Capter 109

Effects of interdisciplinary therapy on reducing ultra-processed food consumption and its impact on cardiometabolic risks factor in women with obesity

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1 INTRODUCTION

The prevalence of obesity has grown at an epidemic rate in recent years. According to the World Health Organization (WHO), there are more than 1.9 billion overweight adults, and of these, more than 600 million are classified as being obese, which is equivalent to more than 13% of the world population (1). Obesity is a chronic disease, characterized by the presence of low-grade inflammation, which contributes to the development of other comorbidities including type 2 diabetes mellitus, cardiovascular diseases, non-alcoholic fatty liver disease, and different types of cancer (2).

The etiological pivot in respect of excess body weight is the existence of a chronic positive energy balance, with energy intake exceeding energy expenditure, which induces hormonal changes and favors an increase in lipogenesis and adipogenesis and a consequent increase in body weight (3). Although obesity has a complex and multifactorial etiology with interactions between genetic, psychological, socioeconomic, environmental, and behavioral factors (4), research suggests that dietary patterns are one of the most important determining factors in respect of the development of obesity. Changes in diet across the world, are generally characterized by a significant reduction in the consumption of high-fiber low-fat foods, fruits, and vegetables and increased consumption of food products with a high level of processing and low nutritional quality, such as soft drinks, cookies, and snacks, be strongly associated with obesity (5-9).

When considering the influence of dietary patterns on the pathogenesis of obesity, it is important that the analyses carried out a strategy that includes quantitative and qualitative information in the battle against obesity (10). Corroborating, in 2014 the Dietary Guidelines for the Brazilian Population, replaced the traditional division of foods into groups according to nutrient composition with a division considering the degree of processing, with foods being defined as *non-processed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods, the NOVA classification* (11-14).

Interestingly, some longitudinal studies recently have associated high consumption of ultra-processed foods (UPF) with a higher risk of obesity (6, 15, 16), cardiovascular diseases (17-20), diabetes mellitus (21), cancer (22) and mortality in general (23). Furthermore, a review study by Moradi et al. (24), which analyzed nine cross-sectional and three longitudinal studies, concluded that a 10% increase in the caloric intake from ultra-processed foods was associated with a 7%, 6%, and 5% higher risk of overweight, obesity, and abdominal obesity, respectively.

Additionally, recently the Brazilian Institute of Geography and Statistics (IBGE) published data from the last national population survey on food consumption, which revealed undesirable food consumption from processed and ultra-processed foods in a population aged over 10 years [11] which may negatively contribute to the development of obesity and related chronic diseases in the precocious age.

Since, increased focus on understanding the impact of analyses the qualitative eating habits, rather than simply on the quantification of caloric intake, especially among individuals with obesity, is an important target in the prevention of many disabilities because of nutritional conditions. Thus, the present study set out to evaluate the effect of clinical interdisciplinary therapy on ultra-processed foods consumption and its potential impact on cardiometabolic risks factor analyzed by *weight loss magnitude* in women with obesity.

2 METHODS

Study Population

Thirty-six women with obesity were recruited from ads published in different media (newspapers, magazines, radio, television, and Instagram®). The inclusion criteria for the participants were to: i) live in the city of São Paulo or nearby, so they could attend meetings; ii) be between the ages of 20 and 45 years; iii) present a body mass index (BMI) above 30 kg/m²; iv) be free of any diseases that could interfere the weight loss therapy, such as heart disease, musculoskeletal deformities, diseases related to the immune system, or genetic, metabolic, or endocrine diseases.

Once a month, volunteers attended face-to-face interdisciplinary clinical support sessions that included consultations with an endocrinologist, advice on the best nutritional approach, and exercise recommendations, and also covered a range of educational topics to support adherence to the program. Furthermore, the volunteers received weekly support by electronic means and could access educational videos and texts that helped them to understand obesity and its impact on their health, the weight loss process, and the importance of making a change in eating habits and lifestyle to improve their long-term health. Each patient was assessed at baseline and an individual weight-loss plan was produced. Using a blended intervention model, body weight was monitored weekly by self-report. The researchers got in touch weekly via WhatsApp® or e-mail with the participants. There were also closed WhatsApp® and Facebook® groups to help motivate the participants to meet their goals. Any questions in respect of any aspect of the program were answered as they arose. The volunteers were then assessed again at the end of the program.

The Ethics and Research Committee of the Federal University of São Paulo (CEP nº 1277/2020) approved the study. The Clinical Trial registration number is NCT04034472.

Anthropometric measures and body composition

Body mass was measured wearing as little clothing as possible and barefoot on a Filizola® (Brazil, São Paulo) mechanical anthropometric scale, with a maximum capacity of 150kg and a sensitivity of 100g. Height was measured with a Sanny® stadiometer (Brazil, São Paulo) with a precision of 0.1 cm; Body mass index (BMI) was then calculated using the equation BMI = kg/m^2, and values greater than 30 kg/m^2 were classified as indicating obesity.

Waist and hip circumferences were measured with a flexible and inelastic tape according to the recommendation (25). Body composition, including a measure of fat mass, fat-free mass, and resting metabolic rate (RMR) was measured using a 310E Bio-impedance meter (Biodynamics Corp., Shoreline, WA, USA).

Serum Analysis

Blood samples were collected after an overnight 12-hour fast. Concentrations of glucose, insulin, triglycerides (TG), total cholesterol (TC), and cholesterol fractions were determined by enzymatic colorimetric methods (CELM) immediately after blood collection.

Adiponectin was measured using the Milliplex MAP Human adipokine Magnetic Bead 1–3 Plex Panel (Millipore Corporation, Billerica, MA, USA). and leptin using the Milliplex MAP Human Metabolic Hormone Magnetic Bead 2 Plex Panel (Millipore, Billerica, MA, USA).

The homeostasis model assessment for insulin resistance (HOMA-IR) was used to determine insulin resistance (IR) and values above 2.71 were considered indicators of IR (26).

Interdisciplinary Therapy

All the participants then underwent a program of interdisciplinary weight loss therapy aimed at changing their lifestyles and eating behaviors. The goal was to reduce body weight by 5 to 10% and change eating and physical exercise habits to improve lifestyle and health. Each volunteer was assessed at baseline and an individual weight loss plan was produced. Using a blended intervention model, body weight was monitored weekly by self-report. The program is described in detail in a previous publication (27).

Food categorization according to the NOVA food classification system

The volunteers were asked to complete a three-day food diary covering two days of the week and one day of the weekend so that their eating habits and preferences, as well as the quality of their food intake, could be understood and analyzed.

For food categorization according to the NOVA food classification system, in which food groups are distinguished by the extent and purpose of processing used in food production, the consumption of each food group was analyzed by a dietitian using the Diet Smart program (Diet Smart Copyright©, 2012-2018). According to the NOVA division, the groups are defined as (1) non-processed or minimally processed foods; (2) processed culinary ingredients; (3) processed foods, and (4) ultra-processed foods:

(1) *non-processed or minimally processed foods:* comprise the edible parts of plants, animals, or fungi that have not undergone any processing or only minor modifications necessary for storage and/or consumption, such as husking, grain separation, pasteurization, freezing, and refrigeration, for example, leaves, fruits, meats, eggs, grains, milk;

(2) *processed culinary ingredients:* are extracted from the first group (example: oils, fats, sugars) or nature (example: salt) to season and cook food;

(3) *processed foods:* are food products derived from the addition of culinary ingredients (group 2) to foods of the first group, for example, canned vegetables, fruit in syrup, and cheeses;

(4) *ultra-processed foods:* industrial formulations composed of five or more ingredients, including

food additives, preservatives, and emulsifiers, which undergo several stages of industrial processes and/or processing techniques, for example, soft drinks, stuffed cookies, instant noodles (12-15).

In the present work, the foods classified as culinary ingredients were included in the groups of unprocessed foods.

According to their caloric need, each volunteer received a food plan, divided into food groups, with a list of possible substitutions for the different foods. The distribution of macronutrients was based on the recommendation of the FAO/WHO (28): proteins (10-15%), lipids (15-30%), and carbohydrates (55-75%).

Statistical analysis

G*Power 3.0.10 was used to calculate the sample size, adopting the F-test (ANOVA repeated measures, with factors). We considered a significance level of 5%, a test power of 80%, and an effect size of 0.25. This calculation was based on the benefits of moderate caloric restriction (25%) in reducing body weight, improving metabolic parameters, and reducing cardiometabolic risk in a previous study (29). Under these conditions, we estimated a minimum sample of 36 women with obesity.

Statistical analyses were performed using SPSS 23.0 software (IBM SPSS Statistics for Windows, 2015, Version 23.0. Armonk, NY: IBM Corp). Compare baseline and after-intervention measures were performed through generalized equation estimates (GEE) using appropriate distribution determined by Quasi Likelihood under Independence Model Criterion (QIC) and the Sidak posthoc test was used for pairwise comparisons. A generalized linear model (GzLM) using gamma distribution determined by the Akaike information criterion (AIC) was used to determine the differences between groups in delta values and the Sidak posthoc test was used for pairwise comparisons. Statistical significance was considered when $p \leq 0.05$. The groups were divided according to weight loss (WL) tertile, as follows: High WL(HWL) (n = 12) $\geq$ 6.8 kg (~8.32%), Medium WL(MWL) (n = 12) 5.1 a 6.7 kg (~5.65%) and Low WL(LWL) (n = 12) $\leq$ 5.0 kg (~3.06%).

In addition, a delta (Δ) value was calculated to reflect the effect of the multi-component weight loss therapy (Δ value = 12 post-therapy value − baseline value).

3 RESULTS

The effect of interdisciplinary therapy on the entire group

A total of 36 women with obesity completed the clinical interdisciplinary weight loss therapy. The mean age of the sample was 31.69 years (95% CI 29.81; 33.57), and there was a reduction of 6.03% in body mass (96.26 kg; 95% CI 90.01; 102.50 vs. 90.54 kg; 95% CI 84.52; 96.55); and in the BMI (35.90 kg/m^2; 95% CI 33.82; 37.99 vs. 33.76 kg/m^2; 95% CI 31.75; 35.78) after interdisciplinary therapy ($p<0.001$) (Table 1). We also observed reductions in the following parameters after therapy: waist circumference, hip circumference, body fat, total cholesterol, LDL cholesterol, non-HDL cholesterol, glucose, leptin, leptin/adiponectin ratio, insulin, and HOMA-IR (Tables 1 and 2).

The effect of interdisciplinary therapy according to the magnitude of weight loss

In the present study, the patients were analyzed in three groups according to weight loss (WL) tertile as follows: High WL (HWL) (n = 12) ≥ 6.8 kg (~ 8.32%), Medium WL (MWL) (n = 12) 5.1 a 6.7 kg (~ 5.65%) and Low WL (LWL) (n = 12) ≤ 5.0 kg (~ 3.06%). After therapy, the HWL and MWL groups presented reductions in five anthropometric and body composition parameters (body mass, BMI, body fat, waist circumference, and hip circumference) and two metabolic parameters (total cholesterol and leptin). Significant improvements in two other metabolic parameters (insulin and HOMA-IR) were observed in the HWL group. Additionally, the leptin/adiponectin ratio was reduced in the LWL group (Tables 1 and 2; Fig. 2). About HOMA-IR, the HWL group presented lower values, and these differences remained when compared with the other groups (MWL and LWL groups) (Table 2).

Food Consumption

Calories, macronutrients, fibers, and sodium intake

Before therapy, the volunteers consumed an average of 2149.99 kcal(95% CI 1902.29; 2397.69) per day, of which 46.83% (95% CI 44.34; 49.32) came from carbohydrates (245.49 g; 95% CI 220.42; 270.56), 18.09% (95% CI 16.37; 19.81) from proteins (94.74 g; 95%CI 82.55; 106.92), and 30.23% (95% CI 27.98; 32.47) from lipids (72.60 g; 95% CI 63.19; 82.00), as well as 21.77 g (95% CI 19.27; 24.27) of fiber and 2358.82 mg (95% CI 1991.15; 2726.48) of sodium daily.

Twelve weeks after therapy, daily calorie intake had decreased to 1577.03 kcal (95% CI 1415.96; 1738.11), with 44.20% (95% CI 40.68; 47.71) coming from carbohydrates (170.30 g; 95% CI 152.49; 188.11), 23.85% (95% CI 20.84; 26.86) from proteins (91.40 g; 95% CI 78.15; 104.65), and 28.95% (95% CI 26.47; 31.42) from lipids (50.36 g; 95% CI 44.20; 56.52)($p<0.001$). The intake of fibers decreased to 17.32 g (95% CI 15.19; 19.45) and sodium to 1385.48 mg (95% CI 1160.77; 1610.18) daily (Table 3).

Consumption of unprocessed or minimally processed food, processed food, and ultra-processed food

The present study also evaluated the calorie consumption obtained through unprocessed or minimally processed, processed, and ultra-processed foods before and after the program. The average caloric contributions of the food groups categorized according to the NOVA classification at the baseline and after the clinical approach were, respectively: 34.15% (95% CI 28.50; 39.81) to 51.60% (95% CI 44.41; 58.78) for unprocessed or minimally processed food, and 42.10% (95% CI 37.15; 47.05) to 29.04% (95% CI 22.98; 35.10) for ultra-processed food ($p<0.01$) for ultra-processed food (Table 3).

Additionally, in the group that showed greater weight loss after therapy (HWL group) there was an improvement in the dietary pattern, represented not only by the reduction in the intake of ultra-processed foods but also by the increase in the proportion of calories from unprocessed foods (Table 3).

4 DISCUSSION

The main aim of the present study was to evaluate whether interdisciplinary therapy effectively improved cardiometabolic risk factors and dietary patterns according to weight loss in women with obesity. There was a 5.94% reduction in body mass and reductions in five anthropometric and body composition parameters (body mass, BMI, body fat, waist circumference, and hip circumference), five metabolic parameters (total cholesterol, LDL cholesterol, non-HDL cholesterol, glucose, and insulin) and three pro-inflammatory markers (HOMA-IR, leptin, and leptin/adiponectin ratio) in women with obesity after weight loss.

All of these improvements are important in controlling obesity, CVD, and subclinical atherosclerotic processes and corroborate data from the literature that demonstrate that a modest 5% reduction in body weight can have a significant impact on comorbidities associated with obesity and produce significant, clinically relevant improvements in CVD risk factors in women with obesity. Furthermore, we were able to show that in the groups with *a higher and medium* reduction in body weight (8% and 5%) respectively, occur a significant reduction in many cardiometabolic risk factors, which is to the findings from other similar studies (30, 31).

Furthermore, another important finding in the present study was an improvement in dietary patterns, represented by an increase in the consumption of unprocessed foods and a reduction in the consumption of ultra-processed foods, in the group of women who achieved the greatest weight loss during treatment.

This study, which to the best of our knowledge is the first to analyze the effects of an interdisciplinary therapy on food choices in women with obesity, at baseline found that 20% of calories consumed came from processed foods and 30% from ultra-processed foods. A possible reason for this is that ultra-processed foods are easier to prepare and cheaper than unprocessed whole foods. According to the NOVA food classification system, ultra-processed foods are defined as those that contain high levels of saturated fat and added sugar while having low levels of dietary fiber, which makes these products more appealing to the consumer and less perishable (32).

After interdisciplinary therapy, there was a reduction in energy intake of 26.65% after the 12-week intervention in this group which is in line with the 25% reduction recommended as a gold standard in the management of overweight and obesity by the guideline for the management of overweight and obesity in adults (33).

Importantly, in the group with the greatest weight loss (HWL), there was a reduction in carbohydrate consumption (in grams and as a percentage of daily caloric intake) and an improvement in insulin sensitivity, represented by the reduction in serum levels of insulin and HOMA-IR. It is worth mentioning that the addition of sugars and saturated fats to ultra-processed foods can activate brain regions associated with the reward system, impairing food choices. In addition, increases in the glycemic index can impair satiety signaling, favoring the ingestion of larger and more frequent portions, thus contributing to an increase in caloric intake, and consequently stimulating the differentiation of adipocytes and accumulation of body fat, resulting in greater cardiometabolic risk (7, 34).

On the other hand, other studies show that low-carbohydrate diets can contribute to the reduction of leptin levels and improve insulin sensitivity (35, 36). Moreover, the reduction in caloric consumption from carbohydrates can be associated with an increase in the caloric contribution from proteins, which contributes to the regulation of hunger-satiety control (7, 37).

Caloric intake is strongly influenced by food choices, which involve the interaction of neuroendocrine, sensory, and genetic factors.[33] Furthermore, the low nutritional value of ultra-processed foods is not only related to the high content of some nutrients, but also to the low content of fiber, micronutrients, and bioactive compounds, and the inclusion of food additives, preservatives, and emulsifiers, which has been associated with an imbalance in the composition and metabolism of the intestinal microbiota (7, 23), which, in turn, can affect neuroendocrine regulation of the energy balance (38).

In addition, a positive association between the consumption of ultra-processed foods and low-grade chronic inflammation has been reported in women with obesity, as described in the study by Lopes et al. The potential mechanisms include the consequent inflammatory response to excess adipose tissue, but also the composition of ultra-processed foods that promote oxidative stress, and so this increased production of free radicals suppresses the antioxidant capacity of foods and leads to hypersecretion of pro-inflammatory cytokines (39).

Another interesting finding of the present study was a decrease in the leptin/adiponectin ratio following the interdisciplinary therapy in all analyzed groups, suggesting a decrease in cardiovascular mortality risk after weight loss. It has been shown that the leptin/adiponectin ratio is an early indicator of metabolic disturbances in individuals with obesity and may be a potentially useful clinical surrogate biomarker of metabolic disorders such as atherosclerotic index in patients with type 2 diabetes, regardless of body weight and obesity level, and an indicator of insulin resistance and screening for vascular risk and endothelial dysfunction (40).

Corroborating, another study from our group in a sample of women with extreme obesity found that there were changes in the pattern of adipokines in the blood in response to food intake restriction or reduced body fat mass, with a decrease in leptin and insulin levels and the leptin/adiponectin ratio which favor the restoration of leptin and insulin responsiveness in this analyzed population (41).

Our study has some limitations that should be noted, such as the time of multidisciplinary intervention. We believe that with a time of more than 12 weeks of intervention, the magnitude of the benefits could be more expressive, however, our model proved to be effective. Furthermore, the fact that only leptin and adiponectin were evaluated as biomarkers for chronic inflammation due to logistical issues. We believe that the inclusion of other biomarkers such as TNF-α, CRP, and IL-6 would have made our study more informative. The strengths of the study include the design of the interdisciplinary therapy, including clinical, nutritional, and physical exercise counseling, favoring together, a more holistic approach to treating obesity and its related comorbidities.

In conclusion, an improvement in dietary patterns associated with a reduction in ultra-processed food consumption and weight loss from 5% to 8% had a significant impact on cardiometabolic risk factors and produced significant, clinically relevant outcomes in women with obesity. We hope that the results of our study will encourage researchers to seek new dietary counseling strategies in the treatment of obesity targeting a reduction in processed and ultra-processed food intake consumption, and avoid the development of cardiometabolic risks in women with obesity.

Conflict of Interest: The authors declare no conflict of interest.

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REFERENCES

1. Obesity and overweight. Key facts. Fact sheet no. 311; June, 2021. Available online: http://www.who.int/mediacentre/factsheets/fs311/en/index.html (accessed on 11 March 2022).

2. Definition of Obesity. Anna Welcome, MD, FACOG. Available online: https://obesitymedicine.org/definition-of-obesity/ (accessed on 28 March 2022).

3. Cinti, S. The Endocrine Adipose Organ. Rev Endoc Metab Dis 2022; 23, 1-4.

4. Posicionamento sobre o tratamento nutricional do sobrepeso e da obesidade 2022/ABESO. Available online: http://www.abeso.org.br/ (accessed on 27 July 2022).

5. Archer, E.; Lavie, C. J.; Hill, J. O. The Contributions of 'Diet', 'Genes', and Physical Activity to the Etiology of Obesity: Contrary Evidence and Consilience. Prog Cardiovasc Dis 2018; 61, 89-102.

6. Poti, J.; Braga, B.; Qin, B. Ultra-processed food intake and obesity: what really matters for health – processing or nutrient content? Curr Obes Rep 2017; 6, 420-431.

7. Canhada, S. L.; Luft, V. C.; Giatti, L., Duncan, B. C.; Chor, D.; Fonseca, M. J. M. et al. Ultra-processed Foods, Incident Overweight and Obesity, and Longitudinal Changes in Weight and Waist Circumference: The Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). Public Health Nutr 2020; 23, 1076-1086.

8. Menegassi, B.; Sato, P. M.; Scagliusi, F. B.; Mourabac, J. Comparing the Ways a Sample of Brazilian Adults Classify Food with the NOVA Food Classification: An Exploratory Insight. Appetite 2019; 137, 226-235.

9. IBGE (Instituto Brasileiro de Geografia e Estatística). *Pesquisa de Orçamentos Familiares 2017-2018: Análise do Consumo Alimentar Pessoal no Brasil.* Instituto Brasileiro de Geografia e Estatística: Rio de Janeiro, Brasil, 2020.

10. Couch, S. S.; Helsley, R. N.; Siegel, F. U.; Saelens, B. E.; Magazine, M.; Eckman, M. H. et al. Design and rationale for the supermarket and web-based intervention targeting nutrition (SuperWIN) for cardiovascular risk reduction trial. Am Heart J 2022; 248, 21-34.

11. Ministério da Saúde. *Guia Alimentar para a População Brasileira*, 2 nd ed, Ministério da Saúde: Brasília, Brasil, 2014.

12. Monteiro, C. A.; Cannon, G.; Levy, R.; Moubarac, J.; Jaime, P.; Martins, A. P. et al. NOVA. A Estrela Brilha. W Nutr 2016; 7, 28-40.

13. Monteiro, C. A.; Cannon, G.; Lawrence, M.; Louzada, M. L. C.; Machado, P. P. NOVA. *Ultra- Processed Foods, Diet Quality, and Health using the NOVA Classification System*. Food and Agriculture Organization of the United Nations (FAO): Roma, Italy, 2019.

14. Monteiro, C. A.; Cannon, G.; Levy R. B.; Moubarac, J.; Louzada, M. L C.; Rauber, F. et al. NOVA. Ultra-processed foods: what they are and how to identify them. Public Health Nutr 2019; 22, 936-941.

15. Beslay, M.; Srour, B.; Méjean, C.; Allès, B.; Fiolet, T.; Debras, C. et al. Ultra-processed Food Intake in Association with BMI Change and Risk of Overweight and Obesity: A Prospective Analysis of the French NutriNet-Santé Cohort. Plos Med 2020; 17, e1003256.

16. Rauber, F.; Chang, K.; Vamos, E. P.; Louzada, M. L. C.; Monteiro, C. A.; Millett, C. et al. Ultra-processed food consumption and risk of obesity: a prospective cohort study of UK Biobank. Eur J Nutr 2021; 60, 2169-2180.

17. Srour, B.; Fezeu, L. K.; Kesse-Guyot, E.; Allès, B.; Méjean, C.; Andrianasolo, R. M. et al. Ultra-processed food intake and risk of cardiovascular disease: prospective cohort study (NutriNet-Santé). BMJ 2019; 365, 11451.

18. Juul, F.; Vaidean, G.; Lin, Y.; Deierlein, A. L.; Parekh, N. Ultra-processed Foods and Incident Cardiovascular Disease in the Framingham Offspring Study. J Am Col Cardiol 2021; 77, 1520-1531.

19. Pagliai, G.; Dinu, M. Madarena, M. P.; Bonaccio, M.; Iacoviello, L.; Sofi, F. Consumption of ultra-processed foods and health status: a systematic review and meta-analysis. Br J Nutr 2021; 125, 308-318.

20. Zhang, Z.; Jackson, S. L.; Martinez, E.; Gillespie, C.; Yang, Q. Association between ultraprocessed food intake and cardiovascular health in US adults: a cross-sectional analysis of the NHANES 2011-2016. Am J Clin Nutr 2021; 113, 428-436.

21. Levy, R. B.; Rauber, F.; Chang, K.; Louzada, M. C. L.; Monteiro, C. A.; Millett, C. et al. Ultra-processed food consumption and type 2 diabetes incidence: a prospective cohort study. Clin Nutr 2021; 40, 3608-3614.

22. Fiolet, T.; Srour, B.; Sellem, L.; Kesse-Guyot, E.; Allès, B.; Méjean, C. et al. Consumption of ultra-processed foods and cancer risk: results from NutriNet-Santé prospective cohort. BMJ 2018; 360, k322.

23. Schnabel, L.; Kesse-Guyot, E.; Allès, B.; Touvier, M.; Srour, B.; Hercberg, S. et al. Association Between Ultraprocessed Food Consumption and Risk of Mortality Among Middle-aged Adults in France. JAMA Intern Med 2019; 179, 490-498.

24. Moradi, S.; Entezari, M. H,; Mohammadi, H.; Jayedi, A.; Lazaridi, A.; Kermani, M. A. H. et al. Ultra-processed food consumption and adult obesity risk: a systematic review and dose-response meta-analysis. Criti Rev Food Sci Nutr 2021; 1-12.

25. Lohman, T.G., Roche, A.F. (1991) Martorrel R. Anthropometric Standardization Reference Manual. Human Kinetic Books: Illinois.

26. Geloneze, B.; Repetto, E. M.; Geloneze, S. R.; Tambascia, M. A.; Ermetice, M. N. The threshold value for insulin resistance (HOMA-IR) in an admixtured population IR in the Brazilian Metabolic Syndrome Study. Diabetes Res Clin Pract 2006; 72, 219-220.

27. Dâmaso, A. R.; Machado, P. P.; Rhein, S. O.; Masquio, D. C. L.; Oyama, L. M.; Boldarini, V. T. et al. Effects of an interdisciplinary weight loss program on fibroblast growth factor 21 and inflammatory biomarkers in women with overweight and obesity. Arch Endocrinol Metab 2021; 65, 821-831.

28. FAO (Food and Agriculture Organization of the United Nations). *Human vitamin and mineral requirements.* Report of a Joint FAO/WHO Expert Consultation. Bangkok, Thailand: Food and Agriculture Organization of the United Nations, 2003.

29. Most, J.; Tosti, V.; Redman, L. M.; Fontana, L. Calorie restriction in humans: an update. Ageing Res Rev 2017; 39, 36-45.

30. Dunn, C.; Olaboda-Dada, O.; Whetstone, L.; Thomas, C.; Aggarwal, S.; Nordby, K. et al. Using synchronous distance education to deliver a weight loss intervention: a randomized trial. Obesity 2016; 24, 44-50.

31. Hintze, L. J.; Kravchychyn, A. C. P.; Ferreira, Y. A. M.; Campos, R. M. S.; Dantas, A. A.; Masquio, D. C. L. et al. Semi-intensive and Intensive Interdisciplinary Treatments Have Similar Effects on Metabolic Syndrome and Selected Inflammatory Markers in Adolescents with Obesity. J Obes Metab Syndr 2021; 30, 386-395.

32. Elizabeth, L.; Machado, P.; Zinocker, M.; Baker, P.; Lawrence, M. Ultra-Processed Foods and Health Outcomes: A Narrative Review. Nutrients 2020; 12, 1955.

33. Jensen, M. D.; Ryan, D. H.; Apovian, C. M.; Ard, J. D.; Comuzzie, A. G.; Donato, K. A. et al. AHA/ACC/TOS Guideline for the Management of Overweight and Obesity in Adults. Circulation 2014; 129, 67-77.

34. Stanhope, K. L. Pathways and mechanisms linking dietary components to cardiometabolic disease: thinking beyond calories. Obes Rev 2018; 19, 1205-1235.

35. Haufe, S.; Engeli, S.; Kast, P.; Bohnke, J.; Utz, W.; Haas, V. et al. Randomized comparison of reduced fat and reduced carbohydrate hypocaloric diets on intrahepatic fat in overweight and obese human subjects. Hepatology 2011; 53, 1504-1514.

36. Varady, K. A.; Bhutani, S.; Klempel, M. C.; Phillips, S. A. Improvements in vascular healthy by low-fat diet, but not a high-fat diet, are mediated by changes in adipocyte biology. Nutr J 2011; 10, 8.

37. Hall, K. D.; Ayuketah, A.; Brychta, R.; Cai, H.; Cassimatis, T.; Chen, K. Y. et al. Ultra-processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of ad libitum Food Intake. Cell Metab 2019; 30, 67-77.

38. Farias, G.; Netto, B. D. M.; Bettini, S. C.; Damaso, A. R.; Freitas, A. C. T. Neuroendocrine regulation of energy balance: implications on the development and surgical treatment of obesity. Nutr Health 2017; 23, 131-146.

39. Lopes, A. E. S. C.; Araújo, L. F.; Levy, R. B.; Barreto, S. M. Association between consumption of ultra-processed foods and serum C-reactive protein levels: cross-sectional results from the ELSA-Brasil study. São Paulo Med J 2019; 137, 169-176.

40. Selthofer-Relatic, K.; Radic, R.; Stupin, A.; Sisljagic, V.; Bosnjak, I.; Bulj, N. et al. Leptin/adiponectin ratio in overweight patients – gender differences. Diab Vasc Dis Res 2018; 15, 260-262.

41. Farias, G.; Netto, B. D. M.; Boritza. K.; Bettini, S. C.; Vilela, R. M.; Damaso, A. R. Impact of weight loss on inflammation state and endothelial markers among individuals with extreme obesity after gastric bypass surgery: a 2-year follow-up study. Obes Surg 2020; 30, 1881-1890.