Original Article

Initial body composition and sex affects to the velocity of body weight loss: a PRONAF study

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ABSTRACT

Rojo-Tirado, M.A., Peinado, P.J., Lozano, A.B., Revenga, J., & Montero, F.J. (2015). Initial body composition and sex affects to the velocity of body weight loss: a PRONAF study. *J. Hum. Sport Exerc., 10*(4), pp.883-890. Aim. To evaluate the effect of the initial Body Mass Index (BMI) and sex on the velocity of the body weight loss. Methods. The methods used included 180 overweight and obese participants (18 – 50 years; Body Mass Index (BMI) >25 and <34.9 kg/m2). Training groups exercised three times per week, and participants from only diet group respected the recommendations about physical activity from American College of Sports Medicine (ACSM), during twenty-four weeks while having 25-30% calorie restriction. Two-way repeated-measures ANOVA was employed to analyze the initial and final body composition by sex and initial BMI. Results. The main finding of this study is that the BW loss is affected by the initial BMI and sex. Conclusion. Body weight loss is affected by the initial BMI and sex, being greater for the obese people than for the overweight one, showing differences between sexes only in the overweight condition. Registered in Clinical Trials Gov.: number NCT01116856. **Key Words**: BODY WEIGHT, BODY COMPOSITION, CALORIC RESTRICTION, EXERCISE INTERVENTION, WEIGHT LOSS VELOCITY.

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INTRODUCTION

The latest World Health Organization estimates are that around 1.2 billion people in the world are overweight and at least 300 million of them are obese. (James, Leach, Kalamara & Shayeghi, 2001) Increasing rates of obesity across the world are broadly attributed to obesogenic environments. (Hill, Wyatt, Reed & Peters, 2003) Obesity is a complex, multifaceted problem with no easy or obvious solutions. The Foresight Project provides clarity to this complexity through the use of an obesity systems map and explore the environment for action through the development of a range of future scenarios (Kopelman, Jebb & Butland, 2007).

The prevalent view of public health organizations is that both diet and exercise are important for body weight (BW) loss. (Andersson et al., 1991; Stiegler & Cunliffe, 2006) Of the two interventions, energy restriction through dieting is seen as the most important factor for a change in weight with exercise making a contribution to the retention of fat-free mass and long-term maintenance of BW loss (Stiegler & Cunliffe, 2006). Previous studies have shown no differences in the BW loss between different ranges of age (Ghroubi et al., 2009) or type of treatment if diet is included, (Brochu et al., 2009; Rojo-Tirado, Benito, Atienza, Rincon & Calderon, 2013) while the sex condition has been shown as an important factor (Hagan, Upton, Wong, & Whittam, 1986) for the BW loss. Moreover, initial adiposity may impact changes in body mass after an intervention, (Forbes, 2000; Goodwin et al., 1998) as Hall (2007) stated that the person with more initial body fat has a greater fraction of their weight change attributable to changes of body fat. (Hall, 2007) As far as we know, few studies have compared the two BMI conditions (overweight [OW] and obesity [OB]), showing that the BW loss depends on the degree of energy restriction. (Hansen et al., 2001; Varaday, 2011) For this reason, the purpose of this study was to evaluate the effect of the initial BMI and sex on the velocity of body weight loss, when the degree of energy restriction is similar for all participants.

MATERIAL AND METHODS

Details of the study's theoretical rationale, protocol, and intervention are described elsewhere. (Zapico et al., 20012) For the sake of completeness, we describe the specific methodology used in this study.

Participants

One hundred eighty volunteers participated in this study (from 18 to 50 years). All the subjects had an overweight or obese condition, namely with a BMI between 25 and 34.9 kg/m^2, non-smokers, sedentary (i.e., two or less hours of structured exercise per week) (Brochu et al., 2009) and norm glycemic. Female had regular menstrual cycles. Exclusion criteria included thyroid diseases or metabolic disorders.

The participants were classified by sex and their initial BMI condition (OW -25 to 29.9 kg/m^2- or OB -30 to 34.9 kg/m^2-), and divided in a stratified random fashion into a strength training group (S), an endurance training group (E), a combined strength and endurance training group (SE), and a physical activity recommendations group (C) (figure 1). An institutionally-approved informed consent document was signed by each individual before the start of the intervention in agreement with the guidelines of the Declaration of Helsinki regarding research on human subjects. In addition, the project was approved by the Human Research Review Committee of the La Paz University Hospital (PI-643).

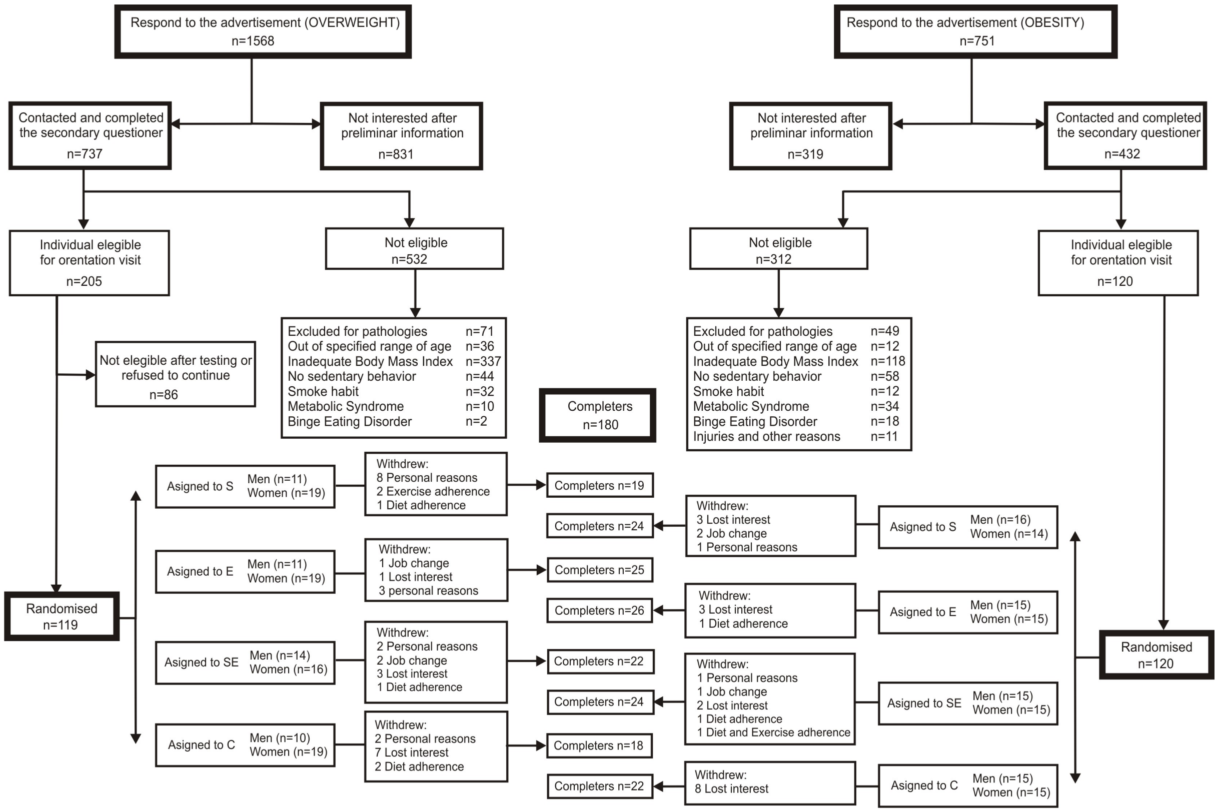

Figure 1. Participants flow diagram.

Study design

The 24-weeks intervention consisted of an individualized hypo-caloric diet for all participants, with a 25-30% caloric restriction (CR) from their own daily energy expenditure (DEE), (Panel, N. O. E. I. E., 1998) which was measured by using the SenseWear Pro Armband™ accelerometer (Body Media, Pittsburgh, PA). All training groups (S, E and SE) followed a personalized training program, which consisted in three times per week exercise sessions during six months, carefully supervised by certified personal trainers. Participants from C group respected the recommendations about physical activity from American College of Sports Medicine (ACSM). (Donnelly et al., 2009) Significant details about the programs have been described previously (Zapico et al., 20012).

Before the intervention started, all participants were instructed to continue their usual daily activities as done right before the intervention period, and their physical activity was assessed by a SenseWear Pro3 Armband™ accelerometer (Body Media, Pittsburgh, PA) for a full week every month. Participants were instructed to wear the monitor continuously for 5 days including weekend days and weekdays following general recommendations. (Murphy, 2009) Data was recorded by 1 min intervals. Daily energy expenditure was calculated using the Body Media propriety algorithm (Interview Research Software Version 6.0). In addition, they were required to report the kind, duration, and intensity of any physical activity and the amount of any food undertaken during the intervention period, through a personal diary.

At the beginning of the intervention, the negative energy balance was calculated taking into account the daily energy expenditure, and a 3-day food record, in order to decrease the energy intake of the diet by a 25-30% during the intervention. Adherence to diet was calculated as the estimated Kcal of the diet divided by the real Kcal intake in percentage ([estimated kcal of diet/real Kcal intake]x100), being 100% the highest adherence to it, following a similar methodology as used previously. (Acharya et al., 2009) Moreover, adherence to exercise was calculated by the number of sessions completed in regard to the theoretical sessions ([sessions performed /total sessions]x100). Assistance over 90% of the training sessions (Hunter, Wetzstein, Fields, Brown & Bamman, 2000) and an adherence to diet over to 80% (Del Corral, Chandler-Laney, Casazza, Gower & Hunter, 2009) were required.

Body composition assessments

Initial and final body composition was assessed by Dual-energy X-ray absorptiometry (DXA) (GE Lunar Prodigy; GE Healthcare, Madison, WI) and scan analysis was performed using GE Encore 2002, version 6.10.029 software, measuring the total fat mass (FM), body fat-free mass (FFM), android fat mass, gynoid fat mass and bone mineral density (BMD). The anthropometric measures included height (stadiometer SECA; range 80-200cm) and BW, which was measured in kilograms with a scale to the nearest 100 g.

Modelling the slopes of the body weight loss

Conventional linear regression analyses were performed to identify the time course of body weight loss dynamics in both sexes and BMI conditions, by plotting initial and final BW for each subject individually using a linear scale. The body weight scores were regressed on the linear of time given f (t)= a+b (t), where t is the time of intervention, a is the BW score at intervention onset, and b is the slope of BW loss dynamics. Thus, the slopes of these lines appeared to provide a valuable measure of the velocity of the body weight loss.

Statistical analyses

The data was statistically analyzed using the PASW Statistics version 18.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Data was presented as mean ± standard deviation (Mean ± SD). Changes between initial and final body composition measurements were compared employing a repeated measures three-way analysis of variance (ANOVA) by sex and BMI condition. A multivariate analysis of variance was employed to compare the slopes of the functions of the dynamics of weight loss by sex and initial BMI. Additionally, multiple comparisons were made with the Bonferroni post hoc test. Finally, those values of $p < 0.05$ were considered statistically significant.

RESULTS

Figure 2 show the slopes of the linear regressions of the functions of weight loss dynamics by sex and initial BMI. When the slopes are compared significant differences are found between overweight and obese conditions ($F_{1,175}$ =22.806;p<0.001) and both sexes ($F_{1,175}$=8.938;p=0.003). The slopes from the obese men and women (-0.889±0.368 and -0.764±0.312, respectively) are significantly greater than the overweight ones (-0.673±0.368 and -0.493±0.308, respectively). The slopes of the men functions are significantly higher than the women ones in the overweight condition, while in the obese condition both slopes are similar (p>0.05).

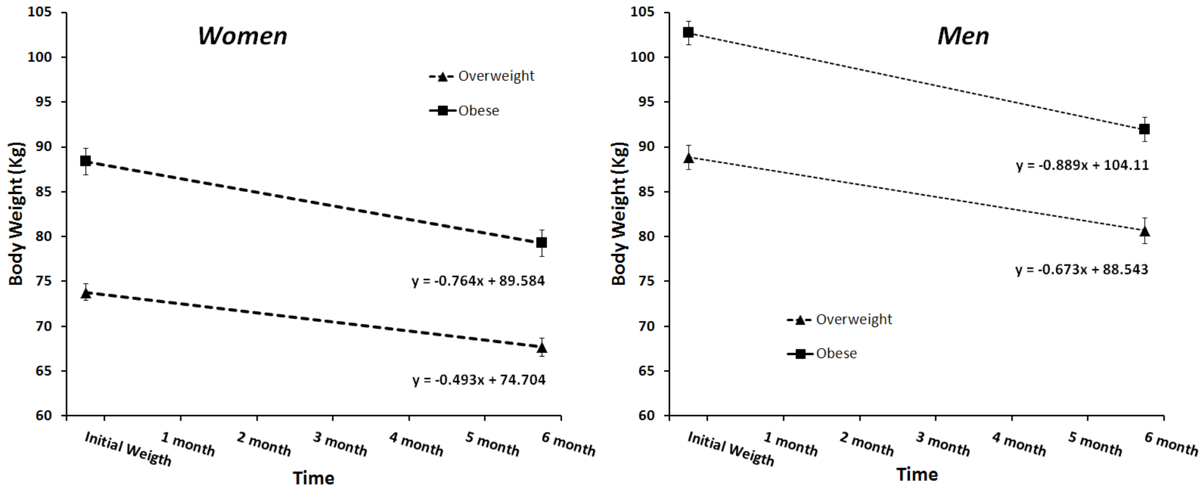

Figure 2. Slopes of the functions of the dynamics of weight loss.

The characteristics of the one-hundred and eighty volunteers who completed the intervention are shown in Table 1. ANOVA revealed differences regarding sex conditions vs. BW ($F_{1,175}$=124.351), vs. height ($F_{1,175}$=183.028), vs. body fat (%) ($F_{1,175}$=242.039), vs. fat-free mass ($F_{1,175}$=458.035) and vs. bone mineral density ($F_{1,175}$=34.672) ($p<0.001$ for all comparisons) at the baseline characteristics. Differences were also revealed regarding initial BMI condition vs. BW ($F_{1,175}$=126.456), vs. BMI ($F_{1,175}$=289.759), vs. body fat (%) ($F_{1,175}$=49.866), vs. fat-free mass ($F_{1,175}$=28.917) and vs. bone mineral density ($F_{1,175}$=7.221) ($p<0.001$ for all comparisons) at the baseline characteristics. No interactions between sex and BMI conditions were discovered ($p>0.05$)

After the intervention period, overweight women significantly reduced their BW by 5.96±3.84 kg, obese women by 9.35±3.79 kg, overweight men by 8.08±4.42 kg and obese men by 10.69±4.46 kg. Differences were found between sexes ($F_{1,175}$=7.3273;p=0.008) and initial BMI condition ($F_{1,175}$=22.14;p<0.001) in the BW loss. In the one hand, the BW loss of the overweight men was greater than the women ones ($p<0.05$), while the obese men and women lost the same amount of BW ($p>0.05$). On the other hand, the obese participants lost more BW than overweight participants, in both sexes ($p<0.05$). Focusing on FM, overweight women significantly reduced it by 5.25±3.30 kg, obese women by 6.96±3.27 kg, overweight men by 6.94±3.48 kg and obese men by 8.09±3.67 kg, after the intervention period. Differences were found between sexes ($F_{1,175}$=7.33;p=0.007) and initial BMI condition ($F_{1,175}$=7.485;p=0.007) in the FM loss. In the one hand, the FM loss of the overweight men was greater than the women ones ($p<0.05$), while the obese men and women lost the same amount of FM ($p>0.05$). On the other hand, the obese women lost more FM than overweight women ($p<0.05$), while overweight and obese men lost the same amount of FM ($p>0.05$). Analyzing the FFM, after the intervention period, obese women reduced it significantly by 0.46±1.24 kg, overweight men by 0.26±1.84 kg and obese men by 0.58±1.60 kg, while overweight women reduced their FFM by 0.32±0.97 kg, but not significantly. No differences were found between sexes ($F_{1,175}$=0.02;p=0.888) and initial BMI condition ($F_{1,175}$=1.099;p=0.296) in the FFM loss.

Table 1. Participants characteristics (n=180). Presented as Mean ± SD

	Overweight (n= 84)				Obese (n= 96)			
	Women (n=48)		Men (n=36)		Women (n=48)		Men (n=48)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Age (years)	37.29 ± 8.25	37.29 ± 8.25	37.42 ± 8.02	37.42 ± 8.02	39.02 ± 7.74	39.02 ± 7.74	38.79 ± 7.99	38.79 ± 7.99
BW (kg)	73.46 ± 5.92	$67.53^{\#}$ ± 7.14	88.21^{*} ± 8.13	$80.13^{\#*}$ ± 9.44	$88.33^{\wedge}$ ± 10.1	$79.15^{\#\wedge}$ ± 10.08	$102.04^{*\wedge}$ ± 8.94	$91.36^{\#*\wedge}$ ± 8.78
Height (cm)	1.62 ± 0.06	1.62 ± 0.06	1.75^{*} ± 0.07	1.75^{*} ± 0.07	1.64 ± 0.07	1.64 ± 0.07	1.77^{*} ± 0.06	1.77^{*} ± 0.06
BMI (kg/m^2)	27.99 ± 1.32	$25.70^{\#}$ ± 1.96	28.57 ± 1.12	$25.95^{\#}$ ± 1.88	$32.41^{\wedge}$ ± 1.85	$29.54^{\#\wedge}$ ± 2.64	$32.40^{\wedge}$ ± 1.90	$29.23^{\#\wedge}$ ± 2.34
FM (%)	43.28 ± 3.62	$38.57^{\#}$ ± 4.88	33.80^{*} ± 4.63	$27.84^{\#*}$ ± 5.60	$47.09^{\wedge}$ ± 3.58	$42.41^{\#\wedge}$ ± 4.66	$38.27^{*\wedge}$ ± 4.00	$32.78^{\#*\wedge}$ ± 4.94
FM (kg)	30.70 ± 3.57	$25.45^{\#}$ ± 4.89	28.79 ± 5.54	$21.84^{\#*}$ ± 5.94	$39.52^{\wedge}$ ± 6.48	$32.56^{\#\wedge}$ ± 7.06	$37.37^{\wedge}$ ± 5.89	$29.28^{\#*\wedge}$ ± 6.36
Android Fat Mass (kg)	2.49 ± 0.51	$1.86^{\#}$ ± 0.56	2.87^{*} ± 0.72	$1.88^{\#}$ ± 0.70	$3.33^{\wedge}$ ± 0.74	$2.66^{\#\wedge}$ ± 0.82	$3.93^{*\wedge}$ ± 0.79	$2.92^{\#\wedge}$ ± 0.86
Gynoid Fat Mass (kg)	5.65 ± 0.91	$4.65^{\#}$ ± 1.02	4.41^{*} ± 1.14	$3.35^{\#*}$ ± 1.08	$7.07^{\wedge}$ ± 1.38	$5.80^{\#\wedge}$ ± 1.28	$5.55^{*\wedge}$ ± 1.00	$4.36^{\#*\wedge}$ ± 1.00
FFM (kg)	40.25 ± 4.30	40.00 ± 4.60	55.99^{*} ± 5.47	55.72^{*} ± 5.70	$44.12^{\wedge}$ ± 4.68	$43.66^{\#\wedge}$ ± 4.80	$59.92^{*\wedge}$ ± 5.02	$59.34^{\#*\wedge}$ ± 4.91
BMD (mg/cm^2)	1.18 ± 0.10	$1.17^{\#}$ ± 0.10	1.26^{*} ± 0.09	$1.24^{\#*}$ ± 0.09	1.21 ± 0.11	1.21 ± 0.11	$1.30^{*\wedge}$ ± 0.10	$1.31^{*\wedge}$ ± 0.10

Note. BW=Body weight; BMI= Body mass index; FM= Fat mass; FFM=Fat-free mass; BMD= Bone mineral density.
$^{\#}$. $p< 0.05$ significantly different from pre; *. $p< 0.05$ significantly different from women; ^. $p< 0.05$ significantly different from overweight.

DISCUSSION

The main finding of this study is that the BW loss is affected by the initial BMI and sex. All participants reduced their BW significantly though the OB participants lost more BW than the OW participants in the same period of time. This greater velocity (slope) of BW loss is shown in figure 2, where the slopes of the linear functions are compared, showing that the obese people lose weight more significantly quick than the overweight one in the same period of time. It can also be observed the velocity is greater for men than for women in the overweight condition, while men and women from obese condition lost their BW at the same rhythm.

The variable group of intervention was not introduced in the analyses due to not significant differences were found between groups within this sample. (Rojo-Tirado et al., 2013) Differences in the BW loss between both BMI conditions could be attributable to its initial body composition. Initial adiposity may impact changes in body mass after an intervention. (Forbes, 2000; Goodwin et al., 1998) Changes of body fat and lean tissue are related by a non-linear function on the initial body fat mass such that people with higher initial adiposity partition a greater proportion of a net energy imbalance towards gain or loss of body fat versus lean tissue than do people with low initial adiposity (Hall, 2007; Forbes, 1987). Hall (2007) stated that the person with more initial body fat has a greater fraction of their weight change attributable to changes of body fat versus changes of lean tissue than does a person with less initial body fat. Since body fat contributes less than lean tissue to overall energy expenditure, (Ravussin, Lillioja, Anderson, Christin, & Bogardus, 1986) the person with higher initial body fat will lose a greater amount of weight to achieve a new state of energy balance. (Hall & Jordan, 2008; Hall et al., 2011) In addition, Hansen et al (2001) showed that participants with a higher BMI lost more weight after an intervention compared with those possessing a lower BMI, as it occurred in our study. Moreover, as the calorie restriction of the diet was similar to every participant because it was adjusted in percentage according to their daily energy expenditure measured by accelerometry, the energy cost of physical activity could have contributed as it is proportional to BW. [30-33] As the obese people have a greater BW and FFM, the energy cost of all of their physical activities is bigger than from the overweight people, resulting in a major BW loss. So, we suggest that any weight loss program should pursue the maintenance of the FFM, with exercise sessions at an intensity about 65-80% of the 1RM, (Hunter, 2008) contributing to the body's overall energy expenditure rate (Ravussin et al., 1986).

On the one hand, there are sex-specific differences in body fat distribution: in males, fat distribution is concentrated in the upper body, while in females, fat distribution is concentrated in the lower body (Lönnqvist, Thörne, Large & Arner, 1997, Shimokata, 1989).

Furthermore, a recent study reported that there was a nonlinear relationship between regional fat mass and visceral fat area, and these relationships differed by visceral obesity levels. (Demura & Sato, 2008) These reports indicate that the relationships between subcutaneous, visceral and total fat may differ by obesity level and obesity type. The contribution of subcutaneous fat to total body fat declines with increasing obesity level. This may suggest that, although subcutaneous and visceral fat increase with increasing obesity level, there may be a limitation in the capacity for subcutaneous fat accumulation which is dependent on sex, and accumulation of visceral fat may progress more when this capacity is exceeded. (Sato & Demura, 2009) These differences in android and Gynoid fat mass were found in our sample between both BMI conditions, as our obese females had more fat in the upper body than the overweight ones (table 1).

On the other hand, there is evidence suggesting than women have greater difficulty in losing weight after exercise than men. Preliminary evidence suggests that women compared with men have different rate of lipolysis, less sympathetic nervous system activity and a smaller catecholamine response at a given intensity to exercise. (McMurray & Hackney, 2005) Research has shown that women tend to lose significantly less weight than men after an exercise program. (Donnelly, 2003; Sartorio, Maffiuletti, Agosti & Lafortuna, 2005) However, in our study these differences were only found in the overweight participants, showing that obese men and women lost the same amount of BW. According to the literature, the body composition would be a related individual factor able to explain these differences. Women who possess upper body obesity (obese women) have been shown to lose more fat than those with lower body obesity (overweight women) (Després, Tremblay, Nadeau & Bouchard, 1987; Tai, Lau, Ho, Fok, & Tan, 2000). This may be due to the effect of exercise-induced catecholamines that have a site-specific on body fat. (Tai et al., 2000; Björntorp, 1999) For example, visceral adipose tissue is especially sensitive to lipolytic activation by the adrenal system. (Arner, 1995) Lipolysis is increased in intra-abdominal adipose tissue because of more catecholamine-sensitive-β-receptors compared with subcutaneous adipose tissue, like femoral and gluteal fat depots, which has a higher density of α2-receptors. (Björntorp, 1999; Arner, 1999; Wahrenberg, Lönnqvist & Arner, 1989) Thus, both males and females possessing more intra-abdominal adipose tissue may lose more fat when undertaking exercise interventions, especially when exercise is performed at an intensity that brings about increases in catecholamines. Moreover, Volek et al. (2004) affirmed that there was a preferential loss of fat in the trunk region in both men and women. Wahrenberg, Lönnqvist and Arner (1989) concluded that the lipolytic effect of catecholamines was four- to fivefold more marked in abdominal adipocytes than in other depots. Consequently, overweight women compared with overweight men may have possessed more subcutaneous rather intra-abdominal fat and had increased gluteofemoral adipose tissue which could account for their lack of exercise-induced weight loss compared with males (Boutcher & Dunn, 2009).

Finally, some limitation should be mentioned. The lack of information about the changes in the visceral adipose tissue of our sample impedes us to full assert that the results obtained in this study are due to lipolytic activity in the visceral adipose tissue. Future research is needed to evidence these changes in the visceral adipose tissue.

CONCLUSIONS

With this work, we can conclude that the BW loss is affected by the initial BMI and sex condition, being greater for the obese people than for the overweight one, showing differences between sexes only in the overweight condition.

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CONFLICTS OF INTEREST

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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