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High-fiber diet promotes metabolic, hormonal, and satiety effects in obese women on a short-term caloric restriction

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HIGLIGHTS

- Body weight and BMI decrease in both the EG and CG groups during the period of caloric restriction.
- For both the EG and CG groups, fat-free mass decreases during food restriction.
- Subjects on a high-fiber diet have reduced fasting glucose and basal insulin as well as improved insulin resistance, as attested by the lower HOMA-IR index.
- Obese women on a high-fiber diet have suppressed postprandial (after 60 min) acylated ghrelin, confirming that the diet composition influences ghrelin levels from the first day.
- In the present study, it was possible to verify that fasting leptin concentration diminishes in obese women on a high-fiber diet.

ABSTRACT – **Background** – Several mechanisms, including excessive hunger, account for patients' difficulties in maintaining weight loss and dietary changes after caloric restriction. **Objective** – To evaluate the effect of short-term high-fiber calorie-restricted diet in appetite-regulating hormones, and hunger and satiety sensations in women with obesity. **Methds** – In a randomized controlled trial study, thirty women with body mass index (BMI) higher than 30 kg/m^2, and aged from 20 to 50 years were hospitalized following a calorie-restricted diet (1000 kcal/day) for three days. The experimental group (n=15) received high-fiber diet and the control group (n=15), conventional diet. Body weight, BMI, resting energy expenditure (REE), acylated and total ghrelin, leptin, insulin and glucose, and hunger and satiety sensations were evaluated. Linear regression models with mixed effects (fixed and random effects) helped to assess the variables between the two groups and within the groups. **Results** – Body weight and BMI decreased in both the experimental and control groups (P<0.001). After the high-fiber diet, postprandial acylated ghrelin (P=0.04), glucose (P<0.001), insulin (P=0.04), and leptin (P=0.03) levels as well as the HOMA-IR index (P=0.01) decreased, whereas satiety improved (P=0.02). Obese women that followed the conventional diet had increased body fat percentage (P=0.04) and lower REE (P=0.02). The two diets did not differ in terms of hunger sensation. **Conclusion** – A short-term high-fiber diet improves satiety sensations and metabolic parameters while suppressing postprandial acylated ghrelin (60 minutes) and maintaining the resting energy expenditure.

Keywords – High-fiber diet; obese women; caloric restriction; appetite-regulating hormones; hunger and satiety sensations.

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INTRODUCTION

There are many disagreements about diets for the treatment of obesity, but the importance of different types of dietary interventions for the treatment of body weight loss is known[1].

Obesity management should focus on improving the patient's well-being and metabolic health. Caloric restriction is the main point of weight reduction treatment. It consists in reducing 20 to 40% of the *ad libitum* food intake while keeping adequate nutrients ingestion[2]. Dietary restriction can result in weight loss and offers metabolic benefits[3] in the short term. However, weight loss maintenance is difficult to achieve in the long term, possibly because the lower weight makes the organism turn to compensatory mechanisms that increase the food intake and reduce the energy expenditure[4]. Indeed, the majority of people on weight loss programs have difficulty modifying their lifestyle and food intake habits. Hunger and the desire to consume the usual food may culminate in individuals returning to the food pattern that they used to adopt before the caloric restriction[5].

Ghrelin, an orexigenic hormone, is implicated in both mealtime hunger and long-term body weight regulation[6,7]. Plasma ghrelin levels increase in response to diet-induced weight loss, suggesting that ghrelin participates in an adaptive response that limits the weight loss achieved through dieting. On the other hand, leptin constitutes one of the anorectic messengers to the central nervous system and circulates at concentrations proportional to the fat mass, thereby inhibiting food intake. Lower ghrelin and higher leptin levels occur in obese people[8]; this situation is reversed after a period of caloric restriction[9].

Hunger and low compliance with the diet limit weight loss during dietary changes[4]. Individuals who undertake a weight loss program perceive hunger associated with caloric restriction as a negative point[10]. In contrast, programs that demand less restrictive sacrifice can mitigate such effects[11]. Therefore, nutritional strategies that aim to increase satiety; for example, programs that adopt a high-fiber diet, can lead to more satisfactory results[12,13].

This study aimed to evaluate how hormones that regulate the appetite, metabolism, hunger, and satiety sensations change in obese women on a short-term caloric restriction based on a high-fiber diet as compared with obese women on a conventional restrictive diet.

METHODS

This randomized controlled trial study was conducted after approval by the Research Ethics Committee of the University Hospital of Ribeirão Preto Medical School, University of São Paulo. All the participants signed the written informed consent form.

Participants

Thirty obese women weighing up to 130 kg, with body mass index (BMI) higher than 30 kg/m^2, and aged from 20 to 50 years participated in the study. The participants were randomly distributed into two groups: the experimental group (n=15) and the control group (n=15). The exclusion criteria were presence of menopause; diabetes mellitus; tobacco addiction; illiteracy; pre-existing clinical conditions such as cardiovascular, renal, pulmonary, hepatic, biliary, and gastrointestinal disorders; use of oral contraceptives or discontinuation of contraceptive less than 6 months previously; untreated thyroid dysfunction; cancer; dietary treatment over the previous 6 months; and use of medications that affected weight and/or appetite.

Study protocol

The experimental protocol lasted four days. All the participants were hospitalized at the University Hospital of University Hospital of Ribeirão Preto Medical School, University of São Paulo During the hospital stay, the participants received a calorie-restricted diet of 1000 kcal/day for three days, but they did not engage in any physical activity. The experimental group (EG) received a high-fiber diet consisting of 127 g of carbohydrates (51%), 59 g of protein (24%), 29 g of fat (25%), and 40 g of fiber. The high-fiber diet was prepared using the typical menu offered by the hospital added with 24 g of high-fiber foods, such as whole grain bread, linseed, tangerine, pectin, brown rice, wheat bran, and apple. The control group (CG) received a conventional diet that included 130 g of carbohydrates (51%), 65 g of protein (25%), 27 g of fat (24%), and 16 g of fiber. The CG conventional diet relied on refined grains like white rice and white bread. Both diets were fractionated into six daily meals.

Body weight, BMI, body composition (fat mass, fat-free mass, and body fat percentage), resting energy expenditure, fasting glucose, basal insulin, HOMA-IR (Homeostasis Model Assessment-Insulin Resistance), basal leptin, and basal and postprandial (30 and 60 min after breakfast) acylated and total ghrelin were evaluated on the first day (day 1) and after three days of caloric restriction (day 4). Hunger and satiety sensations were also assessed during the caloric restriction using visual analogue scales.

Body measurements and resting energy expenditure

The participants' body weight was obtained in the morning, after fasting and urination. To this end, the individuals wore light clothes but no shoes. An electronic platform scale Filizola® (São Paulo, SP – Brazil) with a capacity of 150 kg and precision of 0.1 kg was employed. The height was measured using a stadiometer accurate to 0.1 cm. The BMI was calculated by dividing the body weight (kilogram) by the square of the height (square meter). Fat mass and fat-free mass were determined by dual energy X-ray absorptiometry (DXA, Hologic 4500W, Bedford, MA, USA). The calorimetric measurements were conducted on a portable calorimeter VO 2000 (MedGraphics®, USA). To obtain the resting energy expenditure in kcal/day, the volume of consumed oxygen (VO_2) and the volume of produced carbon dioxide (VCO_2) were measured using indirect calorimetry, by applying the Weir formula[14].

Laboratory measurements

Fasting glucose was determined by a colorimetric method (Labtest Diagnostic S/A, Lagoa Santa, MG). Basal insulin was measured by chemiluminescence (IMMULITE®1000 Immunoassay System, Siemens Healthcare Diagnostics). Insulin resistance was evaluated by HOMA-IR[15]. Leptin and acylated and total ghrelin (fasting and postprandial) were assessed by means of commercial Enzyme Linked Immunosorbent Assay (ELISA) kits from Millipore Corporation (Billerica, MA, USA; Cat. # EZHL-80SK, Cat. # EZGRA-88K, and Cat. # EZGRT-89K, respectively).

Hunger and satiety

During caloric restriction, hunger and satiety were evaluated four times a day, before (hunger) and after (satiety) breakfast, lunch, snack, and dinner. To this end, the methodology adapted from Flint and colleagues[16] as well as a subjective 100-mm visual analogue scale (VAS) was used to score how subjects were feeling. The participants were asked the following questions: *1) How hungry are you feeling? 2) How full are you feeling?* By this method, the results are presented as the mean and standard deviation of the score obtained for each day.

Statistical analysis

Data are presented as the mean and standard deviation (SD). Statistical analyses were accomplished using the SAS software version 9.0. Linear regression models with mixed effects (fixed and random effects) were used to assess the variables between the two groups and within the groups (paired samples). This model assumed that residues obtained by the differences between the predicted and observed values have normal distribution with mean value equal to zero as well as constant variance[17]. When these requirements were not met, a logarithmic transformation was performed on the data. The Pearson correlation coefficient was used for all the variables under study. The area under the curves of hunger and satiety were empirically calculated by employing the trapezoidal rule to obtain the difference between groups. The significance level was 95% ($P<0.05$).

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This project was approved by the Research Ethics Committee of the University Hospital of Ribeirão Preto Medical School, University of São Paulo (process n. 14167).

RESULTS

The mean ages in the experimental and control groups were 40±7 years and 39±6 years, respectively. In basal conditions, the groups presented similar values of body weight, BMI, fat mass, body fat percentage, resting energy expenditure, and HOMA-IR; similar acylated and total ghrelin, leptin, insulin, and glucose levels; and similar hunger and satiety sensations. The fat-free mass was the exception (TABLE 1).

After three days of caloric restriction (day 4), both the EG and CG groups had significantly reduced body weight (EG: 1.7 kg, $P<0.001$, CG: 2.1 kg, $P<0.001$), BMI ($P<0.001$), and fat-free mass (EG: $P=0.03$, CG: $P=0.001$). However, the women belonging to the CG group exhibited increased body fat percentage ($P=0.04$) and significantly lower resting energy expenditure ($P=0.02$). Comparison between the EG and CG groups revealed decreased resting energy expenditure in the CG group ($P=0.01$) (TABLE 2).

TABLE 1. Baseline characteristics of the obese women following a high-fiber diet and a conventional diet.

	high-fiber diet (n=15)		conventional diet (n=15)		*P* value
	Mean	SD	Mean	SD	
Body weight (kg)	88.0	9.4	95.8	13.0	0.06
Height (cm)	156.6	5.2	157.7	4.8	0.55
BMI (kg/m²)	35.9	3.5	38.5	4.9	0.09
Fat-free mass (kg)	49.3	6.1	54.0	5.6	0.04*
Fat mass (kg)	38.9	6.5	42.1	8.7	0.26
Body fat (%)	44.0	4.7	43.5	4.3	0.80
Resting energy expenditure (kcal/day)	1234.3	173.7	1293.8	175.1	0.36
Acylated ghrelin (pg/mL)	67.3	49.0	56.9	24.3	0.44
Total ghrelin (pg/mL)	277.3	139.2	252.6	86.8	0.47
Leptin (ng/mL)	25.9	8.9	28.3	11.5	0.47
Insulin (µIU/mL)	5.1	5.3	5.9	5.1	0.64
Glucose (mg/dL)	87.0	11.0	85.9	9.2	0.79
HOMA-IR	1.1	1.1	1.3	1.1	0.62
Hunger (mm)	52.2	38.3	48.3	26.2	0.73
Satiety (mm)	68.0	27.0	74.5	28.0	0.44

BMI: body mass index. *Statistically significant difference.

TABLE 2. Body measurements, resting energy expenditure, and laboratory measurements during caloric restriction.

	high-fiber diet (n=15)				conventional diet (n=15)			
	Day 1		Day 4		Day 1		Day 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Body weight (kg)	**88.0**	9.4	**86.2***	9.4	**95.8**	13.0	**93.7***	12.7
BMI (kg/m²)	**35.9**	3.5	**35.2***	3.5	**38.5**	4.9	**37.7***	4.8
Fat-free mass (kg)	**49.3**	6.1	**48.1***	4.9	**54.0**	5.6	**51.5***	5.9
Fat mass (kg)	38.9	6.5	38.2	6.1	42.1	8.7	42.2	8.7
Body fat (%)	44.0	4.7	44.1	3.7	**43.5**	4.3	**44.8***	4.3
Resting energy expenditure (kcal/day)	1234.3	173.7	1269.4	207.0	**1293.8**	175.1	**1203.6***	156.8
Fasting glucose (mg/dL)	**87.0**	11.0	**74.5***	10.3	85.9	9.2	85.7	11.3
Basal insulin (µIU/mL)	**5.1**	5.3	**3.6***	4.2	5.9	5.1	6.7	4.1
HOMA-IR	**1.1**	1.1	**0.7***	0.8	1.3	1.1	1.5	1.0
Fasting leptin (ng/mL)	**25.9**	8.9	**21.3***	7.9	28.3	11.5	24.3	6.3
Fasting acylated ghrelin (pg/mL)	**67.3**	49.0	80.0	45.4	56.9	24.3	**70.5**	33.7
Postprandial acylated ghrelin 30 minutes (pg/mL)	**44.0†**	4.6	62.8	21.6	45.4	6.6	**52.2†**	7.1
Postprandial acylated ghrelin 60 minutes (pg/mL)	**49.0†**	5.8	45.8	4.4	48.2	5.6	53.1	20.4
Fasting total ghrelin (pg/mL)	277.3	139.2	243.7	89.1	252.6	86.8	251.5	75.3
Postprandial total ghrelin 30 minutes (pg/mL)	**229.8‡**	14.8	230.3	37.5	218.4	20.4	229.6	40.7
Postprandial total ghrelin 60 minutes (pg/mL)	235.3	14.1	238.1	44.1	238.4	45.8	227.7	50.6

BMI: body mass index. *$P<0.05$ versus Day 1 for the the same group. †$P<0.05$ versus fasting acylated ghrelin (day 4 for the same group); ‡$P<0.05$ versus fasting total ghrelin (day 1 in the experimental group).

Compared with the CG group, the women in the EG group presented significantly lower levels of fasting glucose (*P*<0.001), basal insulin (*P*=0.04), HOMA-IR (*P*=0.01), and basal leptin (*P*=0.03), whereas fasting acylated and total ghrelin remained the same (TABLE 2) after three days of caloric restriction. Basal leptin positively and significantly correlated with basal insulin (r=0.36, *P*=0.04), body weight (r=0.51, *P*=0.004), and BMI (r=0.53, *P*=0.002) in all the participants.

During the first day (day 1) of caloric restriction, the women that followed a high-fiber diet presented significantly reduced concentration of acylated ghrelin 30 min (*P*=0.009) and 60 min (*P*=0.04) after breakfast. At the end of the caloric restriction (day 4), acylated ghrelin was also lower 60 min after breakfast (*P*<0.001). As for the women on a conventional diet, only at the end of the restriction period (day 4) did they display significantly reduced acylated ghrelin 30 min after breakfast (*P*=0.04). As for total ghrelin, on the first day (day 1) of caloric restriction this variable decreased significantly 30 min after breakfast (*P*=0.04) in the women belonging to the EG group. Total ghrelin remained unaltered in the women that followed the conventional diet (TABLE 2).

In the EG group, preprandial hunger sensation reduced from breakfast to snack on day 1 (*P*<0.001). On days 2 and 3, preprandial hunger sensations diminished on going from lunch to snack (*P*<0.001 and *P*=0.005, respectively), but they augmented on going from snack to dinner (*P*=0.04 and *P*=0.006, respectively) (FIGURE 1). In the CG group, preprandial hunger sensation decreased on going from breakfast to dinner on day 2 only (*P*=0.03) (FIGURE 2). However, for hunger, the area under the curve did not differ significantly between groups within three days of caloric restriction (*P*=0.34, *P*=0.28, and *P*=0.40 on days 1, 2, and 3, respectively).

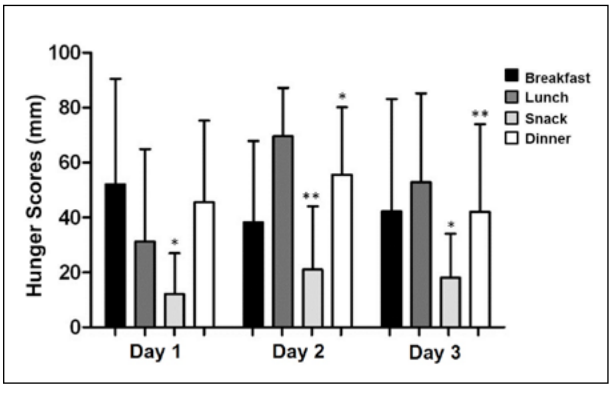

FIGURE 1. Hunger scores during caloric restriction in obese women on experimental group high-fiber diet.
**P*<0.05 *versus* breakfast at the same day, ***P*<0.05 *versus* lunch at day 2, ***P*<0.05 *versus* snack at day 3.

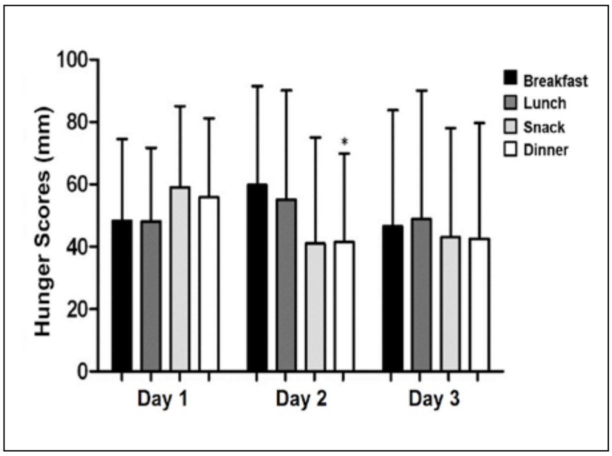

FIGURE. 2. Hunger scores during caloric restriction in obese women on a conventional diet.
**P*<0.05 versus breakfast on the same day.

Concerning postprandial satiety sensation, it improved in the women in the EG group on going from breakfast to dinner on day 1 (*P*=0.02) and from lunch to snack on day 2 (*P*=0.03) (FIGURE 3). Only on the second day did women on the conventional diet have higher satiety sensation on going from breakfast to dinner (*P*=0.018) (FIGURE 4). For satiety, the area under the curve was significantly larger for the EG group on days 2 and 3 as compared with the CG group (346.16 vs 286.70 mm², *P*=0.02; and 360.69 vs 338.40 mm², *P*=0.007, respectively).

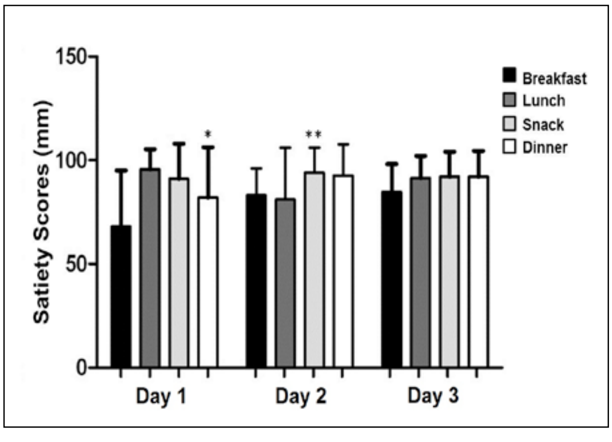

FIGURE 3. Satiety scores during caloric restriction in obese women on a high-fiber diet.
**P*<0.05 versus breakfast on the same day, ***P*<0.05 versus lunch on the same day.

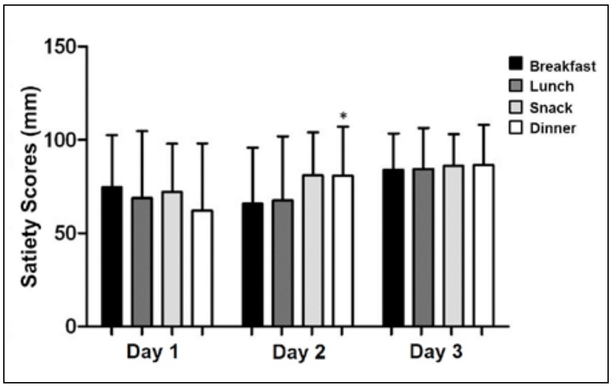

FIGURE 4. Satiety scores during caloric restriction in obese women on a conventional diet.
*$P<0.05$ versus breakfast on the same day, **$P<0.05$ versus lunch on the same day.

DISCUSSION

Several mechanisms, including increased food intake[6,18] and excessive hunger[10], account for the difficulty in maintaining weight loss and dietary changes following caloric restriction. In the present study, we hypothesized that a high-fiber calorie-restricted diet could alleviate hunger, thereby improving compliance with caloric restriction. The results reported here point to increased satiety; reduced basal insulin, HOMA index, and basal leptin; and suppressed postprandial (60 min) acylated ghrelin even in the presence of unaltered resting energy expenditure in subjects following a high-fiber calorie-restricted diet.

Body weight and BMI decrease in both the EG and CG groups during the period of caloric restriction. This finding agrees with previous evidence that whole grains intake does not exert any beneficial effects on body weight regulation. However, other studies have described greater body weight reduction in subjects following a high-fiber diet as compared with individuals on a conventional diet[19,20], in accordance with epidemiological observations[21].

For both the EG and CG groups, fat-free mass decreases during food restriction. A cross-sectional study has found that fiber intake is positively associated with lower body fat percentage[22]. Several other studies have demonstrated that caloric restriction reduces the fat-free mass, regardless of the diet type[1,23,24]. Lower resting energy expenditure occurs in subjects on a conventional diet, but this variable remains unaltered in individuals on a high-fiber diet. Several publications have shown that caloric restriction diminishes the resting energy expenditure[5,23,25,26] and the ups and downs of calorie restriction and fasting and their molecular effects[27].

Individuals with high fiber intake have larger energy expenditure as compared with those that ingest a small quantity of fiber. Also, energy expenditure has been associated with physical activity[28]. Maintenance of the energy expenditure in women following a high-fiber diet may contribute to successful weight reduction as well as compliance with caloric restriction, as observed by Gilhooly and colleagues[13].

Subjects on a high-fiber diet have reduced fasting glucose and basal insulin as well as improved insulin resistance, as attested by the lower HOMA-IR index. These parameters usually vary among obese people[3], which is also true in our study. These parameters improve because the high amount of fiber delays nutrients absorption; indeed, the fiber slows gastric emptying by forming a viscous gel to which the nutrients adhere[19]. Dietary fiber may also hinder the enzymatic digestion of macronutrients such as fat and starch in the small intestine, leading to weight loss. In other words, slow carbohydrates digestion and absorption decrease postprandial blood glucose and enhance insulin sensitivity[29].

Obese women on a high-fiber diet have suppressed postprandial (after 60 min) acylated ghrelin, but not total ghrelin, confirming that the diet composition influences ghrelin levels from the first day. However, in the case of obese women on a conventional diet, postprandial (after 30 min) acylated ghrelin levels decrease only on the last day. Gruendel et al., 2006[30], have reported significantly reduced postprandial acylated ghrelin and total ghrelin in adults after meals containing increasing amount of fiber (0, 5, 10, and 20 grams). In lean people, postprandial ghrelin suppression depends directly on the energy content of the meal, whilst obese people experience impaired ghrelin suppression regardless of the consumed energy[31]. Ghrelin, an orexigenic factor, exerts potent metabolic effects[7,9,32], but the specific regulatory mechanisms need clarification, especially in obesity.

In the present study, it was possible to verify that fasting leptin concentration diminishes in obese women on a high-fiber diet. Mars et al., 2006[33], verified reduced fasting leptin levels, irrespective of body weight. Lower leptin levels seem to increase the appetite, consequently augmenting the body weight. In contrast, suppression of leptin levels during caloric restriction reduces the subsequent food intake in rats, but it does not prevent weight regain[34]. And there is recent evidence that leptin inhibits the fasting-induced increase in food intake and activates hypothalamic neurons, this being an important role of leptin in the regulation of food intake[35]. Another study showed that leptin alters energy intake and fat mass, but not energy expenditure in lean subjects[36].

Although it was not the object of study in the present work, another fact to consider refers to negative emotions; which could influence food intake[37]. In a recent study that explored the relationship between leptin and food intake, triggered by negative emotions in obese women, the authors observed that negative emotions promoted an increase in food intake[37]. And there is still recent evidence of the relevance of epigenetic regulation of energy metabolism in obesity[38].

In this study, the subjective visual analogue scale helped to assess hunger and satiety sensations. The subjects on high-fiber diet experience greater satiety from the second day of food restriction as compared with women on a conventional diet. Hence, individuals on a high-fiber diet present early satiety response. Regarding hunger sensation, the women on a high-fiber diet and on a conventional diet are not different. A previous study did not detect any significant difference in hunger and satiety sensations with increasing doses of fiber[39]. However, it is known that the intake of dietary fiber at adequate levels can contribute to weight loss in women[12].

On the other hand, several studies have shown that high fiber intake enhances the perception of satiety, reduces the appetite, and decreases food intake in patients consuming meals with high fiber content[19,40,41].

Strength and limits

The strength of this study refers mainly to the type of study and the fact that several laboratory tests were analyzed. The main limitation of our study refers to the sample size. The present study is a clinical research that requires hospitalization and incurs high costs. For this reason, it was not possible to increase the sample size.

CONCLUSION

Our findings suggest that a short-term high-fiber diet improves satiety sensations and metabolic parameters while suppressing postprandial acylated ghrelin (60 minutes) and maintaining the resting energy expenditure. These data suggest that a dietary approach based on high fiber intake dietary may help to minimize weight regain during the critical period of early food restriction, contributing to patient's compliance with caloric restriction.

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Authors' contribution

Triffoni-Melo AT: protocol and study design, data collection and analysis and writing the manuscript. Castro M: critical revision and correction of the manuscript. Jordão AA: laboratorial analysis and interpretation. Leandro-Merhi VA: critical revision. Dick-de-Paula I: doctor responsible for patients care in the study. Diez-Garcia RW: conception, design and supervision of the study, data analysis and writing and correction of the manuscript. The authors approved the final version of the manuscript.

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RESUMO – Contexto – Vários mecanismos, incluindo a fome excessiva, são responsáveis pelas dificuldades dos pacientes em manter a perda de peso e mudanças na dieta após a restrição *calórica*. **Objetivo** – Avaliar o efeito da dieta de curta duração rica em fibras e com restrição calórica nos hormônios reguladores do apetite e nas sensações de fome e saciedade em mulheres com obesidade. **Métodos –** Em um estudo randomizado controlado, 30 mulheres com índice de massa corporal (IMC) superior a 30 kg/m² e com idade entre 20 e 50 anos foram hospitalizadas seguindo dieta com restrição calórica (1000 kcal/dia) por 3 dias. O grupo experimental (n=15) recebeu dieta rica em fibras e o grupo controle (n=15), dieta convencional. Foram avaliados peso corporal, IMC, gasto energético de repouso (GER), grelina acilada e total, leptina, insulina e glicose e sensações de fome e saciedade. Modelos de regressão linear com efeitos mistos (efeitos fixos e aleatórios) ajudaram a avaliar as variáveis entre os dois grupos e dentro dos grupos. **Resultados –** O peso corporal e o IMC diminuíram tanto no grupo experimental quanto no controle (P<0,001). Após a dieta rica em fibras, os níveis de grelina acilada pós-prandial (P=0,04), glicose (P<0,001), insulina (P=0,04) e leptina (P=0,03), bem como o índice HOMA-IR (P=0,01) diminuiu, enquanto a saciedade melhorou (P=0,02). Mulheres obesas que seguiram a dieta convencional apresentaram aumento do percentual de gordura corporal (P=0,04) e menor GER (P=0,02). As duas dietas não diferiram em termos de sensação de fome. **Conclusão –** Uma dieta rica em fibras de curto prazo melhora as sensações de saciedade e os parâmetros metabólicos, suprimindo a grelina acilada pós-prandial (60 minutos) e mantendo o gasto energético de repouso.

Palavras-chave – Dieta rica em fibras; mulheres obesas; restrição calórica; hormônios reguladores do apetite; sensação de fome e saciedade.

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