CHANGES IN BODY COMPOSITION AFTER A FOUR-MONTH PROGRAMME OF NUTRITIONAL EDUCATION AND PHYSICAL EXERCISES IN OBESE WOMEN

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Abstract

Aims: to identify changes in body composition in obese women, after a nutritional education and physical activity programme; - to discuss positive and negative factors related to these changes. Methods: 24 women were studied, 30 to 50 years old, BMI ≥ 30 kg/m\textsuperscript{2}. The women were submitted to a programme composed of: nutritional education (lectures and practical activities) and physical exercise (walking and resistance exercises, 60 minutes per day, and three days per week). Variables analysed at the beginning and at the end of the programme: body weight and body mass index (BMI); fat mass and fat-free mass (DEXA); intra and extracellular water estimation (bioelectrical impedance), waist and hip circumferences; aerobic power test (ergoespirometric analysis); food ingestion (three food diary calculated from energy and macronutrients). Main results: - An improvement in aerobic conditioning was observed; on average, body weight and BMI were not modified; however, there was a great individual variability in these results; - at the end of the programme, the women enhanced their lipid ingestion; - protein ingestion did not modify from the initial to final values, and was strictly according to consumption references. Conclusions: Our programme resulted in significant reduction in abdominal fat mass as well as in fat-free mass. These results allow us to suggest that, for nutritional education programmes, a quantitative control of food ingestion appears to be important, at least at the beginning of the weight loss process. In addition, studies regarding protein requirements in obese people undertaking physical activity are needed. Key-words: obesity, nutritional education, physical exercise, body composition.

1. Introduction

All over the world, obesity has reached startling proportions (1,2,3). In an attempt to control this epidemic, strategies have been developed, such as surgeries and medications. These strategies, despite their efficiency in many situations, can result in health risks (4,5). In the same way, very restricted diets may bring problems such as: adaptations and/or resistance to weight loss (6); risks of developing eating disorders (7,8); risk of micronutrient deficiencies (9) among many other consequences. Therefore, it is sensible to consider nutritional education and physical exercises in the search to find safe strategies for controlling body weight (10). With regard to nutritional education, it is important to stimulate the subjects to make their own choices, in a perspective of developing the autonomy (11,12).

To monitor the possible risks related to any kind of intervention in obesity, it is important to consider the maintenance and/or recovery of nutritional status. The term nutritional status embodies different components, including anthropometric measurements and body composition. It is important to include the broadest spectrum of methods and techniques to evaluate the nutritional status, in order to obtain a good profile of health status (10,13,14,15,16,17). Considering the importance of recognizing the changes in nutritional status for a physical exercise and nutritional education combination program, this study aims to: identify changes in body composition in obese women, after a physical exercise and nutritional education programme; and to identify factors that positively or negatively contribute to the changes found.

2. Methods

Study type

We conducted a \textit{quasi-experimental} study, comparing “before” and “after”, in a non-probabilistic sample. Subjects’ participation was voluntary, after advertising in the press media and via the internet. Inclusion criteria were: female gender, aged from 30 to 50 years, without any menopausal signs and body mass index (BMI) above 30 kg/m\textsuperscript{2}. Exclusion criteria were: the use of drugs that modify metabolic rate and participation in any body weight loss programme during the last 6 months or during the study. Subjects also needed to be free from any pathologic thyroid alterations (checked by TSH analysis) and were non-smokers, at least during the previous six months. Written agreement was obtained from all individuals, and the study was approved by local Ethics Committee, protocol number 087/2006.

Subjects

Fifty women who satisfied the inclusion and exclusion criteria were selected and took part in a physical activity and nutritional education programme, as described below. Subjects were evaluated at the start and at the end of the programme, and only subjects who attended more than 75% of the total number of the physical activity and nutrition education sessions were included in the data analysis file.
Anamnesis

The women answered questions related to past diseases, medicines use, physical activities practice, social habits (smoke and alcoholic drinks), time at school and economic status.

Physical Training Programme

The women participated in a four-month physical exercise programme that included 30 minutes of aerobic and 30 minutes of resistance exercise three times a week. The combination of aerobic and resistance exercise was based on the recommendation of the ACSM®. During the first two weeks of familiarization, sessions were carried out together with a baseline one maximal repetition (1MR) strength test, and the ergo-spirometric test. The exercise protocol consisted of walking on a treadmill at 65% \( \text{VO}_{2\text{peak}} \) with heart rate monitored (Polar®). The resistance training consisted of three sets of 10 repetitions of different muscle groups, at 60-70% of the 1MR. Once a week, the women undertook a sub-maximal 8MR strength test to enable progressive adjustment of the weight lifted and a 12 minute run test, to adjust the intensity of the aerobic exercise within a given heart rate zone.

Since physical training consisted of an aerobic and a resistance component, we considered the prediction of energy expenditure resulting from these exercises inappropriate. Excess post-exercise oxygen consumption (EPOC) can last for many hours after resistance exercise, thus, we concluded that energy expenditure prediction could be miscalculated. Since physical training was individualized with respect to \( \text{VO}_2 \) and 1MR percentage, all the women were considered to be in negative energy balance and, therefore, were capable of reducing their body weight.

Nutritional Education Programme

The aim of the programme was to promote healthy behavior in relation to food choices, without recommending severe energy restriction or food exclusion or restriction. The subjects participated in weekly sessions in which topics such as the importance of nutrients and the definition of a healthy diet were presented and discussed. These meetings included lectures, discussions and practical activities in a dietetic laboratory. The total number of meetings, including practice and theory was 13, and the topics discussed were: - 1. Introduction and identification of different food patterns; 2. Basic concepts of nutrition; 3. Sensory analysis, spices and herbs; 4. Food groups and the food guide; 5. Food servings; 6. Suggestions for healthy recipes; 7. Food behavior changes; 8. Food labeling, dietetic foods and light foods; 9. Low calorie deserts; - 10. Chronic diseases and diet; 11. Functional foods; 12. Usual diets; 13. Final evaluation.

Initial and final assessment

Food consumption

To monitor the food consumption (FC), subjects filled in three daily food records, on non-consecutive days, at the start and at the end of the programme. They recorded all food and drink intake on the specified days, using domestic measurements. Women were instructed to record the information as soon as possible after eating or drinking. The records were analysed quantitatively for energy and macronutrients using Nutri-UNIFESP® software.

Anthropometry

Body mass (BM) (Filizola® scale with 0.1g precision) and height (Secca® stadiometer to the nearest 0.1cm) were evaluated to calculate BMI (body mass index, in Kg/m²), and to classify subjects according to World Health Organization categories. The waist (WC) and hip (HC) circumferences were measured, and the waist/hip ratio was calculated (WHR). All the anthropometric procedures were based on Lohman, Roche & Martorell and all measurements were performed by the same researcher at start and at the end of the programme.

Bioelectrical impedance analysis

Many studies of nutritional status use phase-sensitive single-frequency BIA measurement, which allows the impedance \( Z \) to be differentiated into its two components, resistance and reactance. With this technique, body cell mass (BCM), extracellular mass (ECM) and body water can be estimated. Whole body bioelectrical impedance (Biodynamics 450e) was taken while the subject was in a supine position and on a non-conductive surface, with the electrodes placed on the recommended locations on the hands and feet. The resistance and reactance were measured, and from these, the body cell mass, extra-cellular mass, total body water, intracellular and extra-cellular water were estimated.

Dual energy X-ray absorptiometry (DEXA- Lunar®)

There is no consensus regarding the best method for assessment of body composition in the obese. However, imaging methods are considered to be the most accurate method for in vivo quantification at the tissue-organ level. Body composition was determined using dual-energy X-ray absorptiometry (DEXA) with scans analysed for total and regional fat mass (FM) and lean mass (LM), using adult software (Lunar Radiation corp, Madison, WI).

Aerobic Power Test

Subjects were advised to dress appropriately, to eat a light meal two hours before the test, and not to perform any exercise during the 24 hours prior to the test. After clinical history investigation and physical examination, an electrocardiogram was obtained. A short simulation of the test was performed, with the necessary explanations given. The test was conducted using a graded cycle ergometer (Biotec 2100, CEFISE®) and a metabolic analyser (VO2000 Imbrasport®), using a
ramp protocol. The VO\textsubscript{2}, VCO\textsubscript{2} and RQ were measured continuously. After a warm-up period, subjects pedaled against an initial resistance of 30W, increasing 10W per minute until volitional fatigue. The tests were performed at time intervals of 8 to 12 minutes.

**Data Analysis**

Firstly, normal distribution of data was confirmed using the Komolgorov-Smirnov test. Initial and final values were compared using the paired t-test for dependent variables. Statistical significance was defined as p<0.05, and data were analysed using Statistica software (Copyright StatSoft, Inc, 1984-2005).

### 3. Results

After checking the inclusion and exclusion criteria of 250 women, 50 were included in the study. Of these women, 33 finished the programme, but only 24 attended the minimum number of sessions required for inclusion in the analyses.

The participants’ mean age was 41.3 ± 7.5. There was a large variability in BM changes, ranging from -6.0 to +4.0 Kg. Table 1 depicts the results from anthropometric analysis and from DEXA analysis. The WC and HC were significantly reduced at the end of the programme, in contrast to body weight and BMI, whose measurements were not reduced. The only body composition variable that was reduced was lean mass (in Kg). To better understand these results, Figure 1 shows the frequency histogram for variations in body weight, BMI, fat mass and lean mass, from the beginning to the end of the programme. It is possible to note high data variability.

Table 2 depicts the results for cell mass, obtained from BIA. The percentage of lean mass water was the only variable that presented significant differences from the start to the end of the programme. Results from aerobic power test are presented in Table 3. An improvement in this variable may be observed at the end of the programme. Data from the food register are presented in Table 4. The energy intake did not change, but it is possible no observe a significant increase in fat intake at the end of the programme.

#### Table 1. Anthropometric variables and body composition (analysed by DEXA) at the start and at the end of the programme

<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial values (mean ± SD)</th>
<th>Final values (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (Kg)</td>
<td>92.1±14.9</td>
<td>91.2±14.5</td>
</tr>
<tr>
<td>BMI (Kg/m\textsuperscript{2})</td>
<td>35.8±4.0</td>
<td>35.5±4.0</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>101.7±9.6</td>
<td>98.3±8.9**</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>121.5±10.3</td>
<td>120.0±10.5**</td>
</tr>
<tr>
<td>WHR</td>
<td>0.83±0.07</td>
<td>0.82±0.06**</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>41.0±8.8</td>
<td>41.0±8.7</td>
</tr>
<tr>
<td>Fat mass (%)</td>
<td>44.2±3.0</td>
<td>44.6±3.4</td>
</tr>
<tr>
<td>Free fat mass (kg)</td>
<td>51.1±6.4</td>
<td>50.3±6.9*</td>
</tr>
<tr>
<td>Free fat mass (%)</td>
<td>50.9±3.0</td>
<td>50.5±2.7</td>
</tr>
</tbody>
</table>

BMI body mass index; WC – waist circumference; HC –hip circumference; WHR- waist/hip rate; (*) = p<0.05; (**)= p<0.01.

#### Table 2. Cell components analyzed by bioelectric impedance (BIA)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Initial values (mean ± SD)</th>
<th>Final values (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactance (Ω)</td>
<td>58.3±9.3</td>
<td>59.3±8.8</td>
</tr>
<tr>
<td>ECM/BCM</td>
<td>1.10±0.09</td>
<td>1.10±0.10</td>
</tr>
<tr>
<td>Total body water (L)</td>
<td>39.3±5.5</td>
<td>39.0±5.2</td>
</tr>
<tr>
<td>Intracellular water (%)</td>
<td>50.6±2.7</td>
<td>50.5±2.8</td>
</tr>
<tr>
<td>Extracellular water (%)</td>
<td>49.3±2.7</td>
<td>49.4±2.8</td>
</tr>
<tr>
<td>Water in free fat mass (%)</td>
<td>72.4±1.4*</td>
<td>71.9±1.5*</td>
</tr>
</tbody>
</table>

ECB/BCM= extracellular mass/total cellular mass ratio. (*) p<0.05; (**)= p<0.01.

#### Table 3. Values for VO\textsubscript{2 peak} from the aerobic power test at the start and at the end of the programme

<table>
<thead>
<tr>
<th>VO\textsubscript{2 peak} values</th>
<th>Initial values (mean ± SD)</th>
<th>Final values (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO\textsubscript{2 peak} (L/min)</td>
<td>1.9 ±0.4*</td>
<td>2.2 ±0.4*</td>
</tr>
<tr>
<td>VO\textsubscript{2 peak} (ml/kg/min)</td>
<td>20.0 ±3.5*</td>
<td>23.8 ±4.0*</td>
</tr>
</tbody>
</table>

VO\textsubscript{2 peak} – oxygen consumption at peak; (*) = p<0.05; (**)= p<0.01
Table 4. Data from food records at the start and at the end of the programme.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Initial values (mean ± SD)</th>
<th>Final values (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kcal/ day</td>
<td>1829±446</td>
<td>1816±458</td>
</tr>
<tr>
<td>Energy Kcal/kg body weight/day</td>
<td>20.0±5.5</td>
<td>19.6±4.1</td>
</tr>
<tr>
<td>% daily energy intake</td>
<td>29.6±4.5**</td>
<td>34.0±5.5**</td>
</tr>
<tr>
<td>Lipids g/day</td>
<td>60.8±16.7</td>
<td>69.4±21.4</td>
</tr>
<tr>
<td>% daily energy intake</td>
<td>54.8±5.8</td>
<td>50.8±17.6</td>
</tr>
<tr>
<td>Carbohydrates g/day</td>
<td>252.2±73.5</td>
<td>221.9±68.3</td>
</tr>
<tr>
<td>% daily energy intake</td>
<td>16.4±3.3</td>
<td>16.9±3.1</td>
</tr>
<tr>
<td>Proteins g/Kg body weight/day</td>
<td>0.8±0.2</td>
<td>0.8±0.2</td>
</tr>
<tr>
<td>% daily energy intake</td>
<td>73.6±18.1</td>
<td>75.9±16.5</td>
</tr>
</tbody>
</table>

(*) p<0.05; (**) p<0.01

Figure 1. Variation in body weight and body composition (analyzed by DEXA), from the start to the end of the programme. (A)= body weight variation (Kg); (B)= BMI variation (Kg/m²); (C)= fat mass variation (Kg) and (D)= fat free mass variation (Kg).

4. Discussion

This study investigated the changes in anthropometric and body composition variables, in obese women submitted to a programme that combined physical exercises and nutritional education. As our main findings, the programme was able to significantly improve the women’s aerobic condition; although anthropometric measurements were not modified at the end of the programme; a great variability among these changes was clearly observed in the women studied. At the end of the programme, the women presented a higher ingestion of lipids and did not modify their protein intake (0.8g/Kg/day).

Many authors have described, in similar studies, a great variability in body weight reduction; reasons for these findings vary, however, and a definite
explanation has not been identified (6,25,26). To explain our results, we may suppose that some of the women did not exert themselves in the physical training prescribed. However, we have many reasons to disagree with this possibility: 1- only the women who attended at least 75% of all the activities were included in the final data file to assure the reliability of our results; 2- aerobic power results were significantly improved for all the women studied. Aerobic power is considered an important indicator of the results of physical training; 3- it is important to highlight that, in the present study, we followed the American College of Sports Medicine recommendations for prescribing the physical training (19). In addition, we chose to combine aerobic and resistance exercise due to specific advantages of both kinds of exercise, especially for obese individuals (27,28,29,30). For instance, Ades et al (27) compared changes in aerobic power, between one group performing only aerobic exercises, and another group combining aerobic and resistance exercises. After 12 weeks of training, the group who combined the different exercise methods had improved 38% more than the group that only did aerobic exercises.

Another important change shown by the women was the waist circumference reduction. This measurement is indirectly related to visceral adipose tissue, and therefore to the risk of some diseases. In general, visceral adipose tissue is more sensitive to lipolysis (via catecolamins and β-adrenoreceptors) than subcutaneous adipose tissue (31,32). From these findings, the WC reduction can be explained mainly due to the physical exercise. Our results suggest that the women, in general, did not present any significant reduction in their body weight, possibly indicating a redistribution of total body fat, from the visceral to subcutaneous region. Rogge (33) reported this possibility in molecular studies relating to molecular changes related to obesity.

Another intriguing result of our study was the fat free mass water reduction in some of the subjects (which resulted in a significant reduction in the mean value). Excluding the possibility of an inadequate physical training (for the reasons described above), another possibility to explain this result could be factors from the diet. Two factors should be taken into consideration. Firstly, lipid ingestion was enhanced at the end of the study, despite the nutritional education programme. King et al (25), in a study that resembled ours in some aspects, reported differences in food preferences, especially in fat intake, particularly in the individuals who did not reduce their body weight. The authors hypothesized that enhances in hunger/appetite mechanisms could promote a selective enhance in fat intake. The authors defined these individuals as “compensatory”. Additionally, it is important to note that we did not calculate the proportion of the different kind of lipids ingested (due to limitations in the software used), enabling us to affirm unhealthy behaviors regarding lipid intake. It is also important to remember that nutritional education activities were included in the nutritional education programme, to discuss the benefits of monounsaturated and polyunsaturated fatty acids.

Another factor in the diet that could possibly be related to fat mass reduction was the protein intake, which was not higher, both at the start and at the end of the programme, being 0.8g/kg body weight per day. An enhancement in the protein needs of these women should be taken into account during the four month period where women changed from a sedentary condition to a physically active condition. Although Dietary Reference Intakes (34) do not suggest that physically active individuals should enhance their protein intake, many authors disagree with this reference. Bopp et al (35) pointed that a reduction in fat free mass during body weight reduction processes was associated with a low protein intake. In the same study, after elevating protein intake above recommendations, a fat free mass loss was attenuated. In the same way, Gordon et al (36) compared fat free mass changes in post-menopause women submitted to a hypocaloric diet. The women were distributed into groups: one receiving a diet that was normal in protein (15% of energy intake; 0.5 to 0.7 g protein per kg body weight) and a high-protein diet (30% of energy intake; 1.2 to 1.5 g of protein per kg body weight). After 20 weeks, the group receiving the normal in protein diet presented a reduction of 37.5±14.6% in their fat-free mass, while the high-protein group reduced this parameter by only 17.3±27.9%. In addition, Layman et al (37,38) compared the effects of two carbohydrate/protein ratios: 1.4 (approximately 1.6g protein per kg body weight) and 3.5 (approximately 0.8g protein per kg body weight). The authors analysed the results after 10 weeks of energy restriction in the diet. The group who received the higher protein ratio had preserved most their fat free mass. Additionally, the International Society of Sports Nutrition, in its Official Position, suggests that physically active individuals should consume between 1.4 to 2.0 g/kg body weight per day (39). The data from the literature regarding active individuals who are not athletes are scarce. The recommendations are, in their majority, directed to athletes or extremely physically active individuals (40).

Our results allow us to suggest that the enhancement of physical activity in the women provoked a physiologic and metabolic impact, at least at the beginning of the programme. More studies are necessary to investigate the relationship between physical activity and diet in obese individuals who are seek to lose weight. Therefore, even considering that nutritional education has many advantages over restrictive diets, our data seem to direct toward the
need for a more rigorous control of energy and nutrient intake.

Finally, in a more critical analysis of our results, it is important to highlight this study’s limitations: - the limited number of participants and a high variability in the results make a more detailed analysis difficult; - bioelectrical impedance does not have the same sensibility for measuring body water as other methods, such as stable isotope methods; - the food register for obese individuals is subject to errors (for instance underreporting) which could make our discussion incorrect. Methods such as the direct weight of food intake could provide better results.

5. Conclusions

Our programme resulted in significant reduction in abdominal fat mass as well as in fat-free mass. These results allow us to suggest that, for future nutritional education programmes, a quantitative control of food ingestion appears to be important, at least at the beginning of the weight loss process. In addition, studies regarding protein requirements in obese people undertaking physical activity are needed.

6. Acknowledgments

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