both groups were divided into two subgroups according to sex, men in group AE (group AE males), women in group AE (group AE females), and men in group ARE (group ARE males) and women in group ARE (ARE females).

This study was approved by the University Ethics Committee and thus meets the standards of the Declaration of Helsinki. All subjects were informed about possible risks and benefits of the exercises and DXA method. After that, subjects read and signed the patient consent form before beginning of the study. All subjects were instructed not to change their eating habits.

Study design

Assessment parameters

Anthropometric measurements.—Weight was measured with a standard scale (EKS, German).

Height was assessed with a wall-mounted stadiometer. The circumferences were measured in centimeters with non-elastic tape to the nearest millimeter. Waist circumference (WC) was measured at the midpoint between the lower border of the rib cage and the iliac crest, and hip circumference (HC) was measured at the widest part of the hip region. Waist/hip ratio (WHR) was calculated. All anthropometric measurements were made by the same investigator (ES).

Body composition by DXA.—Whole and regional body composition was assessed by the DXA method (Hologic, QDR 4500W, Bedford, MA) to determine FM, FFM, percent of fat (PF). The same technician positioned the subjects, performed scans and completed the scan analysis using the standard analysis protocol according to the computer's manual. Quality-assurance tests were done every morning before scanning. CV is 1.0 % at 95% confidence level.

Training protocol

All training protocols were made in the exercise unit of the department of physical medicine and rehabilitation under supervision by a physiatrist.

AE

For aerobic training, subjects were instructed to walk briskly out of the door and then to exercise on the leg cycle ergometer for 15 minutes. The intensity of exercise was adjusted by target heart rate at 50-85% of the maximum heart rate. The running intensity was determined by a percentage of heart rate reserve calculated according to Karvonen.[26] All subjects exercised in their target heart rate ranges for 12-15 minutes in three days/week within the first month; 20-30 minutes in four days/week during the second month; and 30-45 minutes in five days/week in the third month. Initial intensity and progression were compatible with the recommendations of ACSM.[26]

Combined AE and ARE

The combined endurance resistance exercise group performed aerobic exercise as described above and they also performed resistance exercise two days a week. Six stations were used to exercise upper- and lower-body large muscle groups: leg extension (quadriceps), hip abduction (gluteus medius), abdominal flexion (rectus abdominalis) chest press (pectoralis major), arm flexion (biceps), and arm extension (triceps). At each station, subjects completed the repetitions and sets. The rest time between sets was two minutes. Subjects did their resistance exercises for 3-6 sets with 10 repetitions and in 50% of one-repetition maximum (1RM); in the first 6 weeks and during second 6 weeks, 2-3 sets with 10 repetitions and in 75-80% of 1RM.

Flexibility exercises to gastrocnemius, quadriceps, hamstring, gluteal and back, pectoral, triceps and biceps muscles stretching were performed before and after the training. All stretching were done for 20 seconds and three times for each muscle.

If one of the subjects couldn't come to his/her session, we contacted with her/him and another day was set for the subject. If the time between two sessions was longer than one week, the subject was excluded from the study.

Statistical analysis

SPSS version 11.0 for Windows (SPSS, Chicago, IL, USA) was used for statistical analyses. This was an efficacy study; therefore, primary analyses were completed for the 65 participants who completed the 12-week study. Between baseline and follow-up in each group, if the number of subjects more than thirty paired t-test was used. If the number of subjects was smaller than thirty, Wilcoxon's rank-sum test was used for each group. For the effectiveness of exercise between groups [Change%: (pretreatment score-post treatment score)/pretreatment score) x 100], an independent samples t-test was used for the parametric data, otherwise the Mann-Whitney U-test was used for non-parametrical data. Parametric and non-parametric tests were determined according to subject number (N.>30). Levene test and Plot test were used. The $P<0.05$ criterion was used for establishing statistical significance.

Results

Baseline characteristics of two groups were similar (Table I).

Table II shows the changes in anthropometric measurements of the AE and ARE groups after the 12-week exercise programs. There were no statisti-

TABLE I.—*Characteristics of participants at baseline.*

	Group AE (N.=33)	Group ARE (N.=32)	P-value
Sex (M/F)	15/18	16/16	0.90
Age (years)	39.0±10.5	39.0±9.7	1.00
Height (m)	1.6±0.1	1.6±0.0	0.60
Weight (kg)	85.8±13.6	89.2±13.8	0.33
BMI (kg/m²)	31.4±4.8	31.9±4.0	0.60
Waist-hip ratio	0.87±0.0	0.8±0.0	0.38

Values presented as mean ± SD.
AE: aerobic exercise; ARE: combined aerobic resistance exercise; BMI: Body Mass Index

TABLE II.—*Results of anthropometric measurements at baseline and after 12 weeks and the differences (% change) in 2 groups.*

	AE (N.=33)		ARE (N.=32)	
	Baseline	12 W	Baseline	12 W
Weight (kg)	85.8±13.6	82.1±13.2*** (4.3±2.5)	89.2±13.8	85.4±13.4*** (4.2±3.1)
BMI (kg/m²)	31.4±4.8	29.9±4.0*** (4.5± 2.6)	31.9±4.0	30.5±3.7*** (4.2±3.1)
WC (cm)	95.5±9.4	92.1±8.9*** (3.5±2.5)	97.1±10.2	92.9±9.8*** (4.1±2.6)
HC (cm)	110.5±10.7	107.2±10.8*** (3.2±2.6)	109.0±9.7	106.1±8.7*** (3.5±2.1)
WHR	0.8±0.09	0.8±0.09 (0.6±2.9)	0.8±0.1	0.8±0.1 (1.2±2.7)

Values presented as mean ± SD. AE: aerobic exercise; ARE: combined aerobic resistance exercise; 12W: 12 weeks; BMI: Body Mass Index; WHR: waist-hip ratio; HC: hip circumference; WC: waist circumference. Significant difference between baseline and 12-week. ***P<0.001

cally significant differences between the groups in the pre-training. After the exercise period, decreases in weight, BMI and circumference measurements in AE and ARE groups were all significant (P<0.05) but decreases in WHR was not. There was no significant difference for these measurement changes between groups (P>0.05).

Whole and regional (arms, trunk, legs) body composition (FM, FFM, and PF) were similar before the training period for both groups (Table III) (P>0.05). Significant changes were observed in the measures of body composition with weight loss. Assessing the regional body composition, FM, and PF of arms, trunk and legs were significantly decreased after a 12 week training period in both AE and ARE groups. FFM of arms, and trunk were significantly increased in ARE group. AR exercises were more effective in increasing FFM and decreasing FM (except arm FM) and reducing PF in all regional and whole body composition measurements than AE alone (Table III).

Table IV shows the anthropometric measurements changes after 12 weeks training period for sub-groups; AE males, AE females, ARE male and ARE females. All values in all sub-groups significantly decreased except WHR (P<0.05). Changes in the anthropometric measurements were not significant between those all subgroups (P>0.05).

Changes of regional and whole body composition parameters after 12 weekly exercise periods for sub-groups are shown in Table V. After the exercise program, reduction in FM and PF of arms, legs and whole body, and FM of trunk were significant in all sub-groups (P<0.05). FFM of arms in AE female group and FM in AE male group were significantly different from the other.

When comparing the effectiveness of the two exercise types in men, the gains in arm, trunk and whole body FFM and also reducing trunk PF for ARE male group were higher than AE male group (P<0.05) (shown as C in Table V). As a result, adding resistance exercise to aerobic exercise was more effective on increasing the FFM of arms, trunk and whole body and decreasing PF of trunk in men than aerobic exercise alone.

When comparing the effectiveness of the two exercise types in women, only reductions in FM of legs were superior for ARE female group than AE female

TABLE III.—*Results of body composition measurement by DXA at baseline and after 12 weeks and the differences (%change) in 2 groups.*

	Group AE (N.=33)		Group ARE (N.=32)		P value
	Baseline	12 W	Baseline	12 W	
Regional body composition					
Arms					
FM (kg)	3.3±1.0	3.0±1.0**	3.8±1.2	3.1±0.9**	
Change %		(9.64±7.35)		(14.62±23.83)	
FFM (kg)	5.5±1.7	5.3±1.5*	5.6±2.0	5.8±1.9**	
Change %		(1.35±10.25)		(-6.65±11.92)	##
PF	36.9±12.0	35.1±11.5**	40.2±12.0	34.5±10.4***	
Change %		(5.11±5.46)		(12.48±16.80)	#
Trunk					
FM (kg)	15.6±5.0	14.1±4.01**	16.9±3.9	14.1±3.2***	
Change %		(7.81±10.49)		(15.34±13.75)	#
FFM (kg)	25.3±4.6	25.1±4.4	24.6±5.5	26.1±4.9*	
Change %		(0.60±6.45)		(-7.07±14.20)	##
PF	36.9±8.2	35.2±6.9***	40.0±7.6	34.3±6.2***	
		(3.59±8.31)		(13.01±14.24)	##
Legs					
FM (kg)	10.5±4.1	9.8±3.6***	12.2±4.2	10.3±3.5**	
Change %		(5.86±5.93)		(13.85±14.67)	##
FFM (kg)	17.2±4.0	17.4±3.9	17.1±4.4	18.3±4.3	
Change %		(-1.25±8.68)		(-8.75±15.62)	#
PF	36.3±11.0	34.8±10.3**	40.3±11.2	34.8±9.7*	
Change %		(4.16±5.61)		(12.00±14.94)	##
Whole Body Composition					
FM (kg)	30.2±9.4	28.0±8.0***	33.9±8.7	28.5±6.9***	
Change %		(6.70±6.1)		(14.1±14.4)	##
FFM (kg)	51.4±10.3	51.3±9.7	50.7±11.6	53.8±11.2***	
Change %		(0.01±6.0)		(-7.3±13.5)	##
PF	35.8±8.8	34.1±7.8***	39.0±8.6	33.8±7.0***	
Change %		(4.0±5.6)		(11.8±13.9)	##

Values presented as mean ± SD.
AE: aerobic exercise; ARE: combined aerobic resistance exercise; 12W: 12 weeks; FM: fat mass; FFM: fat-free mass; PF: percentage of fat.
Significant difference between baseline and 12 W
*P<0.05, **P<0.01, ***P<0.001
Significant difference between group-change
#P<0.05, ##P<0.01

group (P<0.05) (shown as D in Table V). As a result, adding resistance exercise to aerobic exercise was more effective on reducing FM of legs in women.

Evaluating the program compliance and adverse effects, all participants performed their training sessions within the 12 weeks. There were no sex differences among subjects who did not complete the study. Adverse events depending on the exercise program rarely occurred. One subject in group AE (knee meniscal tear) and two subjects in group ARE (knee meniscal tear and lumbar pain) had musculoskeletal complaints and were excluded from the study. No other adverse effects were experienced.

Discussion

This study compares the effect of 12-week aerobic exercise vs. aerobic plus resistance exercise on changes in body composition in healthy overweight and obese adults. The results of this study demonstrate two important facts regarding the relationship between the types of exercise prescribed and gender. First, the two different types of training exerted some different effects on body composition. Both types of training were found to be equally effective in decreasing body weight and fat mass whereas only aerobic plus resistance exercise increased FFM. Second, men and women did differ in the response

TABLE IV.—*Results of anthropometric measurements at baseline and after 12 weeks and the differences (% change) in subgroups.*

	AE ♂ (N.=15)		AE♀ (N.=18)		ARE ♂ (N.=16)		ARE ♀ (N.=16)	
	Baseline	12 W	Baseline	12 W	Baseline	12 W	Baseline	12 W
Weight	91.3±13.8	86.9±12.5***	81.3±12.1	78.1±12.6**	93.9±12.9	90.8±11.7**	84.5±13.4	80.0±13.2***
Change %		(4.6±2.5)		(4.0±2.4)		(3.0±2.8)		(5.3±3.0)
BMI	29.7±3.5	28.2±3.0**	32.7±5.4	31.4±5.5***	30.6±3.1	29.6±2.7**	33.3±4.5	31.5±4.5***
Change %		(4.8± 2.7)		(4.1±2.5)		(3.1±2.8)		(5.3±3.0)
WHR	0.9±0.0	0.9±0.0	0.7±0.0	0.7±0.0	0.9±0.0	0.9±0.0	0.8±0.0	0.7±0.0
Change %		(1.1±2.7)		(0.1±2.9)		(1.2±3.3)		(1.1±2.8)
HC	105.6±8.1	103.0±7.5**	114.5±11	110.7±12***	105.2±7.8	102.7±7.5**	113.7±10	109.2±10***
Change %		(2.4±2.5)		(3.3±2.6)		(2.2±1.9)		(4.0±2.5)
WC	101.5±10	97.8±9.23**	90.6±4.7	87.9±4.9***	103.3±9.7	99.6±9.2**	90.0±4.7	86.7±4.8**
Change %		(2.6±2.6)		(2.5±2.6)		(3.5±2.1)		(4.7±2.2)

Values presented as mean ± SD. AE ♂: aerobic exercise man group; AE♀: aerobic exercise woman group; ARE ♂: combined aerobic and resistance exercise man group; ARE ♀: combined aerobic and resistance exercise woman group; 12W: 12 weeks; BMI: Body Mass Index; WHR: waist-hip ratio; HC: hip circumference; WC: waist circumference. **P<0.01 between baseline and 12 W. ***P<0.001 between baseline and 12 W

to the prescribed exercise mode. In men, adding resistance exercise to aerobic exercise was more effective in increasing the FFM of arms, trunk and whole body and decreasing PF of trunk. In women, adding resistance exercise to aerobic exercise was more effective in reducing FM of legs.

WHO defines overweight and obesity as abnormal or excessive fat accumulation that may impair health.[1] The main reason in the development of obesity is an excess of energy intake relative to energy expenditure. This occurs due to the storage of energy excess as adipose tissue. Abdominal obesity more related with the chronic diseases shows the importance of fat mass distribution as the amount.[27] There is insufficient evidence that exercise-induced weight loss is associated with reductions in abdominal fat.[28] Limited evidence from non-randomized or controlled studies suggest a modest reduction in WC that is observed in response to exercise-induced weight loss.[28] We have shown that after a 12 week training program the aerobic and combined exercises decreased the weight, BMI and circumference measurements in agreement with the previous literature.[10]

Fat mass and FFM measurements

As changes in WHR, WC, weight and BMI cannot always predict the visceral and total abdominal FM; imaging techniques have to be used.[29] DXA, which is mainly known as gold standard for assessment of bone mineral density can also be used to assess FM and FFM volume. It is an objective and reliable technique for measuring body composition and its changes. Simple anthropometric measurements seemed to be useful in the cross-sectional analyses, but only DXA was able to detect the group differences in training-induced changes in lean body mass.[16] The radiation level is very low and the reproducibility of the fat mass is excellent, but it has problems in measuring increasing tissue depth and severe obesity.[30] We used this objective and reliable method for measuring regional and whole body composition.

Weight reduction is the common goal in the treatment of obesity. An optimal weight reduction program should selectively deplete body fat while maintaining lean tissue. Several studies have reviewed the effects of exercise on the reduction in total fat mass and/or visceral fat mass but in the most of the studies, effectiveness exercises were evaluated together with diet programs.[10, 31-33] A meta-analysis of 46 studies has evaluated the effects of endurance exercise training on FFM preservation during diet-induced weight loss. The percentage of weight loss as FFM for diet-plus-exercise subjects was approximately half that of dietary restriction subjects of the same sex.[31] In a recent review, it seems that the addition of physical exercise to a diet is important to prevent a decrease in FFM, increase relative visceral FM loss and improve dietary compliance.[32] Andersen *et al.*[34] reported in their study performed DXA, the percentage of weight loss from FFM was significantly less in the diet plus aerobic exercise group compared to the diet plus lifestyle group in obese women at the end of 16 weeks. Ghroubi *et al.*[10] have suggest-

TABLE V.—*Results of body composition measurement by DXA at baseline and after 12 weeks and the differences (% change) in subgroups.*

	AE ♂ (N.=15)		AE♀ (N.=18)		ARE ♂ (N.=16)		ARE ♀ (N.=16)	
	Baseline	12 W	Baseline	12 W	Baseline	12 W	Baseline	12 W
Regional body composition								
Arms								
FM	2.6±0.7	2.3±0.7**	3.8±0.9	3.6±0.9**	3.4±1.3	2.6±0.6*	4.2±1.1	3.6±0.9*
Change %		(12.7±8.2)^{A}		(7.0±5.4)		(15.9±29.9)		(13.2±16.5)
FFM	7.2±0.9	6.8±0.8**	4.0±0.5	4.1±0.5	7.1±1.5	7.4±1.3*	4.0±0.9	4.3±0.8
Change %		(6.1±8.8)		(-2.6±11.3)^{A}		(-5.0±7.6)^{C}		(-8.2±15.1)
PF	25.6±5.7	24.3±6.2*	46.3±6.2	44.1±5.7***	31.2±8.6	25.3±4.5*	49.2±7.1	43.7±4.7***
Change %		(5.4±7.2)		(4.8±3.5)		(14.8±20.8)		(10.0±11.6)
Trunk								
FM	14.0±4.8	12.9±3.8*	17.0±4.9	15.2±3.9**	16.1±3.8	13.1±2.7**	17.7±4.0	15.1±3.5***
Change %		(6.1±11.0)		(9.1±10.1)		(6.2±15.8)		(14.4±11.1)
FFM	29.1±3.5	28.4±3.3*	22.2±2.8	22.3±3.0	27.5±4.6	29.6±3.8*	21.8±3.6	22.6±3.2
Change %		(2.2±2.9)		(-0.7±8.1)		(-8.7±13.1)^{C}		(-5.1±14.6)
PF	30.7±6.4	30.1±5.7	42.0±5.5	39.5±4.5**	36.0±6.8	29.6±4.1**	44.0±6.3	39.0±4.1**
Change %		(1.2±6.3)		(5.5±9.3)		(15.7±16.2)^{C}		(10.2±11.7)
Legs								
FM	8.1±3.2	7.6±2.9**	12.5±3.6	11.7±1.5**	10.0±3.3	8.1±2.0**	14.5±3.9	12.6±3.4***
Change %		(6.0±5.7)		(5.7±6.2)		(15.4±18.4)		(12.2±10.0)^{D}
FFM	20.7±3.2	20.6±3.1	14.4±1.8	14.7±2.1	19.8±3.7	21.4±3.3	14.4±3.4	15.2±2.8
Change %		(0.1±4.2)		(-2.4±11.1)		(-9.4±16.7)		(-8.0±14.9)
PF	26.4±5.6	25.3±5.7**	44.6±6.5	42.7±5.2*	32.0±8.1	26.2±3.9*	48.6±7.1	43.4±4.6***
Change %		(4.3±5.0)		(3.9±6.1)		(14.4±19.1)		(9.6±9.1)
Whole body composition								
FM	25.4±8.2	23.8±7.1**	34.2±8.7	31.4±7.3**	30.5±8.1	24.9±4.8**	37.4±8.1	32.2±7.0***
Change %		(5.6±5.1)		(7.5±6.8)		(15.1±17.7)		(13.1±10.6)
FFM	60.7±7.0	59.5±6.8*	43.8±5.0	44.3±5.3	58.2±9.5	62.2±8.2*	43.2±8.1	45.4±6.5
Change %		(1.7±2.3)		(-1.4±7.7)		(-7.8±11.2)^{C}		(-6.8±15.5)
PF	28.1±5.5	27.2±5.1*	42.2±5.2	39.9±4.1**	33.1±6.8	27.6±2.9**	44.9±5.9	40.1±3.4**
Change %		(2.8±4.4)		(5.0±6.4)		(13.8±17.0)		(9.7±10.1)

Values presented as mean ± SD. AE ♂: aerobic exercise man group; AE♀: aerobic exercise woman group; ARE ♂: combined aerobic and resistance exercise man group; ARE ♀: combined aerobic and resistance exercise woman group; 12W: 12 weeks; FM: fat mass; FFM: fat-free mass; PF: percentage of fat. Significant difference between baseline and 12 W. *P<0.05, **P<0.01, ***P<0.001. Subgroup comparisons (P<0.05): ^{A}group AE♂ *versus* group AE♀ (AE ♂ *versus* ♀); ^{B}group ARE♂ *versus* group ARE♀ (ARE ♂ *versus* ♀); ^{C}group AE♂ *versus* group ARE♂ (♂ AE *versus* ARE); ^{D}group AE♀ *versus* group ARE♀ (♀ AE *versus* ARE)

ed that the combination of dietary measures with exercise training including resistance exercise may contribute to improvements in body composition in the management of obesity. They did not find any variations in lean mass in the patients having performed aerobic training; in contrast, patients having performed additional strength exercises displayed an increase in lean mass and a greater decrease in FM measured by Bioelectrical impedance analysis (BIA).[10] The difference between our study and these studies is that we examined effectiveness of exercise programs without any diet restrictions. We found that only aerobic plus resistance exercise without diet change increased FFM in all regional and whole body composition measurements.

There are a small number of studies about pure exercise efficacy. We previously conducted a longitudinal, randomized controlled clinical study to compare the effects of 12-week period resistance exercise (RE) and AE on BMI, weight, FM, in obese women who cannot adhere to energy-restricted diets.[35] In this study, significantly decreased BMI, waist, and weight measurements were observed in both training groups; however reduced FM was seen only in the AE group. The weakness of this study was the usage of BIA to measure of FM and FFM. Sasai *et al.*[8] demonstrated that participants with high intra-abdominal fat exhibited greater reductions in intra-abdominal and total fat in response to 12-week aerobic exercise program than those with moderate intra-abdominal fat. As we did, they used DXA to measure body composition analysis.

Recently, Friedenreich *et al.*[11] published an article reporting the effects of the aerobic exercise intervention among postmenopausal women on both total and abdominal adiposity, as assessed with dual X-ray absorptiometry and computed tomography. This yearlong aerobic exercise intervention resulted in statistically significant reductions in overall and abdominal adiposity without any intervention to change dietary intake. In our study, significant changes were observed in the measures of body composition with weight loss. We have shown with DXA that after a 12 week training program the both exercises types declined the fat mass of trunk in overweight and obese adults without diet.

In a recently published systematic review and meta-analysis researching the effects of aerobic vs. resistance exercise training on visceral fat stated that the most potent exercise prescription for visceral adipose tissue benefit is unclear.[13] Indeed, in two studies no difference was reported between AE and ARE on lowering FM of trunk.[9, 16] However, in another study, ARE were found more effective in decreasing FM of trunk as consistent with our study.[36] Sillanpaa and *et al.*[16] demonstrated there were no differences between the two exercises in decreasing FM of legs and increasing FFM of all regions. But we ascertained that ARE is superior on those. In two studies, aerobic exercises were found to be effective in increasing trunk FFM, whereas no efficacy was found in our study.[16, 36] We have annotated that these different findings due to various methodological distinctions of studies.

Sex differences in fat loss

In the literature, a few studies compared the effect of exercise training on body composition in both sexes.[37] The results of our study suggest that both training produces marked reductions in body fat in both sexes. This is in contrast to research suggesting that exercise-induced reductions in body weight and fat mass are more pronounced in males than females.[21, 38] In randomized controlled efficacy trial, Donnelly et al. reported that aerobic exercise prevented weight gain in women and produced weight loss in men.[38] Ballor and Keesey [21] observed in their meta-analysis that men showed a larger bodyweight loss as a result of dietary restriction and exercise training, when compared with women. In contrast, Andersson *et al.*[22] showed that the bodyweight and FM loss was comparable between obese men and women as a result of a 3-month combined intervention program. However, when we looked at the data in more detailed, it revealed that the baseline fat mass was greater in the female participants. After correction for differences in baseline fat mass, the men had actually lost a higher amount of fat. In HERIGATE Family Study,[23] the effect of a 20 week aerobic training program on body composition was assessed in 557 individuals (258 men, 299 women) by hydrostatic weighing and computerized tomography. They reported that aerobic exercises provided small but significant increases in the FFM of the whole body, a decrease in FM, and PF in both sexes; but men lost a greater amount of abdominal visceral fat in comparison to women. In our study, we did not observe any difference in the reduction of whole body FM in group AE males and AE females.

Geer and Shen [24] reviewed gender differences in body composition. They concluded that men and women differed in regard to body composition. For a given BMI, men had higher lean mass and more visceral and hepatic adipose tissues, whereas women had elevated general adiposity, subcutaneous adipose tissue in particular. Recently, Kuk and Ross [25] published an article about the distribution of body fat and its response to weight loss program (calorie restriction, exercise or both) in obese men and women. The participants were 81men and 72 women with a starting BMI of over 27. They assessed the body fat by whole-body magnetic resonance imaging scans before and after the intervention. They found no significant difference regarding total fat loss between men and women, but men lose more visceral fat than women, while the women lose more lower body total subcutaneous fat than man. It seems impossible to distinguish the cause between whether it is the sex difference or initial fat distribution. The limitation of this study is the effect of exercises on these findings is not clear, because of the usage of wide range of interventions acting differently. However we have investigated the effects of two types exercise training in two sexes of non-dieting overweight and obese adults. Two types of exercise in both men and women reduced whole body as well as trunk fat. However, the AER increased only in males, trunk and whole body FFM.

Especially in males, the addition of resistance-exercise appears more effective results.

Donnelly *et al.*[38] did not find any significant changes occurred in fat-free mass in either men or women; however, both had significantly reduced visceral fat with aerobic exercise. The superiority of our study is we showed that in addition these findings, adding resistance exercise to aerobic exercise were more effective on increasing the FFM of arms, trunk and whole body in men.

McTiernan *et al.*[39] examined long-term effects of aerobic exercise on adiposity in women and men. This randomized, controlled clinical trial showed that moderate-to-vigorous intensity exercise, results in significant weight and fat loss over 12 months in sedentary individuals. They found no statistically significant difference between men and women. The comparison of the patients' self-reports with the observation of professionals was the major weakness of their study. They also did not specifically test different types of exercises. Our study involves two different types of exercise and all of the patients did their exercises under supervision. Therefore, this gender- and training-specific effect could be due to a combination of type of exercise and the supervision.

We randomized 92 patients, but data were available for 65 of them. The modest adherence to the intervention is a major problem of exercise programs. It has been reported that 1 in 3 patients do not attend to first appointment of exercises programs and the completion rates range from 12-52%.[40]

The strong aspects of our study are that it is the first study to the examine effects of gender and type of exercise in overweight or obese people, it is a randomized study, usage of DXA as a reliable measurement (DXA has been used as a reliable measurement), and the patients were under supervision.

In regards to evaluating the effectiveness of the type of exercises in men, ARE were more effective in increasing the FFM of arms, trunk and whole body and decreasing PF of trunk than AE. We can predict that the health benefits of this program would be impressive for combined exercising men. Considering cardiovascular diseases, adding resistance exercise into training programs in men in order to reduce the trunk fat can be recommended.

In assessing the effectiveness of the type of exercises in women, ARE was observed to be superior on reducing FM of legs compared to AE. When women were usually considered as gynecoid type body shape, more fat mass in legs, this result showed the importance of AR exercises.

There are some limitations in our study. One is the low number of subjects in sub-groups, other limitation is that no data about what happened after end of the training program. Statistical limitation is weakness of significance of data from multiple comparisons. There is need for more randomize-controlled studies involving larger numbers of men and women.

Conclusions

We can conclude that, as there was no calorie restriction and not too much weight loss in our study group, an increase in FFM instead of a decrease was observed. Resistance exercises have a favorable impact on body composition by preventing the loss of FFM. Dissimilar results of exercises on sexes should be taken into consideration in obese men and women. Studies with a longer follow-up duration would provide further information regarding the effects of regular exercise in overweight or obese people.

References

1. World Health Organization (2006) Obesity and Overweight. Global Strategy on Diet, Physical Activity and Health. Fact sheet Nº 311.
2. Shaw K, Gennat H, O'Rourke P, Del Mar C. The Cochrane Collaboration. Exercise for overweight or obesity. Cochrane Database Syst Rev 2006;4:1-88.
3. Wadden TA, Vogt RA, Andersen RE, Bartlett SJ, Foster GD. Exercise in the treatment of obesity:Effects of four interventions on body composition, resting energy expenditure, appetite, and mood. J Consult Clin Psychol 1997;65:269-77.
4. Lambers S, Van Laethem C, Van Acker K, Calders P. Influence of combined exercise training on indices of obesity, diabetes and cardiovascular risk in type 2 diabetes patients. Clin Rehabil 2008;22:483-92.
5. Sarsan A, Ardic F, Ozgen M, Topuz O, Sermez Y. The effects of aerobic and resistance exercises in obese women. Clin Rehabil 2006;20:773-82.
6. Ross R, Dagnone D, Jones PJ, Smith H, Paddags A, Hudson R *et al.* Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men:a randomized, controlled trial. Ann Int Med 2000;133:92-103.
7. Mayo MJ, Grantham JR, Balasekaran G. Exercise-induced weight loss preferentially reduces abdominal fat. Med Sci Sports Exerc 2003;35:207-13.
8. Sasai H, Katayama Y, Nakata Y, Ohkubo H, Tanaka K. Obesity phenotype and intra-abdominal fat responses to regular aerobic exercise. Diabetes Res Clin Pract 2009;84:230-8.

9. Park SK, Park JH, Kwon YC, Kim HS, Yoon MS, Park HT. The effect of combined aerobic and resistance training on abdominal fat in obese middle-aged women. J Physiol Anthropol Appl Human Sci 2003;22:129-35.
10. Ghroubi S, Elleuch H, Chikh T, Kaffel N, Abid M, Elleuch MH. Physical training combined with dietary measures in the treatment of adult obesity. A comparison of two protocols. Ann Phys Rehabil Med 2009;52:394-413.
11. Friedenreich CM, Woolcott CG, McTiernan A, Terry T, Brant R, Ballard-Barbash R *et al*. Adiposity changes after a 1-year aerobic exercise intervention among postmenopausal women:a randomized controlled trial. Int J Obes (Lond) 2011;35:427-35.
12. King N, Byrene NM, Hunt A, Hills A. Comparing exercise prescribed with exercise completed:Effects of gender and mode of exercise. J Sports Sci 2010;28:633-40.
13. Ismail I, Keating SE, Baker MK, Johnson NA. A systematic review and meta-analysis of the effect of aerobic vs. resistance exercise training on visceral fat. Obes Rev 2012;13:68-91.
14. Villareal DT, Chode S, Parimi N, Sinacore DR, Hilton T, Armamento-Villareal R *et al*. Weight loss, exercise, or both and physical function in obese older adults. N Engl J Med 2011;31:1218-29.
15. Plasqui G, Soenen S, Westerterp-Plantenga MS. Measurement of longitudinal changes in body composition during weight loss and maintenance in overweight and obese subjects using air-displacement plethysmography in comparison with the deuterium dilution technique. Int J Obes 2011;35:1124-30.
16. Sillanpää E, Häkkinen A, Nyman K, Mattila M, Cheng S, Karavirta L *et al*. Body composition and fitness during strength and/or endurance training in older men. Med Sci Sports Exerc 2008;40:950-8.
17. Friedl K, Vogel J, Marchitelli L, Kubel S. Assessment of regional body composition changes by dual-energy x-ray absorptiometry (OEXA). Basic Life Sci 1993;60:99-103.
18. Snowling NJ, Hopkins WG. Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients. A meta-analysis. Diabetes Care 2006;29:2518-27.
19. Gibson CA, Kirk EP, Lecheminant JD, Bailey BW, Huang G, Donnelly JE. Reporting quality of randomized trials in the diet and exercise literature for weight loss. BMC Med Res Methodol 2005;23:5-9.
20. Young MD, Morgan PJ, Plotnikoff RC, Callister R, Collins CE. Effectiveness of male-only weight loss and weight loss maintenance interventions:a systematic review with meta-analysis. Obes Rev 2011 [Epub ahead of print].
21. Ballor DL, Keesey RE. A meta-analysis of the factors affecting exercise-induced changes in body mass, fat mass and fat-free mass in males and females. Int J Obes 1991;15:717-26.
22. Andersson B, Xu XF, Rebuffé-Scrive M, Terning K, Krotkiewski M, Björntorp P. The effects of exercise, training on body composition and metabolism in men and women. Int J Obes 1991;15:75-81.
23. Wilmore JH, Després JP, Stanforth PR, Mandel S, Rice T, Gagnon J *et al*. Alterations in body weight and composition consequent to 20 wk of endurance training: the HERITAGE Family Study. Am J Clin Nutr 1999;70:346-52.
24. Geer EB, Shen W. Gender differences in insulin resistance, body composition, and energy balance. Gend Med 2009;6:60-75.
25. J L Kuk JL, Ross R. Influence of sex on total and regional fat loss in overweight and obese men and women. Int J Obes 2009;33:629-34.
26. Kenney WL, Humphrey RH, Bryant CX. ACSM's guidelines for exercise testing and prescription. Fifth edition. New York: Lippincott Williams & Wilkins; 1995. p. 153-77.
27. National Heart Lung and Blood Institute Expert Panel. Clinical Guidelines on the Identification, Evaluation and Treatment of Overweight and Obesity in Adults: Evidence Report. National Institutes of Health: Bethesda, MD; 1998.
28. Ross R, Jansessen I. Is abdominal fat preferentially reduced in response to exercise-induced weight loss? Med Sci Sports Exerc 1999;31:568-72.
29. Kay SJ, Fiatarone Singh MA. The influence of physical activity on abdominal fat:a systematic review of the literature. Obes Rev 2006;7:183-200.
30. Lundqvist K, Neovius M, Grigorenko A, Nordenström J, Rössner S. Use of dual-energy x-ray absorptiometry in obese individuals: the possibility to estimate whole body composition from OXA half-body scans. Radiography 2008;1:1-8.
31. Ballor DL, Poehlman ET. Exercise-training enhances fat-free mass preservation during diet-induced weight loss:a meta-analytical finding. Int J Obes Relat Metab Disord 1994;18:35-40.
32. Hansen D, Dendale P, Berger J, van Loon LJ, Meeusen R. The effects of exercise training on fat-mass loss in obese patients during energy intake restriction. Sports Med 2007;37:31-46.
33. Schaar B, Moos-Thiele C, Platen P. Effects of exercise, diet, and a combination of exercise and diet in overweight and obese adults – a meta-analysis of the data. Open Sports Med J 2010;4:17-28.
34. Andersen RE, Wadden TA, Bartlett SJ, Zemel B, Verde TJ, Franckowiak SC. Effects of lifestyle activity vs structured aerobic exercise in obese women:a randomized trial. JAMA 1999;27;281:335-40.
35. Fenkci S, Sarsan A, Rota S, Ardic F. Effects of resistance or aerobic exercises on metabolic parameters in obese women who are not on a diet. Adv Ther 2006;23:404-13.
36. Pierson LM, Herbert WG, Norton HJ, Kiebzak GM, Griffith P, Fedor JM *et al*. Effect of combined aerobic and resistance training versus aerobic training alone in cardiac rehabilitation. J Cardiopulm Rehabil 2001;21:101-10.
37. Ardic F. Anthropometry and exercise in obesity. In: Preedy VR, editor. Handbook of anthropometry: physical measures of human form in health and disease; New York: Springer; 2012.p.1919-35.
38. Donnelly JE, Hill JO, Jacobsen DJ, Potteiger J, Sullivan DK, Johnson SL. Effects of a 16-month randomized controlled exercise trial on body weight and composition in young, overweight men and women:The Midwest Exercise Trial. Arch Int Med 2003;163:1343-50.
39. McTiernan A, Sorensen B, Irwin ML, Morgan A, Yasui Y, Rudolph RE *et al*. Exercise effect on weight and body fat in men and women. Obesity 2007;15:1496-512.
40. Moore GF, Moore L, Murphy S. Facilitating adherence to physical activity: exercise professionals' experiences of the National Exercise Referral Scheme in Wales. A qualitative study. BMC Public Health 2011;15:935.

The preliminary report of this paper was presented in the 5th World Congress of the International Society of Physical and Rehabilitation Medicine (ISPRM), June13-17, 2009, Istanbul.

Funding.—Pamukkale University Scientific Research Projects Management Unit provided a research funding for this prospective study (Project number:2008TPF 015).

Conflicts of interest.—The authors declare no conflict of interest.

Received on September 9, 2011.
Accepted for publication on March 15, 2012.
Epub ahead of print on May 8, 2012.