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Regional Fat Mobilization and Training Type on Sedentary, Premenopausal and Overweight and Obese Women

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Running head: ***Regional Body Composition and Training Type***

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‘What is already known about this subject’

- Acute exercise studies with fat biopsies and dialysis observed preferential mobilization from trunk and abdomen in women.
- Aerobic (AT) and resistance training (RT) have differential effects on body composition in heterogenous populations.
- Aerobic combined with resistance training (AT+RT) are thought to promote reductions of fat mass and increments of fat free mass simultaneously.

‘What this study adds’

- The observation that AT, RT and AT+RT, affect whole body composition in a similar manner in pre-menopausal women
- Specific analyses of regional fat mobilization.
- Comparisons of whole and regional body composition (fat mass and fat free mass) between training groups.

Abstract

Little is known about the influence of different training types on relative fat mobilization with exercise. **Objective:** The purpose of this study was to analyze the changes induced by aerobic training (AT), resistance (RT) or a combination of both (AT+RT) on total fat mass (TFM) and regional fat mass (RFM). Further, the relative contribution of different regions, upper limbs (UL), lower limbs (LL), and trunk (Tr), were compared. **Design and Methods:** Forty-five overweight and pre-menopausal women were randomized in either AT, RT or AT+RT. All training groups exercised for the same duration (60 minutes), 3 times/wk for 5 months. Body composition was estimated using dual energy x-ray absorptiometry. **Results:** TFM decreased significantly in all groups (-4.6±1.9kg; -3.8±2.6kg and -4.7±3.0kg in AT, RT, and AT+RT groups respectively; $P<0.001$). The relative contribution of FM into each segment changed significantly: TrFM represented 46.6±5.8% of TFM at baseline and reduced to 43.1±5.5% ($P<0.001$); LLFM was 39.7±5.8% vs. 41.6±5.7% ($P<0.01$); ULFM was 11.3±1.3% vs. 12.2±1.4% ($P<0.01$). **Conclusion:** Training type did not influence changes of TFM and RFM. Fat mobilization came predominantly from Tr in all training protocols. These findings suggest that overweight and obese women can reduce TFM and RFM, independently of training type.

INTRODUCTION

Excess of adiposity has been associated with several metabolic complications (1). It is well recognized that obesity-related disorders are associated with regional fat distribution independently of total body fat (TBF) (1, 2). Indeed, metabolic differences have been shown between regional fat depots (3, 4), across gender (5) and within the same gender but of different regional phenotype (upper or lower fat distribution) (6). Besides FM, fat free mass (FFM) is another indirect determinant of obesity, as it is the main predictor of resting metabolic rate (RMR) (7). Regional distribution of FFM influences RMR, due to the relative contribution of the different compartments and the fact that their response to intervention are not homogeneous (7). Increasing FFM is considered as an important factor to facilitate physical activity and improve exercise energy expenditure (8, 9). Maintenance or increase of FFM through exercise is an important concern in weight loss programs (10, 11, 12). In weight loss conditions, several studies have looked at the effects on regional body composition (RBC) of exercise volume and intensity (13), fractionation (one longer bout vs. several shorter bouts)(14) or different types of exercise (9, 15).

In healthy premenopausal women, studies comparing aerobic training (AT) vs. resistance training (RT) (16, 17) and AT vs. the combination of both (AT+RT) (18) have pointed to the maintenance of FFM with RT (16, 19) and to a reduction of FM only if combined to dietetic interventions (18, 19). To our knowledge, there are only two studies comparing the effects of AT, RT and RT+AT on TBC and RBC in overweight and obese subjects (20, 21), but none have been conducted specifically in healthy premenopausal women without dietary intervention.

The aim of this study was to compare changes of regional and overall body composition, in sedentary overweight or obese healthy women, with AT, RT or AT+RT. We hypothesize that the three exercise protocols will influence similarly

TBC without significant changes in RBC when controlling for the same total duration.

METHODS AND PROCEDURES

Participants

Sixty-six pre-menopausal (>25 yrs) overweight and obese women, previously enrolled in an institutional registry, were recruited by telephone. All participants were free from metabolic diseases and weight stable. None were engaged in any exercise programme for at least six months. All participants signed the informed consent. The Institutional Review Board at the Faculty of Human Movement, Technical University from Lisbon, approved all procedures of this study.

Study design

The study design was a pre/post-intervention with randomization in one of three exercise protocols arms (AT, RT, or AT+RT). Randomization and allocation was performed by statistical software (SPSS version 13.0, Inc. Chicago, IL). All arms were of equal duration and included 3 sessions per week for 5 months. All sessions were supervised and registered by an exercise specialist to ensure compliance to the prescribed load and duration.

Exercise Protocols

Aerobic training protocol (AT, n=14): Exercise sessions progressed in the first six weeks from 30 to 60 minutes, and were then maintained at 60 minutes for the rest of the intervention. The mode of exercise was mostly walking on a treadmill (Technogym®, Italy). Stationary cycling was selected occasionally. Exercise intensity was set at 70% of maximal heart rate and was monitored using heart rate monitors (Polar Team System, Finland).

Resistance training protocol (RT, n=15): Resistance training was performed on weight-training machines (Technogym®, Italy). After 10 minutes aerobic exercise warm up, 10 exercises were performed in a circuit method: chest press, leg extension, abdominal flexion, lateral pull down, leg press, back extension, row, hip adduction, pullover, arm curl, lower back, shoulder press and vertical traction. After an adaptation period of 7-10 days, all subjects underwent a 1 RM test (22). After that point, all exercises were adjusted to perform 20 RMs. The rest time between exercises was of 30 seconds. At the beginning 1 circuit was performed and progressively the training was increased to 3 circuits. Between circuits, stretching exercises were performed. The training time was at all times matched with the aerobic protocol.

Aerobic and resistance training protocol (AT+RT, n=16): This protocol consisted in two periods of 12 to 20 minutes. The first one was a treadmill walk at 70% of maximal heart rate as described for AT. This was followed by a circuit of 8 resistances machines as described for RT: leg press, chest press, vertical traction, hip adduction, abdominal flexion, hip abduction, back extension and upper row.

Assessments

Subjects visited the laboratory in two separated days during the same week to perform body composition and metabolic assessments. All measurements were performed at baseline and after the 5 months intervention during the follicular phase of the menstrual cycle. For the first visit, subjects were assessed for body composition and resting metabolic rate (RMR). They were requested to come to the lab between 7 and 9 AM and to adhere to the following conditions: 12-h fasting, refrained from the hard exercise at least 36-h, no caffeine and alcohol during the preceding 24-h, consumed a normal evening meal in the previous night, wearing comfortable clothes and arriving at the laboratory calmly. On the second day, cardiopulmonary exercise testing (CPET) was performed to determine the metabolic variables during exercise. Controlled conditions included: No food intake in the 4-hours prior to the test and no exercise in the previous 24-hours.

Body Composition. Dual energy X-ray apsortiometry (DXA) was used to assess TBC and RBC (QDR-1500; Hologic, Waltham, MA, software version 5.67 enhanced whole body analysis). In this study, we analyzed two whole-body compartments: fat mass (FM) and fat free mass (FFM); four body segments: Upper limbs (UL), lower limbs (LL), head (H) and trunk (T), and two abdominal regions: Total abdominal fat (TAbFM) was defined as FM between L2-L4 and was determined by drawing a rectangle with length equal to the distance between the last rib and the upper level of iliac crest, and width equal to the width of the body, including subcutaneous fat. Central abdominal fat (CAbFM) was obtained drawing a similar rectangle with a width that was limited by the ribs. The relative contribution of FM in each segment was computed as (kg FM segment/kg FM) x 100. The same calculations were performed for FFM and total mass.

The absolute mobilization of FM by segment was estimated after 5 months of training as the difference in g of FM in the segment of interest by its baseline amount in kg. This relative measure of selective fat mobilization adjusted to the specific segment mass allows understanding if the fat loss was due to a specific characteristic of fat store into each segment or if it was due to higher FM at baseline. Using this rationale, we created three variables: FromLL, FromUL and FromTr (grams of FM by each kg of FM segment: FM mobilized from lower limbs, upper limbs and trunk, respectively).

RMR was determined by indirect calorimetry with a facial mask (Quark b^2 Cosmed®, Italy). Subjects rested supine for 25-30 min in a quiet room, at an ambient temperature of ±22ºC and humidity of 40-50%. Then the mask was placed and oxygen consumption (VO_2) and CO_2 production (VCO_2) were measured for 30 minutes. RMR was calculated by Weir's equation (23)

Cardiorepiratory Fitness. Peak oxygen uptake (VO_{2peak}) was measured by a treadmill (Quinton Model 640 Treadmill Controller) graded exercise test using indirect calorimetry (Quark b^2 Cosmed®, Italy). Heart rate was assessed during the test using a heart rate monitor (Polar®, Finland). Test protocol consisted in a warm up period (speed 4.6 $km.h^{-1}$, 0% incline) followed by the first step at 5.6 $km.h^{-1}$ and 0º incline for three minutes. Grade was then increased by 2.5% every three minutes until volitional exhaustion.

Energy Expenditure of Training Protocols (EETP). A portable indirect calorimeter was used to measure EETP ($K4b^2$, Cosmed®, Italy) in a subsample of 13 women at week 6. They were asked to perform all 3 training protocols after a resting period of 5 minutes in the sitting position. Controlled conditions included 3 hours after the same meal at each testing. The software (7.3 version) total energy expenditure. EETP was computed as total energy expenditure minus 5 minutes of resting energy expenditure.

Dietary Assessment

A trained nutritionist performed all dietary assessments. First a prospective four-day food record was given to the volunteers. Instructions included recording of all foods and drinks consumed, including water, as well as preparation methods and quantities. Food records were immediately reviewed by the nutritionists who used two Portuguese reference books with food photographic models to assess portion sizes Quantification and record analyses were preformed with the Food Processor Software (Nutrition Analysis Software Version 7.4, by ESHA, Salem, Oregon, 2000).

Statistical analyses

Descriptive values are given as means and standard deviation. Paired sample T-test were performed to compare means between dependent variables at baseline (0M) and at 5 months (5M). Absolute differences of dependent variables were compared using ANCOVA to adjust for baseline values. Changes in relative values (percent change) were compared by ANOVA. When needed, Bonferroni *post Hoc* tests were performed. Significance level was set at $P<0.05$.

RESULTS

Characteristics

Physical characteristics at baseline are presented in table 1. Cardiorespiratory, metabolic and body composition variables were similar between groups ($P>0.05$). Twenty subjects were removed from the analyses these included 7 women who trained below 75% of total trainings and 13 who dropped out and did not finish the study for personal reasons (pregnancy, disease and low motivation). Their characteristics are also presented in table 1 and were not significantly different from subjects that finished the study.

Weight and total body composition

Changes with intervention are presented in table 2. When all subjects were analyzed together weight and BMI did not change significantly ANCOVA adjusted to baseline values did not show any significant differences on body composition changes between training groups after 5-months exercise program. Interestingly, about 50% of the subjects lost weight in each group (figure1). Despite no change in mean weight (-0.23±2.43kg, *P>0.05*), individual analyses indicate that approximately 29% of subjects reduced their weights (figure 1).

Whole body composition changed significantly after the training in the total sample (table 2) Within groups, all presented a significant reduction in FM and % FM (*P<0.001*). Significant differences between groups were not observed (*P>0.05*, table 2). A significant increase in FFM was observed for the total sample (*P<0.001*, table 2). We did not find differences between groups in regards to improvements in FFM (*P>0.05*, table 2).

RBC: Segments

Regarding regional body composition, all compartments within body segments (T, LL and UL) changed significantly, without differences across groups (table 3).

RBC: Abdominal Region

Specific analyses of abdominal region, TAbFM and CAbFM showed non-significant changes after intervention for the whole total sample (TAbFM, difference = 4.5±287g, *P>0.05*; CAbFM, difference = 2.2±21g, *P>0.05*). Although significant differences were found between groups, and we observed that AT+RT reduced

TAbFM more than AT, these differences disappeared after adjustments for TAbFM at baseline (*P>0.05*). This pattern was similar in CAbFM. Paired sample *t*-test for waist circumference (WC) between 5M and 0M did not show significant changes (92.5±8.4cm vs. 90.1±8.5cm, *P>0.05*), which confirms the DXA data.

Changes in Relative Contribution for Whole Body Mass and Selective Fat Mobilization

When we analyzed the relative contribution of segments masses for the whole body mass, we observed that the trunk was the segment with more relative weight of all compartments (figure 2). The relative contribution of head and trunk in whole mass and FFM changed significantly with intervention (panel A and C, figure 2). FM was the body compartment with the highest change in its relative contribution (panel B, figure 2). The relative contribution of trunk FM for all segments was significantly reduced in all groups (panel B, figure 2).

Regarding to the selective mobilization of fat mass, we could observe that there was a preferential mobilization from trunk, follow by lower limbs and finally upper limbs, and this pattern was similar for all groups (figure 3). While AT was the only group that showed significant difference between FromUL vs. FromLL, RT and RT+AT showed minimal and non-significant differences (table 5).

Nutrition

In this assessment we had a low rate of attrition, and only a subgroup of 20 women were evaluated. This subgroup did not report any significant change in their total energy intake after the training (6801±1392 kJ/day vs. 6701±1505 kJ/day, *P>0.05*) or percentage of carbohydrate (62.9±8.1% vs. 59.4±8.6%, *P>0.05*). Moreover, they increased the percentage of fat (14.4±4.5% vs. 24.1±5.3%, *P<0.001*) and reduce the protein (22.9±6.6% vs. 16.6±5.3%, *P<0.01*). An independent sample t-test comparing this subgroup with nutritional assessment to the rest of the participants without nutritional assessment did not show significant differences for whole body and regional FM (*P>0.05*).

Metabolic Assessments and strength tests

VO_{2peak} was increased significantly in AT (2331±417L·min· vs. 2512±461L·min^{-1}; *P<0.01*) and AT+RT (2296±426L·min^{-1} vs. 2502±591L·min^{-1}; *P<0.01*), but not in RT (2238±311L·min^{-1} vs. 2236±328L·min^{-1}; *P>0.05*). EETP was on average 25.5±6.6kJ·min^{-1}; 11.6±3.3kJ·min^{-1} and 23.1±4.5 kJ·min^{-1} for AT, RT and AT+RT, respectively. This was significantly different between groups (ANOVA, P*<0.001*) with the RT being lower than the two other groups (Post Hoc, *P<0.001*).

All 1RM tests except for back extension exercise were significantly improved in AT+RT (abdominal flexion 23.8%, row 22.3%, *P<0.01* both; chest press 25.5%, lateral pull down 22.6%, leg press 24.9%, hip adduction 18.2%, *P<0.001* for all) and RT (chest press 32.2%, abdominal flexion 33.9%, leg press 21.7%, row 27.7%, hip adduction 22.8%, back extension 20.3%, *P<0.01* for all; lateral pull down 23.0%, *P<0.001*). AT did not gain strength significantly (*P>0.05*).

DISCUSSION

The main finding of this study was that, when controlling for exercise duration, aerobic training, resistance training or the combination of both, promote similar changes in whole and regional body composition in sedentary and healthy overweight premenopausal women. Furthermore, we did not observe specific effects on body compartments or regions.

In our study we did not observe significant alterations of body mass. This is in accordance with other exercise only studies (i.e. that did not use a combination of exercise and dietary intervention) (16, 24, 25). This confirms that exercise is effective on short and middle term weight reduction only with caloric restriction (13, 26). In disagreement with our results, Willis and al. (20) showed a statistically significant weight reduction (approx. 1.5 kg) with 8 months of AT or AT+RT training in a heterogeneous population (men and women, 18-70 years old). In a recent study, comparing the three same training protocols in men and women, Ho and al. (21) FM was decreased only in the AT+RT group. The difference with our data could be explained by a gender effect or the fact that a great proportion of their female population was post-menopausal (aged 44 to 66).

In our cohort, the effects of exercise on lipolytic responsiveness are independent of weight loss. This was also demonstrated in former exercise studies where reductions of total fat mass were observed without changes in body mass (27, 28). FM decreased similarly in AT, RT and AT+RT. This observation is in accordance with Sigal et colleges (28) who used equivalent protocols in type II diabetic women and found similar reductions of FM across training groups. In other studies without dietetic intervention, higher FM reductions were observed with AT or AT+RT compared to RT (25, 30). Interestingly in our cohort, individual analyses show that 30% of women reduced significantly their weight. As mentioned by Williams this could be due to a genetically-dependent variability of the weight reduction after exercise interventions (12).

In our homogenous population of middle-aged obese women, FFM increased with training. We did not observe any differences between AT, RT and AT+RT protocols. Although RT or AT+RT had greater effects on FFM than AT in studies involving men (19, 20, 21, 25), we as others (18, 29, 30) did not observe differential responses in women. It is again important to limit the comparison to studies involving only exercise and not a combination of exercise and diet. Indeed, studies using this combination observed FFM reductions (30, 31), which may be due to the caloric restriction, and not to the catabolic effect of AT.

It is well recognized that fat distribution influences lipid metabolism (5, 6, 33). Moreover, FFM changes by segments follow different patterns as a consequence of specific resistance training protocol (34). From the previous evidences, we can speculate that the relative contribution of different compartments (FM and FFM) by region has important consequences for health, functional capacity and well-being in overweight people (1, 17, 35). As proposed in other study (36), we calculated the relative contribution of FM and FFM by each segment to whole-body FM or FFM. Our results show significant reductions on the relative contribution of TrFM to whole body FM and increases in LLsFM, ULsFM and HFM. These data confirm the selective fat mobilization from trunk in women (2, 5). Furthermore, we found similar effects across protocols thus confirming the classical theory that says that exercise promotes adrenergic stimulation to support muscle contraction energy expenditure (37). Our findings are in opposition with a study combining AT with caloric restriction where changes in the abdominal FM were not observed (36). This suggests a differential effect of the combination of caloric reduction on selective fat stores mobilization.

To confirm the hypothesis of selective mobilization we adjusted the reduction of FM in each segment by baseline FM. This confirmed that in the total sample, there was a preferential mobilization of FM from the trunk followed by [LL and UL]. A difference in LL and UL was apparent only for the AT, with a greater reduction in FM from LL than UL. RT had the lowest mobilization from the limbs while AT+RT was the group with more fat mobilization from UL, suggesting that probably AT+RT should be necessary to optimize the reduction of FM within UL.

Regarding FFM, we found more stable changes between regions, which probably reflect the local effects of protein synthesis, induced by exercise training. Since, the maintenance or increase in FFM should have a positive effect on resting metabolic rate and strength (7, 11), the increase in FFM observed in this investigation is an advantage for increased health. In the current study, a set of exercises for all body segments were selected in RT an AT+RT protocols, so FFM changes are expected. With AT, exertion in ULs with walking is a valid stimulus to increase FFM in this segment in sedentary overweight women.

Our study is not exempt of limitations. First, although we designed the study to respect the same training time across protocols (~60 minutes) and prescribe the same energy expenditure, the metabolic intensity was not identical across the three protocols. Indeed, EETP was significantly lower in RT than AT and AT+RT. However, this difference was not enough to induce significant differences between groups in body composition variables, which is in accordance with the results found by Ballor and colleges (38). Higher energy expenditure post exercise in RT could be a plausible explanation to find less difference than expected. The second important limitation is that although we tried to control for food intake, self-reported dietary records, known to be frequently underreported (39, 40), may underestimate changes that can occur in nutrition with exercise training, such as compensation for the energy expenditure of exercise (39). This could be a reason to observe a lower weight loss than expected from changes of energy stores (41). Another limitation is that we were unable to generate a control group, i.e. a non-exercising group, due to the fact that our volunteers were experienced (in registry due to previous participation in other studies) and refused to enter in the study if we were not proposing an intervention.

CONCLUSIONS

Exercise training was a successful treatment to modify TBC and RBC. RBC changed its relative contribution to total FM, with lower proportion of TrFM after intervention, reflecting a higher fat mobilization from the trunk region. FFM changed with the same proportion in all segments. Finally, opposite to other studies with similar design, we did not found significant differences between AT, RT or AT+RT on the different body compartments or segments. These findings may have important implications for exercise prescription in overweight sedentary women. Indeed, if a person cannot perform AT due to other disease or condition impairing walking or cycling, an equivalent volume of RT may result in similar changes on regional and total body composition.

DISCLOSURE

Competing interests: the authors have no competing interests.

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EAC wrote the manuscript, performed statistical analyses and obtained data. FA edited the manuscript, corrected and wrote the final approval of the submitted and published versions. RSP and MJV carried out the intervention and obtained data. PMS conceived and designed the study. LBS conceived and designed the study, edited the manuscript.

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FIGURE LEGEND:

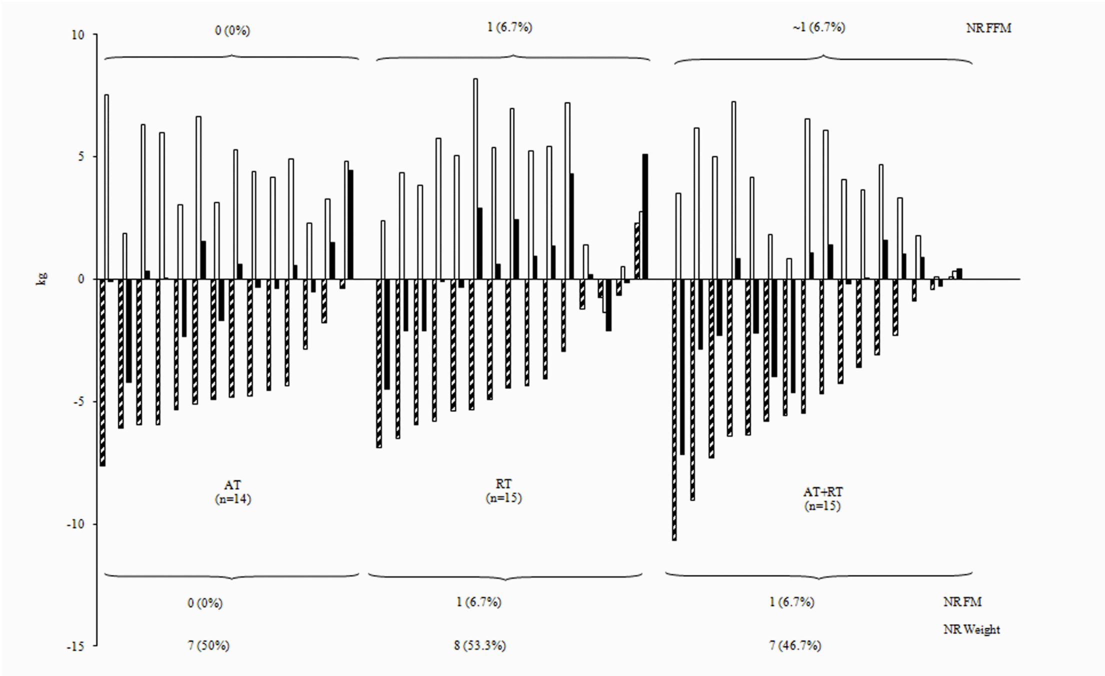
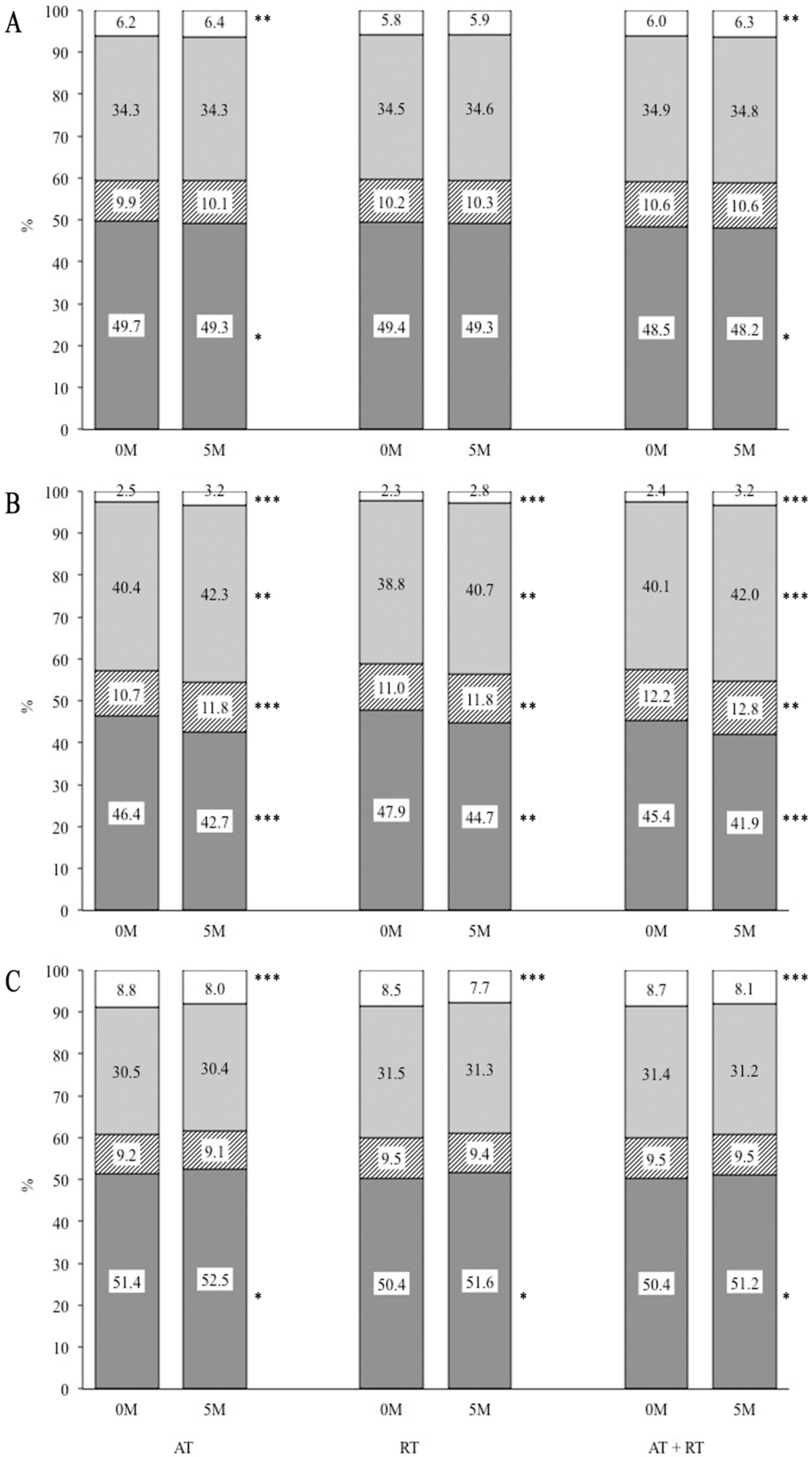


Figure 1. Individual changes in fat mass (FM), fat free mass (FFM) and body weight by groupAT, aerobic training; RT, resistance training; AT+RT, aerobic and resistance training.


A
B
C
%
100
90
80
70
60
50
40
30
20
10
0
6.2
6.4
5.8
5.9
6.0
6.3
34.3
34.3
34.5
34.6
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9.9
10.1
10.2
10.3
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10.6
49.7
49.3
49.4
49.3
48.5
48.2
2.5
3.2
2.3
2.8
2.4
3.2
40.4
42.3
38.8
40.7
40.1
42.0
10.7
11.8
11.0
11.8
12.2
12.8
46.4
42.7
47.9
44.7
45.4
41.9
8.8
8.0
8.5
7.7
8.7
8.1
30.5
30.4
31.5
31.3
31.4
31.2
9.2
9.1
9.5
9.4
9.5
9.5
51.4
52.5
50.4
51.6
50.4
51.2
0M
5M
AT
RT
AT + RT

Figure 2. Relative contribution in percent of body segments before (0M)and after 5 months of training (5M). . A, Body mass; B fat mass; C, fat free mass. White bars, head; grey bars, lower limbs; dashed bars, upper limbs; dark bars, trunk.. AT, aerobic training; RT, resistance training. Paired sample T test: *, *P<0.05*; **, *P<0.01*; ***, *P<0.001*.

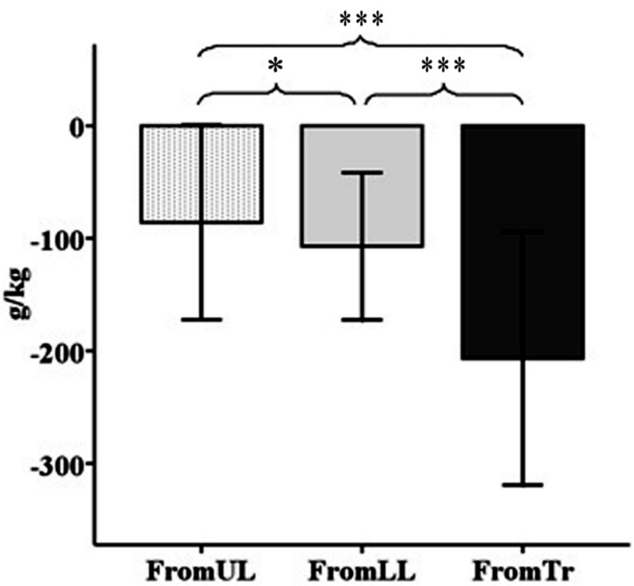

Figure 3. Mobilization of fat mass from upper limbs (UL), lower limbs (LL) and trunk (Tr) after five months of training. *, *P<0.05*; **, *P<0.01*; ***, *P<0.001.*

Table 1.- Descriptives at baseline for all sample and by groups.

Variables	(units)	Total Sample (n=66) Mean	SD	AT (n=15) Mean	SD		RT (n=15) Mean	SD		AT+RT (n=16) Mean	SD	Drop-out (n=20) Mean	SD
TimeT	*(months)*	5.2	± 0.8	5.1	± 0.8		5.2	± 0.8		5.4	± 0.8		
Age	*(Y)*	39.5	± 7.0	42.2	± 5.8	*b	38.7	± 6.2		36.2	± 7.2	40.8	± 7.6
Height	*(cm)*	160.6	± 5.3	160.9	± 5.2		160.0	± 4.7		161.7	± 5.1	159.8	± 6.2
BMI	*($kg.m^{-2}$)*	29.3	± 4.1	28.3	± 3.4		29.7	± 4.0		27.9	± 3.4	30.8	± 4.8
Weight		75.5	± 11.1	73.2	± 8.7		76.1	± 10.6		73.0	± 9.6	78.6	± 13.8
FM	*(kg)*	32.2	± 8.5	30.2	± 6.6		32.6	± 8.3		30.1	± 7.9	35.1	± 10.0
FFM		43.3	± 4.5	43.0	± 4.8		43.4	± 3.8		42.9	± 4.3	43.5	± 5.1
%FM	*(%)*	42.1	± 5.9	40.9	± 5.8		42.3	± 5.7		40.7	± 6.2	44.0	± 5.9
WC	*(cm)*	94.6	± 10.0	93.0	± 9.4		97.7	± 10.0		92.8	± 9.8	94.7	± 10.8
VO_{2peak}	*($L.min^{-1}$)*	2.3	± 0.3	2.3	± 0.4		2.4	± 0.3		2.2	± 0.4	2.3	± 0.3
VO_{2peak_BW}	*($ml.kg\text{-}1.min^{-1}$)*	30.7	± 5.2	31.6	± 5.3		32.0	± 6.2		30.9	± 3.6	29.0	± 5.4
VO_{2peak_FFM}	*($ml.kg\text{-}1.min^{-1}$)*	53.2	± 6.5	52.7	± 6.4		56.1	± 6.9	*b	52.2	± 5.5	52.0	± 6.8
RMR	*($kJ.day^{-1}$)*	5384	± 838	5462	± 551		5396	± 1110		5165	± 589	5492	± 970
VO_{2rest_BW}	*($ml.kg\text{-}1.min^{-1}$)*	2.5	± 0.4	2.6	± 0.4		2.4	± 0.5		2.5	± 0.5	2.4	± 0.4
VO_{2rest_FFM}	*($ml.kg\text{-}1.min^{-1}$)*	4.4	± 0.7	4.5	± 0.6		4.3	± 0.9		4.3	± 0.7	4.3	± 0.5

TimeT, time of training; BMI, body mass index; FM, fat mass; FFM, fat free mass; WC, wais circumference; RMR, resting metabolic rate; AT, aerobic training; RT, resistance training; b, significant difference with AT+RT; *, P<0.05

Table 2.- Differences after the training for total sample (Paired sample T-test) and by groups (one-way ANOVA).

Variables	(units)	Total Sample (n=45) Mean		SD	Sig	AT (n=14) Mean		SD	RT (n=15) Mean		SD	AT+RT (n=16) Mean		SD
Dif FM	*(kg)*	-4.4	±	2.5	***	-4.6	±	1.9	-3.8	±	2.6	-4.7	±	3.0
Dif FFM	*(kg)*	4.1	±	2.2	***	4.6	±	1.7	4.2	±	2.6	3.7	±	2.2
Dif %FM	*(%)*	-5.9	±	2.9	***	-6.2	±	2.0	-5.4	±	3.2	-6.0	±	3.5

FM, fat mass; FFM, fat free mass. ***, P<0.001

Table 3.- Differences after the training for total sample (Paired sample T-test) and by groups (one-way ANOVA) for segments and compartments.

Segment	Variables	(units)	Total Sample (n=44)			AT (n=14)			RT (n=15)			AT+RT (n=15)		
			Mean	SD	Sig	Mean	SD	Q	Mean	SD	Q	Mean	SD	Q
UL	Dif TM	(kg)	0.05	± 0.38	-	0.13	± 0.29	-	0.10	± 0.38	-	-0.08	± 0.45	B
	Dif FM	(kg)	-0.32	± 0.33	***	-0.22	± 0.25	-	-0.24	± 0.29	-	-0.49	± 0.37	B
	Dif FFM	(kg)	0.37	± 0.29	***	0.35	± 0.23	-	0.34	± 0.35	-	0.40	± 0.30	B
	Dif%FM	(%)	-4.48	± 3.20	***	-3.98	± 3.19	-	-3.75	± 3.16	-	-5.68	± 3.11	B
LL	Dif TM	(kg)	-0.07	± 0.89	-	0.02	± 0.61	-	0.21	± 0.83	-	-0.42	± 1.10	B
	Dif FM	(kg)	-1.12	± 1.08	***	-1.29	± 0.41	-	-0.97	± 0.78	-	-1.55	± 0.98	B
	Dif FFM	(kg)	1.20	± 0.60	***	1.32	± 0.53	B	1.18	± 0.67	-	1.12	± 0.63	-
	Dif%FM	(%)	-4.95	± 2.31	***	-5.29	± 1.43	-	-4.24	± 2.56	B	-5.35	± 2.66	-
T	Dif TM	(kg)	-0.32	± 1.42	-	-0.32	± 1.38	-	0.09	± 1.56	-	-0.74	± 1.28	B
	Dif FM	(kg)	-2.97	± 4.03	***	-3.16	± 1.49	B	-2.64	± 1.84	-	-3.11	± 1.81	-
	Dif FFM	(kg)	2.64	± 1.60	***	2.85	± 1.46	B	2.73	± 1.88	-	2.36	± 1.49	-
	Dif%FM	(%)	-7.88	± 1.70	***	-8.26	± 3.16	B	-7.30	± 4.56	-	-8.11	± 4.39	-

Table 4.- Relative differences after the training by segments and relative contribution of each segments for total mass. One-way ANOVA between training groups.

Segment	Variables	(units)	Total Sample (n=44)		AT (n=14)			RT (n=15)			AT+RT (n=15)		
			Mean	SD	Mean	SD	Q	Mean	SD	Q	Mean	SD	Q
UL	%Dif FM	%	-8.6	± 8.6	-6.4	± 8.6		-6.8	± 7.9		-12.4	± 8.7	B
	%Dif FFM	%	9.5	± 8.0	9.8	± 7.5		8.5	± 9.0		10.1	± 7.8	B
LL	%Dif FM	%	-10.7	± 6.5	-11.1	± 3.1		-8.4	± 7.5		-12.6	± 7.6	B
	%Dif FFM	%	9.2	± 5.0	10.4	± 4.8	B	8.8	± 5.1		8.5	± 5.2	
T	%Dif FM	%	-20.7	± 11.2	-21.7	± 8.2		-17.9	± 12.6		-22.5	± 12.4	B
	%Dif FFM	%	12.3	± 7.6	13.1	± 6.9	B	12.6	± 8.7		11.2	± 7.5	

SD; standard deviation; %TFM and %TFFM, percent for total FM or FFM of analyzed segment; 0M, data at baseline; Q, qualification for the group with the best change; B, the best. Gray lines inform of relative contribution of different compartments mass for whole body mass at baseline.

Table 5. Mobilization of FM from upper limbs (UL), lower limbs (LL) and trunk (Tr) after five months of training. Paired sample t-test between segments for three training protocols, aerobic training (AT), resistances training (RT) and AT+RT.

Segment	Units	AT (n=14)			RT (n=15)			AT+RT (n=15)		
		Mean	SD		Mean	SD		Mean	SD	
FromUL		-64.4	± 85.6	*	-68.1	± 79.1	NS	-123.9	± 86.7	NS
FromLL	(g/kgFM)	-110.9	± 30.9	†††	-84.4	± 74.7	†††	-126.1	± 75.8	†††
FromTr		-217.3	± 81.7	‡‡‡	-178.9	± 126.4	‡‡‡	-224.8	± 123.9	‡‡‡

g/KgFM, grams of fat mass mobilized from each segment by kilogram of fat mass at baseline in the same segment. *, P<0.05 to difference between From UL and FromLL; †††, P< 0.001 to difference between From LL and FromTr; ‡ ‡ ‡, P<0.001 to difference between From UL and FromTr; NS, no significant differences.