EFFECTS OF AGE, SEX AND TREATMENT ON WEIGHT LOSS DYNAMICS IN OBESE PEOPLE

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ABSTRACT

Objective: Evaluation of how sex, age and the kind of followed treatment affect weight loss and to explain weight loss dynamics in obese men and women. Material and Methods: A hundred and twenty obese participants (18 – 50 years; Body Mass Index (BMI) >30 and <34.9 kg/m^2) were randomly assigned to four treatments, namely, strength training (S; n = 30), endurance training (E; n = 30), a combination of S and E (SE; n = 30), and diet and physical recommendations group (C; n = 30). Each of the different training groups exercised three times per week during twenty-four weeks while having diet restrictions. Then, body weight changes were evaluated every fifteen days for each participant. Several equation models were developed and evaluated to determine the function that better represents weight loss dynamics. Results: There were no significant differences from the statistical viewpoint, in terms of global body weight change, either on the carried out treatment or on individual's age. However, significant differences on the weight loss tendency were found due to the participant sex. Discussion: The effectiveness of different treatments for weight loss varies by sex and, based on our experimental observations, the most accurate model to capture the weight loss dynamics can be obtained through a quadratic function.

Key words: body weight, caloric restriction, exercise intervention, functions, weight loss dynamics

EFECTOS DE LA EDAD, EL SEXO Y EL TRATAMIENTO EN LA DINÁMICA DE LA PÉRDIDA DE PESO EN LAS PERSONAS OBESAS

RESUMEN

Objetivo: Evaluar cómo el sexo, la edad y el tipo de tratamiento seguido afectan a la pérdida de peso y explicar la dinámica de pérdida de peso en hombres y mujeres obesos. *Material y métodos*: Ciento veinte participantes obesos (18-50 años, Índice de Masa Corporal >30 y <34,9 kg/m^2) se asignaron aleatoriamente a cuatro tratamientos, a saber, entrenamiento de fuerza (S; n=30), entrenamiento aeróbico (E; n=30), una combinación de S y E (SE, n=30), y el grupo de recomendaciones dietéticas y de actividad física (C; n=30). Cada uno de los diferentes grupos de entrenamiento entrenó tres veces por semana durante veinticuatro semanas, mientras seguían una restricción dietética. Los cambios de peso corporal se evaluaron cada quince días para cada participante. Se desarrollaron y evaluaron varios modelos de ecuación para determinar la función que representa mejor la dinámica de pérdida de peso. *Resultados*: No hubo diferencias significativas desde el punto de vista estadístico, en términos de cambio de peso corporal global, ya sea en el tratamiento realizado o en la edad del individuo. Sin embargo, se encontraron diferencias significativas en la tendencia de pérdida de peso debida al sexo de los participantes. *Discusión*: La eficacia de los diferentes tratamientos para la pérdida de peso varía según el sexo y, sobre la base de nuestras observaciones experimentales, el modelo más preciso para adecuar la dinámica de pérdida de peso se puede obtener a través de una función cuadrática.

Palabras clave: peso corporal, restricción calórica, intervención de ejercicio, funciones, dinámica de pérdida de peso

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INTRODUCTION

It took some time, but public health policy makers have now developed a common worry regarding the obesity epidemic, based on strong epidemiologic studies showing increases in body mass index (BMI) throughout the world, during the past three or four decades (Communities, 2007). Forty to sixty percent of the adult population in the Western world is actively attempting to reduce their body weight (BW). Nevertheless, overweight and obesity remain highly predominant sources of health problems, thus suggesting that many of those attempts are unsuccessful (Bendixen, Madsen, & Bay-Hansen, 2002; Bish, Blanck, & Serdula, 2005; Serdula, Mokdad, & Williamson, 1999).

Several studies have analyzed the factors that could influence weight loss and maintenance of BW. They have concluded that diet is a prerequisite in any weight loss program (Ballor, Katch, Becque, & Marks, 1988; Del Corral, Chandler-Laney, Casazza, Gower, & Hunter, 2009; Kraemer et al., 1997), and the possible weight loss is greater if exercise is included (Brochu et al., 2009; Ghroubi et al., 2009; Hagan, Upton, Wong, & Whittam, 1986). Few of these studies have described the weight loss tendency for different treatments (Brochu, et al., 2009; Del Corral, et al., 2009; Larson-Meyer et al., 2010), while others have also analyzed how sex (Hagan, et al., 1986), psychosocial (Jakicic, Marcus, Lang, & Janney, 2008) and lifestyle (Redman et al., 2007; Volpe, Kobusingye, Bailur, & Stanek, 2008) variables affect weight loss. However, to the best of our knowledge, no study so far has focused on the overall combined interaction of those variables on weight loss.

The usual course of weight loss therapy shows that weight is lost quickly at first, and the point of greatest loss occurs 6 months after beginning treatment; then weight is slowly regained until weight returns near the original level (Jeffery, Drewnowski, Epstein, & al., 2000; Svetkey, Stevens, Brantley, & al., 2008). Often, 30-35% of the weight a person loses is regained during the first year after treatment (Wadden, Butryn, & Byrne, 2004). Approximately 20% of individuals could be considered successful when successful weight-loss maintenance is defined as intentionally losing at least 10% of one's weight and maintaining that loss for a minimum of one year (Wing & Hill, 2001). Weight loss has been graphically represented and analyzed in the literature (Hagan, et al., 1986; Jakicic, et al., 2008; Kraemer, et al., 1997; Redman, et al., 2007; Volpe, et al., 2008). Diverse studies have proposed some mathematical models of weight loss based on BW or body composition changes (Hall et al., 2012; Hall et al., 2011; Thomas, Ciesla, Levine, Stevens, & Martin, 2009). However, none of those existing studies have concluded any specific trend line or equation fitting match or have analyzed variations depending on the age, sex or treatment.

Therefore, research is needed to find out a mathematical function that correctly represents weight loss dynamics and, even more importantly, how

this function behaves depending on the sex and age of the individual, as well as the followed treatment. Therefore, the purpose of this work has been to evaluate the effects of these variables on the weight loss and how they affect the function that represents these dynamics. This function could let us make some predictions about the body weight loss and know the most appropriate treatment for each person.

METHOD

Participants

The study participants were recruited through several advertisements campaigns covering a wide variety of media (television, radio, press and Internet). A total of 751 potential participants were informed about the nature of the study and those who were 18 to 50 years old, had a BMI between 25 and 34.9 kg/m^2, were non-smokers, were sedentary (i.e., two hours or less of structured exercise per week) (Brochu, et al., 2009) and had glucose values <5.6 mmol/L (<100 mg/dL) (Rutter, Massaro, Hoffmann, O'Donnell, & Fox, 2012) were invited to participate in this study. Women with any disturbances in menstrual cycle were not eligible to participate in the study. The 120 eligible participants who were willing to participate provided written informed consent prior to joining the study and then completed a baseline assessment at the medical center, after which they were randomly assigned to the groups. Randomization assessment was computer-generated (Figure 1).

Design

The present RCT (ClinicalTrials.gov ID: NCT01116856) was conducted from January, 2011, through June, 2011, and followed the ethical guidelines of the Declaration of Helsinki. The Institutional Review Board of the La Paz University Hospital (PI-643) reviewed and approved the study design and research protocol. Details of the study's theoretical rationale, protocol, and intervention are described elsewhere (Zapico et al., 2012).
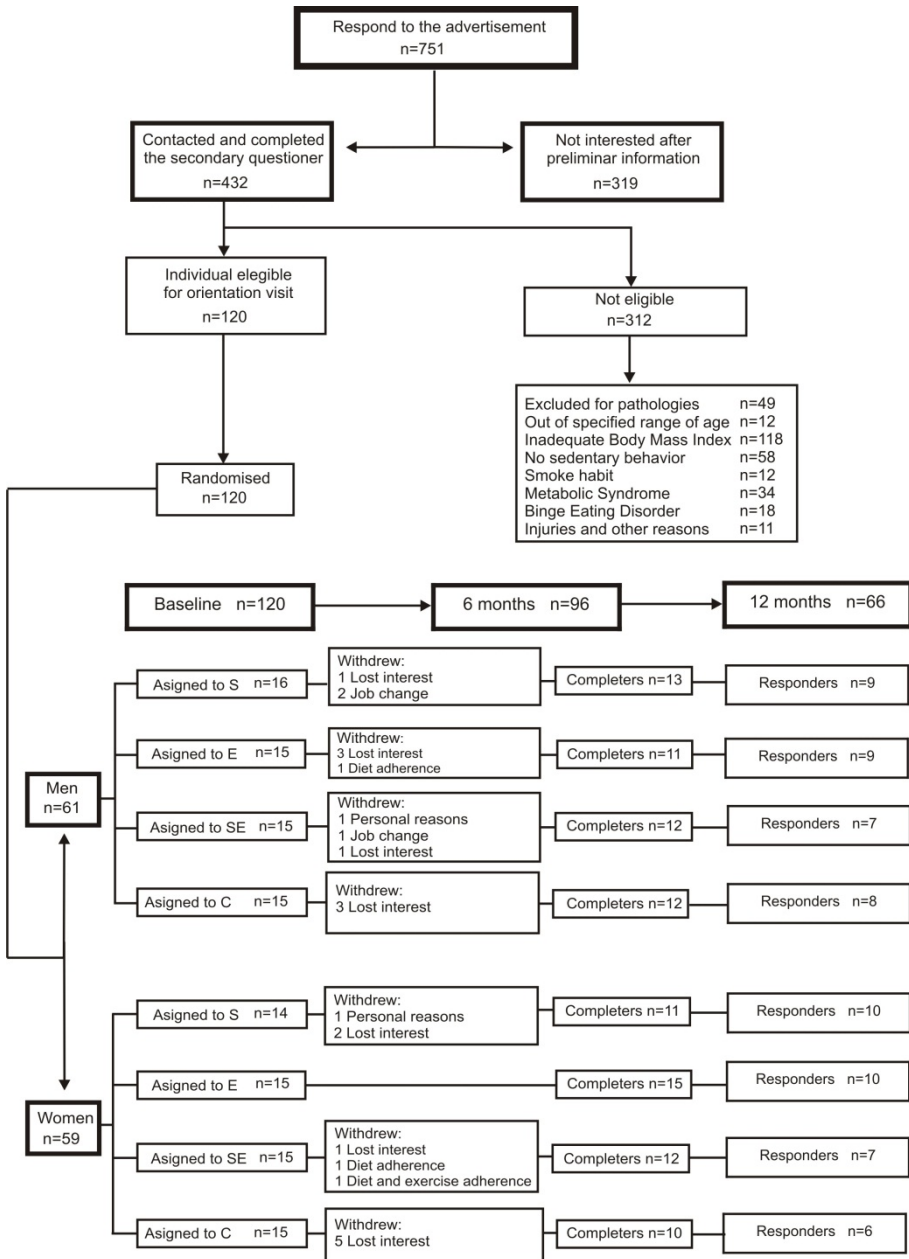
FIGURE 1: Participant flow diagram.

Procedures

A 6-month diet and exercise-based intervention, focusing on a behavior change. Participants were split into four randomly assigned groups, stratified by age and sex: strength group (S), endurance group (E), combined strength and endurance group (SE) and the control group, who follow the physical

activity recommendations. The measurements took place in the first week (pre-intervention values) for all participants before starting and after 22 weeks of intervention, in week 24 (post-intervention values) (Figure 2). After the intervention period, all participants were under a free-living condition, and they were required to inform about their body weight and their nutritional and physical activity behaviors at 6 months, by e-mail or telephone call.

Before the intervention started, physical activity was assessed by a SenseWear Pro3 Armband™ accelerometer (Body Media, Pittsburgh, PA). 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.
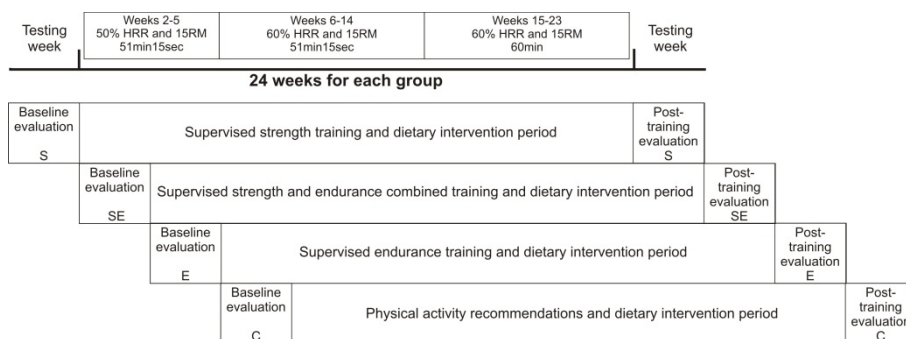

FIGURE 2: Periodization of the intervention.

Diet intervention

All participants followed an individualized hypo-caloric diet, with a 25-30% caloric restriction from their own daily energy expenditure (NIH, 1998), which was measured by using the SenseWear Pro3 Armband™ (Body Media, Pittsburgh, PA), that underestimates by a mean value of 8.8% (Papazoglou et al., 2006). Then, the macronutrient distribution was according to the Spanish Society of Community Nutrition recommendations (Dapcich, Salvador Castell, Ribas Barba, Pérez Rodrigo, & Aranceta Bartrina, 2004).

Exercise intervention

All exercise training groups (Strength, Endurance and Combined-SE groups) followed an individualized training program, which consisted on three times per week exercise sessions during 22 weeks, carefully supervised by certified personal trainers. Details of the different protocols developed by the groups are described elsewhere (Zapico, et al., 2012).

Control group

Participants from the control group followed the dietary intervention and respected the recommendations about physical activity from the ACSM (Donnelly et al., 2009). Thus, the C subjects were advised to undertake at least 200-300 min of moderate-intensity physical activity per week (30–60 min on most, if not all, days of the week).

Outcome measurements

Body weight. It was measured in kilograms every fifteen days with a scale to the nearest 100g. The participants from diet and physical recommendations group used their own scales to monitor BW at home, except for the initial and final measures. Nevertheless, the follow-up of the BW for the individuals of the training groups was done at the gym with a Tanita scale (TANITA BC-420MA. Bio Lógica. Tecnología Médica SL).

Body composition. It was assessed by 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 body fat (%), body fat free mass (kg) and bone mineral density (g/cm^2).

Resting Metabolic Rate (RMR). Subjects were asked to refrain from any exercise for at least 24h before the test. To assess the RMR, participants were cited between 7 h. to 10 h., after a 9h overnight fasted period. RMR was then measured by indirect calorimetry standing up (during 11 min) and in a lying position (additional 20 min). Oxygen consumption (VO$_2$) and carbon dioxide production (VCO$_2$) were recorded by a gas analyzer Jaeger Oxycon Pro (Erich Jaeger, Viasys Healthcare, Germany), and resting heart rate was measured using a heart rate monitor (Polar RS800CX, Polar Electro, Kempele, Finland). All these parameters were averaged during the last 5 min of the standing up position and the last 10 min of the lying position. VO$_2$ and VCO$_2$ data were used to calculate RMR according to the formula of Weir (Weir, 1949).

Physical activity and daily energy expenditure (DEE). Physical activity was assessed, as described in the previous section, once a month, with a SenseWear Pro3 Armband™ (Body Media, Pittsburgh, PA). Hence, subjects were instructed to wear the monitoring system continuously for 5 days, including both weekends and weekdays, following general recommendations (Murphy, 2009).

Then, data was recorded in 15-minute intervals. Finally, DEE was calculated using the Body Media propriety algorithm (Interview Research Software Version 6.0).

Determination coefficients of the functions of the dynamics of weight loss (R^2). BW values obtained every fifteen days were used to obtain the functions of the dynamics of weight loss by applying different types of regression methods. In particular, five different regression equations (linear, power law, exponential, logarithmic and quadratic) were calculated, and the best coefficients were obtained and compared.

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 (M±SD). Then, a multivariate analysis of variance (MANOVA) was employed to analyze the baseline measures by sex, age and treatment. Next, an analysis of covariance (ANCOVA) with repeated measures was used to compare the initial and the final body weight by sex, age and group with the diet, as well as exercise adherence as covariates. A three-way analysis of variance (ANOVA) with repeated measures (cf. in the sixth and twelfth month) was used to compare the R^2 of the functions of the dynamics of weight loss by sex and type of equation. Finally, a two-way analysis of variance (ANOVA) with repeated measures (cf. pre-post six-month intervention) was employed to compare the FFM and the RMR changes by treatment. Additionally, multiple comparisons were made with the Bonferroni post hoc test. Finally, we considered statistically significant those values of p below 0.05.

RESULTS

The characteristics of the ninety-six individuals who completed the intervention are shown in Figure 1. MANOVA revealed differences regarding sex conditions vs. BW (kg) ($F_{1,95}=73.378;p<0.001$), vs. height ($F_{1,95}=99.128;p<0.001$), vs. body fat (%) ($F_{1,95}=135.604;p<0.001$), vs. body fat free mass ($F_{1,95}=247.929;p<0.001$) and vs. bone mineral density ($F_{1,95}=21.45;p<0.001$) at the baseline characteristics. All these values were higher for men than for women, except the body fat (%). Then, no differences were found in these baseline variables by range of age and treatment ($p>0.05$). (see Table 1)

TABLE 1
Baseline data (n=96).

	Women n= 48					Men n= 48				
	Mean	±	SD	Min	Max	Mean	±	SD	Min	Max
Age (years)	39.02	±	7.74	23.00	50.00	38.79	±	7.99	24.00	50.00
Body Weight (kg)	86.8	±	8.6	72.0	110.0	101.27*	±	7.94	83.0	114.0
Height (cm)	1.64	±	0.07	1.48	1.78	1.77*	±	0.06	1.63	1.88
BMI (kg/m²)	32.41	±	1.85	30.10	34.86	32.40	±	1.90	30.02	34.78
Body fat (%)	47.11	±	3.49	39.70	54.50	38.17*	±	4.02	28.20	46.50
Body fat free mass (kg)	44.30	±	4.71	34.27	53.75	59.88*	±	4.98	44.79	69.99
Bone mineral density (mg/cm²)	1.21	±	0.11	1.00	1.47	1.30*	±	0.10	1.09	1.55
RMR (Kcal/day)	1616.42	±	115.91	1422.00	1904.00	2087.88	±	148.00	1727.00	2373.00

Note. BMI= Body Mass Index; RMR= Resting Metabolic Rate.

*. p< 0.05 significantly different from women.

After the intervention period, the FFM was decreased in the SE and C groups (-.741±1.286 kg, p<.01; and -1.348±1.659 kg, p<.001, respectively) while it remained unaltered for the S, E groups (.133±1.349 and -.247±1.059 kg, respectively) (p>.05). The RMR was significantly decreased in all groups (S: -108.96±58.52, E: -124.73±47.78, SE: -122.54±60.87, and C: -114.62±65.96 kcal; p<.001). The DEE remained unchanged in all groups (S: -24.68±250.12, E: 88.84±342.85, SE: -138.82±384.63, and C: 58.17±338.18 kcal; p>.05). No differences were found between the different treatments for FFM, RMR and DEE, either initial or final (p>.05). The RMR significantly decreased in both genders (women: -88.47±35.67, and men: -146.83±60.59; p<.001). The DEE remained similar for women and men (-11.42±330.33, and 29.13±336.81, respectively, p>.05).

Results related to BW remained unaltered when the analyses were adjusted for diet and exercise adherences covariates. Only differences were found between sexes ($F_{1,72}$=38.89;p<0.001) in the BW loss, which cannot be clearly shown when the weight loss is compared to percent changes from baseline. The observed statistical power for these comparisons was 0.999. No differences were found on age ($F_{2,72}$=0.295;p>0.05) and type of treatment ($F_{3,72}$=1.173;p>0.05). Table 2 shows changes in BW (in kg) in the four groups before and after the intervention period, differentiated by sex, range of age and type of treatment. Within each group of treatment there were no differences between the different age ranges, either initial or final (p>0.05). Similarly, within each age range no significant differences were found between the

different treatments, either initial or final. These results should be considered carefully because of the number of subjects in each subgroup.

After the intervention period, women aged 41 to 50 years reduced their BW in S by 10.32%, in E by 11.59%, in SE by 9.27% and in C by 12.49% ($p<0.05$). Women aged 31 to 40 only reduced their BW in S by 7.45%, in E by 10.57%, and in SE by 10.79% ($p<0.05$). Moreover, those aged 18 to 30 reduced their BW in S by 12.57%, in E by 14.41%, in SE by 12.16% and in C by 7.79% ($p<0.05$). In the case of men, those aged 41 to 50 years reduced their BW in S by 10.63%, in E by 12.77%, in SE by 12.59% and in C by 11.1% ($p<0.05$). BW was also reduced for men aged 31 to 40 following S, E, SE and C treatments (7.68%, 10.27%, 8.89% and 10.57%, respectively; $p<0.05$) and for those aged 18 to 30 years was only reduced applying treatments S, E and SE (10.02%, 11.26% and 8.94%, respectively, $p<0.05$).

TABLE 2

Changes in body weight by age, sex and type of treatment. Presented as M ± SD (adjusting for diet and exercise adherences)

	Age (years)	Women Initial BW	Women Final BW	Women %	Men Initial BW	Men Final BW	Men %
S	18 to 30	93.9 ± 0.5	82.1# ± 4.6	-12.57	97.1 ± 8.2	87.4# ± 5.1	-10.02
Women n= 11	31 to 40	90.6 ± 10.8	83.8# ± 13.6	-7.45	102.8 ± 10.1	94.9# ± 8.7	-7.68
Men n= 13	41 to 50	87.4 ± 9.8	78.4# ± 8.5	-10.32	103.5* ± 5.6	92.5#* ± 5.7	-10.63
	Total	89.7 ± 8.9	81.0 ± 9.7	-9.7	101.8 ± 7.9	92.2 ± 7.0	-9.35
E	18 to 30	91.3 ± 5.1	78.1# ± 1.7	-14.41	91.7 ± 2.9	81.4# ± 5.0	-11.26
Women n= 15	31 to 40	91.5 ± 11.4	81.8# ± 12.3	-10.57	106.2* ± 4.3	95.3# ± 2.5	-10.27
Men n= 11	41 to 50	88.5 ± 8.2	78.2# ± 9.0	-11.59	98.2 ± 7.6	85.7# ± 4.7	-12.77
	Total	89.7 ± 8.4	79.2 ± 9.0	-11.7	98.6 ± 7.7	87.1 ± 6.8	-11.65
SE	18 to 30	91.3 ± 0.0	80.2# ± 0.0	-12.16	111.9 ± 3.8	101.9# ± 2.6	-8.94
Women n= 12	31 to 40	92.0 ± 7.6	82.0# ± 10.3	-10.79	98.4 ± 15.7	89.7# ± 13.6	-8.89
Men n= 12	41 to 50	92.2 ± 15.4	83.7# ± 14.9	-9.27	108.3* ± 9.9	94.7#* ± 12.0	-12.59
	Total	92.1 ± 12.1	82.8 ± 12.3	-10.02	105.6 ± 12.0	94.2 ± 11.6	-10.8
C	18 to 30	85.4 ± 9.0	78.7# ± 8.3	-7.79	109.0* ± 0.0	104.7* ± 0.0	-3.94
Women n= 10	31 to 40	76.3 ± 5.5	72.0 ± 3.5	-5.64	101.6* ± 5.7	90.9#* ± 9.2	-10.57
Men n= 12	41 to 50	80.7 ± 8.7	70.6# ± 7.4	-12.49	100.9* ± 8.5	89.7#* ± 7.1	-11.1
	Total	80.3 ± 7.8	72.7 ± 6.8	-9.54	101.9 ± 7.1	91.5 ± 8.4	-10.24
Total	18 to 30	90.3 ± 5.6	79.7 ± 4.3	-11.75	99.9 ± 9.7	90.5 ± 10.3	-9.4
Women n= 48	31 to 40	88.3 ± 10.4	80.4 ± 10.8	-8.93	102.0 ± 9.4	92.6 ± 9.0	-9.52
Men n= 48	41 to 50	87.8 ± 11.1	78.3 ± 10.9	-10.84	102.9 ± 8.5	90.8 ± 8.3	-11.79
	Total	88.3 ± 10.1	79.2# ± 10.1	-10.39	102.0* ± 8.9	91.4#* ± 8.8	-10.78

Note. BW= Body Weight; S= Strength group; E= Endurance group; SE= Strength and Endurance group; C= Diet and physical recommendations group.
*#. p< 0.05 significantly different from pre; *. p< 0.05 significantly different from women.*

Table 3 shows the determination coefficients (R^2) of the linear, power law, exponential, logarithmic and quadratic equations of the BW changes by sex. For this analysis the sample was sixty-six completers of the on-line form done six months after the end of the intervention. When the R^2 represented in kg lost are compared significant differences are found between the type of function ($F_{4,320}=19.045; p<0.001$), but not by sexes ($F_{1,320}=2.63; p>0.05$). The observed statistical powers for these comparisons were 0.999 and 0.366, respectively. Figures 3 and 4 represents the five types of functions analyzed in both sexes, at months six and twelve. In 6 months, no differences were revealed for women and men ($p>0.05$) between the different equations. In both cases, it is shown that the quadratic function has the highest coefficient (0.9619 ± 0.048 for women and 0.9378 ± 0.094 for men) and the power law function has the lowest one (0.8256 ± 0.167 for women and 0.8493 ± 0.118 for men). In 12 months, the R^2 decrease in all functions for women respect to the R^2 at 6 months ($p<0.05$), except in the power law, logarithmic and quadratic functions, in which them remain higher (0.759 ± 0.225, 0.7655 ± 0.227 and 0.9527 ± 0.08, respectively). For men, the R^2 decrease in all functions respect to the R^2 at 6 months ($p<0.05$), except in the quadratic function, in which it remain higher (0.9248 ± 0.112). In the other hand, the quadratic function has the highest R^2 and it is different from the other four functions ($p<0.05$) for both sexes.

TABLE 3

R2 of the linear, power law, exponential, logarithmic and quadratic equations from the BW evolution by sex. Presented as M ± SD.

	Equation	Women				Men			
		6 months		12 months		6 months		12 months	
R^2	Linear	0.8817	± 0.208	0.6481[#]	± 0.268	0.8928	± 0.136	0.5249[#]	± 0.244
	Power law	0.8256	± 0.167	0.759	± 0.225	0.8493	± 0.118	0.7355[#a]	± 0.202
	Exponential	0.8838	± 0.209	0.6536[#]	± 0.273	0.8958	± 0.137	0.5272[#b]	± 0.248
	Logarithmic	0.8315	± 0.168	0.7655	± 0.227	0.8545	± 0.12	0.7407[#ac]	± 0.203
	Quadratic	0.9619[bd]	± 0.048	0.9527[abcd]	± 0.08	0.9378	± 0.094	0.9248[abcd]	± 0.112

Note. n= 66.

a.   p < 0.05 significantly different from linear equation; b. p < 0.05 significantly different from power law equation; c. p < 0.05 significantly different from exponential equation; d. p < 0.05 significantly different from logarithmic equation.

*#. p< 0.05 significantly different from 6 months; *. p< 0.05 significantly different from women.*

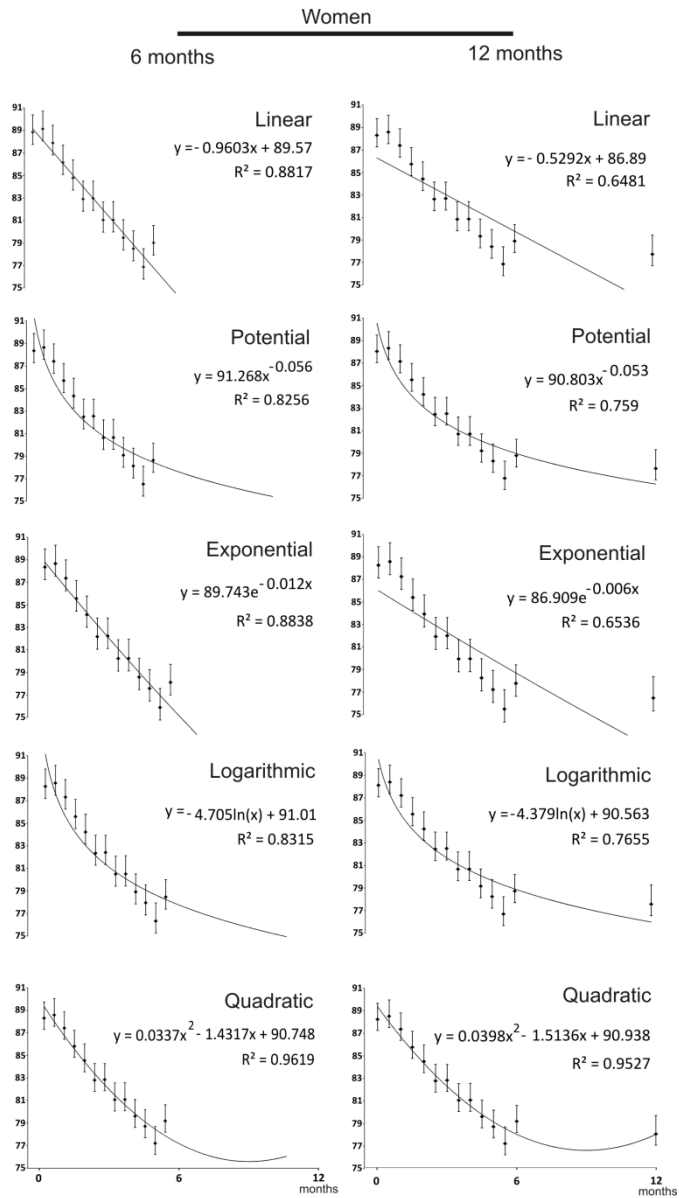FIGURE 3: Functions and R² of dynamics of weight loss for women. Mean values and Statistical Error of Mean.
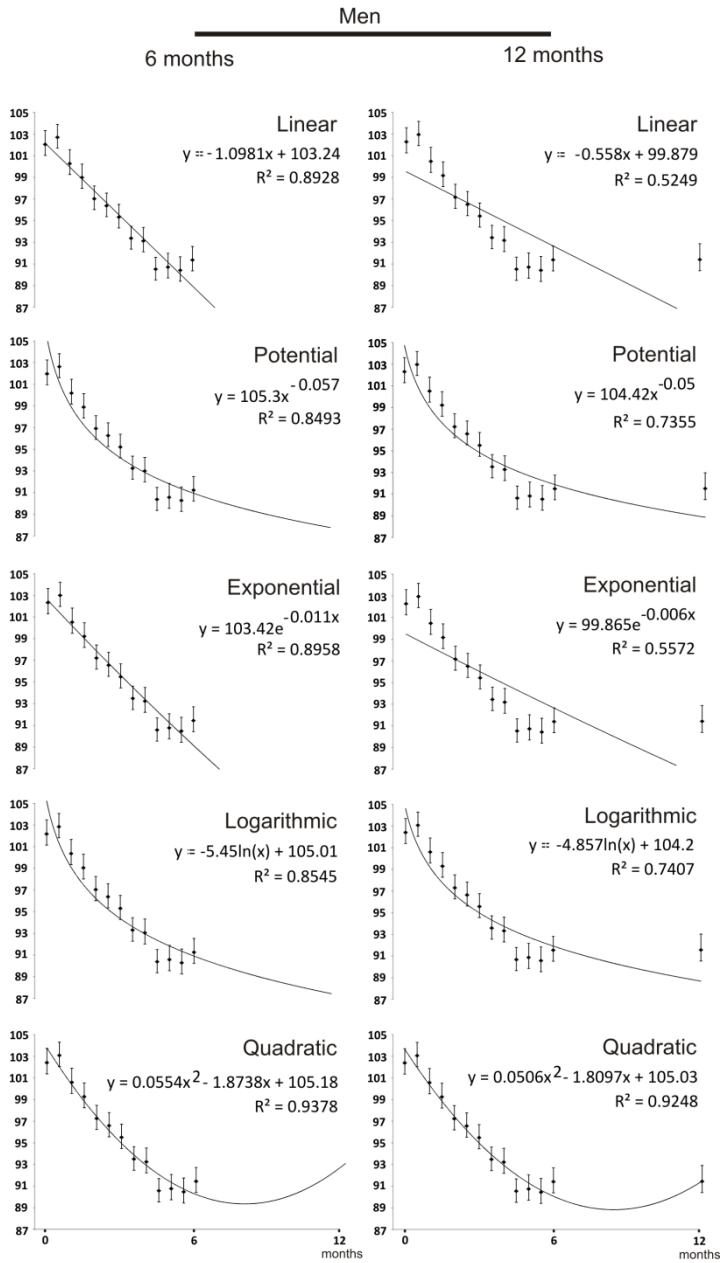
FIGURE 4: Functions and R^2 of dynamics of weight loss for men. Mean values and Statistical Error of Mean.

<div align="center">DISCUSSION</div>

The main purpose of this study was to evaluate the effects of the variables sex, age and treatment on the weight loss and how they affect the function that represents these dynamics. With this work it is shown that the BW loss is mainly affected by sex, as age and treatment have not presented any difference in the BW loss, and the function that better fits the BW loss dynamics is the quadratic one for both sexes.

To analyze the weight loss we had into account the 6 months intervention period. There was a significant reduction in the BW in both sexes, according to the results obtained by Hagan (Hagan, et al., 1986) and Redman in the CALERIE Study (Redman, et al., 2007). Moreover, there were no significant reductions in the BW between the different ranges of age at the end of the intervention, similarly to the results reported by Ghroubi (Ghroubi, et al., 2009). As people age, there is a loss on the fat-free mass and a decrease on the RMR (Kraemer, et al., 1997; Pavlou, Hoefer, & Blackburn, 1986; Redman, et al., 2007). This could produce a lower loss in the middle-aged than the younger-aged. Nevertheless, it does not occur when the intervention is controlled and supervised (Ghroubi, et al., 2009), and the diet is individually adapted to the daily energy expenditure estimated by accelerometry, as in this study. Our results do not show differences in weight loss between the types of treatment. A growing body of literature supports this indicating that exercise, in combination with dietary restriction, leads to similar reductions in BW (Brochu, et al., 2009; Crncevc-Orlic et al., 2008; Deibert et al., 2007; Larson-Meyer, et al., 2010; Redman, et al., 2007). Similar BW changes were obtained in other 6-months interventions with overweight population. In those cases, the BW was also reduced around 10% (Crncevc-Orlic, et al., 2008; Jakicic, et al., 2008; Larson-Meyer, et al., 2010; Redman, et al., 2007; Redman et al., 2009). Hagan and Kraemer showed a reduction in the BW around 10% in a 3-months intervention, differing from previous ones. Hagan's results can be explained by the 1200 kcal•day^{-1} diet intervention and the endurance exercise treatment consisting on 5 days•week-1 instead of 3 days•week^{-1}, and the Kraemer's results can be explained by the exercise intensity, that was from 70 to 80% of the functional capacity for the endurance exercise and 5 to 10 RM for the strength exercise (Hagan, et al., 1986; Kraemer, et al., 1997). Moreover, Del Corral obtained greater values of BW reductions (about 15.6%) due to the 800 kcal•day-1 meals that were provided twice a week (Del Corral, et al., 2009). When the interventions are conducted on a clinic (Del Corral, et al., 2009), programs obtain greater results. However, our results are closer to real life, because each participant prepared their own meals at home, and lead to a long-lasting acquisition of healthy habits. Figures 3 and 4 show how the weight has been maintained for at least 6 months.

In our study, the BW loss matches with a quadratic function in a 6-months program. Furthermore, these results are similar beyond 6 months of weight maintenance after the 6-months program. Our study was based on the observation of the BW evolution when intervention took place and when it ended in a completely autonomous lifestyle. A 6-months intervention could have been a limitation for this study because it has been shown in previous studies that weight regains occur in a longer term. Jackicic (Jakicic, et al., 2008) showed that after a similar weight loss at 6 months in an intervention similar to ours, the BW increases progressively to 24 months. The decrease on the physical activity from the month 6 and the no compliance with dietary recommendations may have contributed (Jakicic, et al., 2008) to regain the BW. In the future, it would be interesting to develop a longer intervention period and to determine different factors that influence the dynamics of weight loss. Probably, the expected weight reduction may not be observed or weight loss maintenance difficult to achieve after intervention period due to hormonal factors (Hagobian et al., 2009), to genetics characteristics (Bray, 2008), to a decline in adherence to diet (Acharya et al., 2009; Svetkey, et al., 2008), to an energy intake substantially higher than reported by the subjects (Heymsfield, Harp, Reitman, & al., 2007; Lichtman et al., 1992) or to a metabolic adaptation (MA) (Heilbronn et al., 2006; Martin et al., 2007).

CONCLUSIONS

In conclusion, in this work for weight loss programs with 25-30% of CR, the BW was significantly decreased in both sexes, regardless the age and type of followed treatment.

According to the results of the study, the weight loss performed by an individual (male or female) during six months can be represented by any of the five functions (linear, power law, exponential, logarithmic and quadratic) in both sexes, being the quadratic one which tends to represent it better. However, six months after the end of the intervention period, the weight evolution can be represented by the quadratic function in both sexes.

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