Chapter 46

Analysis of diet quality according to the food production process in women with different classes of obesity

https://doi.org/10.56238/colleinternhealthscienv1-046

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ABSTRACT
Background: Obesity is a complex disease that has an epidemic character affecting more than 1 billion people worldwide. Excessive accumulation of fat is associated with increased consumption of ultra-processed foods. This type of food provides large amounts of free sugars and saturated fats, which contribute to a high energy intake. It is well established that the main cause of obesity involves regulation between calories consumed and expended, however, this concept may be incomplete. Several methods can be explored to reduce body weight, however, for a healthy weight loss process, it is important to direct the individual to a balanced diet, with control of quantity, correct proportions of macronutrients, variety and combinations of different foods and nutrients. Objective: The aim of the study was to analyse the diet quality according to the food production process considering the different obesity degree by body mass index in a women sample. Methods: 139 women with obesity aged between 20 and 45 years old were included in this observational, cross-sectional study. Body composition and the three-day food record were analyzed. Results: The consumption of carboydrates (%), lipides (%) and monounsaturated fat (%) from ultra-processed foods were higher in the group with the highest BMI. However monounsaturated fat (%) from in nature foods was higher in the group with the lowest BMI. In addition, a positive association between carbohydrates (from ultra-processed foods) and waist circumference was observed. Conclusion: This investigation can stimulate public health programs to reinforce guidelines regarding the type of food procedure, giving priority to take care of the population's health by improving nutritional quality, preventing, and treating obesity in a multidisciplinary way.

Keywords: Diet quality, food production, food classification, obesity

1 INTRODUCTION

The main cause of obesity is the regulation of energy intake and expended calories, but this disease is complex and can interact with biological, social, cultural, public health and political dimensions (Lin X, Li H, 2021). It is well established that a high body mass index (BMI) has an important impact on obesity-related comorbidities, such as diabetes, cardiovascular diseases, hypertension, hepatic steatosis, and cancer, resulting in dramatic decrease of life quality and expectancy (WHO, 2020).

The prevalence of obesity has enhanced in both male and female, and across all ages. More than 1 billion people worldwide are with obesity – 650 million adults, 340 million adolescents and 39 million children (WHO, 2022). According to the National Health Survey (PNS, 2020), in Brazil, more than half of adults are currently overweight (60.3%), with a higher prevalence in females (62.6%) than in males (57.5%). Obesity affects 25.9% of the population, reaching 41.2 million adults (Ministério da Saúde, 2021).

This epidemic scenario can be explained by several possible mechanisms, such as increased consumption of high energy-dense foods since the fundamental cause of obesity and overweight is a positive energy balance. However, this concept may be incomplete. Reduced-calorie diets result in clinically meaningful weight loss, but the food sources and quality of nutrients showed to be more important than their quantities in the diet for weight control and disease prevention (Camacho S, Ruppel A. 2017; Srour B et al., 2019).

Changes in global food system in the last few decades led to an increase in the consumption of ultra-processed foods worldwide. This category of foods are formulations of many ingredients and several of exclusive industrial use. Physical and chemical processes are applied to foods including salting, sugaring, baking, frying, deep frying, curing, smoking, pickling, canning, and frequently the use of preservatives and cosmetic additives, and sophisticated types of packaging. These foods are thought to be microbiologically safe, increasing products shelf life; convenient, by reducing costs; and highly palatable, creating energy-dense and nutritionally imbalanced foods (Srour B et al., 2019; Nardocci M et al., 2019; Monteiro CA et al., 2010).

Chronic consumption of processed and ultraprocessed foods leads to a nutritionally poor diet, deficient in fibre, protein, vitamins, and minerals, and is highly associated with the development of overweight, obesity, metabolic syndrome and functional gastrointestinal disorders. A weight loss strategy by reducing the calorie intake, usually results in a short phase of rapid weight loss, however the patient can be vulnerable to malnutrition (Camacho S, Ruppel A. 2017; Monteiro CA et a., 2019; Juul F et al., 2018; Harrison S et al., 2020).

Despite the high prevalence and cost of obesity, it is a preventable and treatable disease. Several methods can be explored to reduce body weight, however, for a healthy weight loss process, it is important to direct the individual to a balanced diet, with control of quantity, correct proportions of macronutrients, variety and combinations of different foods and nutrients, adopting a balanced diet including fruits, vegetables, and whole grains. Also, a healthier diet includes the decreased intakes of saturated fatty acids and increased consumption of monosaturated and polyunsaturated fatty acids (Balani R et al., 2019, de Carvalho CM et al., 2015).

In this context, the aim of the study was to analyse the diet quality according to the food production process considering the different obesity degree by body mass index in a women sample.

2 METHODS

Population

The present study was an observational, cross-sectional study, approved by the Ethics and Research Committee of the Federal University of São Paulo (CEP nº 1277/2020; CAAE nº 20787319.4.0000.5505). All participants signed an informed consent form.

One hundred and sixty women with obesity, classified according to the WHO were recruited from ads served in the media (newspapers, magazines, radio, television, and Instagram®). To be recruited, these women should have ages between 20 and 45 years old, with Body Mass Index (BMI) ≥30 kg/m². They could not present diseases that could interfere the weight loss therapy, such as, heart disease, musculoskeletal deformities, diseases related to the immune system, genetic, metabolic, or endocrine diseases, identified by the physician. At the end of the process, we had a dropout of 21 volunteers who did not correctly fill in the data in the questionnaire, totaling 139 women.

Anthropometric measures and body composition

The body mass was measured using light clothes and barefoot on a Filizola® (Brazil, São Paulo). Mechanical anthropometric scale, with a maximum capacity of 150kg and a sensitivity of 100g. Moreover, height was measured with a Sanny® brand stadiometer (Brazil, São Paulo) with a precision scale of 0.1 cm. Subsequently, the body mass index (BMI) was calculated.

Neck, waist, abdominal and hip circumferences were measured with a flexible and inelastic tape. Body composition, including measure of fat mass (% and kg) and free fat mass (kg) were measured by Bio-impedance meter (BIA) provided by the device BIODYNAMICS 310e (TBW®) (EUA, Shoreline).

Nutritional analysis

The volunteers had to respond the three-day food record, which has free spaces to complete the date, mealtimes, and details of food consumption, so we could analyze and understand their habits and food preferences. The responses of three-day food record were transferred to a computer and analyzed by a nutritionist using the program Diet Smart (Diet Smart Copyright ©, 2012-2018). Macronutrients including carbohydrate, protein, lipids and fibers were reported and calculated. Thereafter, foods were divided by groups as proposed by NOVA, distinguishing by the extent and purpose of processing used in food production (chart 1). The frequency of consumption of each NOVA food group (1, 2, and 3) was calculated summing the amount (g/day) of each food item within the group. Finally, the consumption of each group was expressed as a percentage of total dietary intake (in g/day) (daily intake of each group in grams/total daily food intake in grams *100).

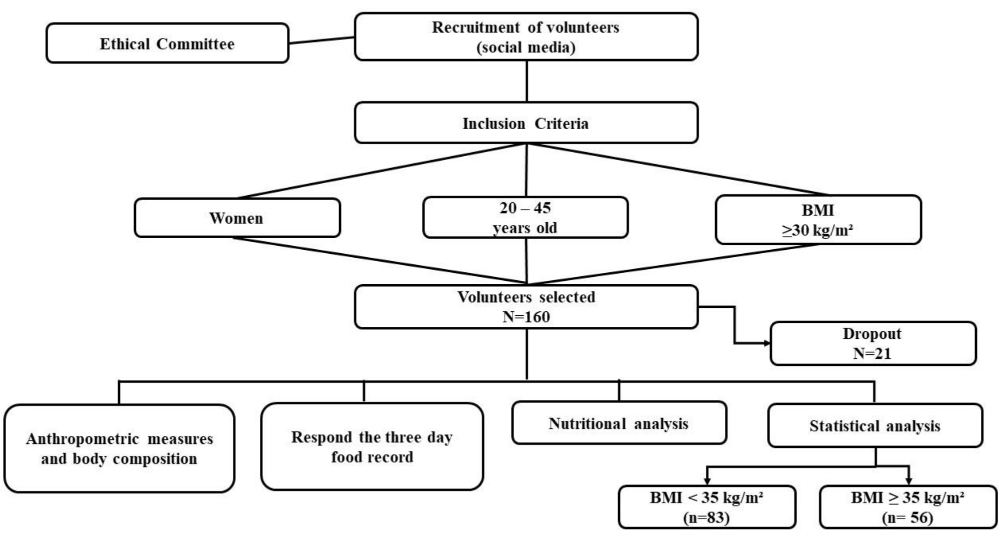
Chart 1: Classification by NOVA. (BRASIL, 2014; MONTEIRO et al., 2018).

(1) *in natura or minimally processed:* comprises 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. Examples: leaves, fruits, meats, eggs, grains, milk; Processed culinary ingredients: they are extracted from the first group (example: oils, fats, sugars) or from nature (example: salt) to season and cook food.
(2) *processed foods:* are food products that derive from the addition of culinary ingredients (group 2) to foods of the first group. Examples: canned vegetables, fruit in syrup, cheeses.
(3) *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. Examples: soft drinks, stuffed cookies, instant noodles.

Statistical analysis

Statistical analyses were performed using SPSS 21.0 software (SPSS Inc., Chicago, Illinois, USA). A generalized linear model (GzLM) using appropriate distribution (Gama or Linear) determined by Akaike information criterion (AIC) was used to determine the differences between groups. Sidak post hoc was applied to pairwise comparisons. Statistical significance was considered when $p \leq 0.05$. The subjects were grouped considering the body mass index groups: class I obesity group (BMI of 30 to < 35 kg/m²) n= 83 and class II-III obesity group (BMI of 35 to <40 kg/m²) n= 56.

Figure 1: Methodological design



3 RESULTS

Table 1 presents the anthropometry measures and body composition according to BMI classification. The BMI of class II-III obesity group showed higher values of body mass (kg), BMI (kg/m²), neck, waist, abdominal and hip circumferences (cm), and body fat mass (%) compared to BMI of class I obesity group. For free fat mass (kg) no difference was observed.

Table 2 shows the analysis of calories and macronutrients from different food groups: in (g) of the total calorie of the day and in (%) separated by the classification based on NOVA, being: in natura, processed and ultra-processed, demonstrating differences between groups in carboydrates (%), lipides (%) and monounsaturated fat (%) from ultra-processed foods - the group with the highest BMI showed the highest consumption of these nutrients. Considering monounsaturated fat (MUFA) (%) from in nature foods - the group with the highest BMI showed the lowest consumption of these nutrients. Interestingly, there was no significant difference in calories between groups.

Positive association between carbohydrates (originated from ultra-processed foods) and waist circumference was observed (Table 3).

4 DISCUSSION

This cross-sectional study aimed to investigate the impact of quality of diet according BMI degrees in a sample of women with obesity. The major findings in the present investigation were that for the clinical treatment of obesity, calories should not be considered alone, but it is important to investigate the origin of each macronutrient in the individual's diet.

Our investigate showed that although the calories intake was similar between the class I obesity group (BMI of 30 to < 35 kg/m²) and class II-III obesity group (BMI ≥ 35 kg/m²), there were an increase in macronutrients from ultra-processed foods relating to the highest values of anthropometric measurements. Therefore, the participation of the food industry and changes in obesogenic marketing that promotes foods with high content of sugar and fats to reverse the obesity epidemic by modulating human behavior seems to be crucial, once different classes of food influence differently the energy balance and the effect of disbalanced foods impacts on people's health and body weight (Camacho S, Ruppel A. 2017).

Although the main cause of obesity development is having more energy stored than expended, there are several mechanisms and factors that lead to obesity. Corroborating the results of this study, Lin X, Li H, 2021, found that the food sources and quality of nutrients is more valuable than the amount of calories intake in the diet for body weight control and prevention of obesity and related comorbidities. In a 13-year follow-up study on 3,000 young, those who consumed much more fast-food were found to weigh an average of ~6kg more and have larger waist circumferences than those with the lowest fast-food-intake. The same condition was found in the results of our study, which also showed that the group with the highest consumption of ultra-processed foods had larger neck, waist, abdomen, and hip circumferences.

It is increasingly known that regional adiposity rather than overall obesity is linked to adverse health outcomes. In particular, excess of visceral fat has been considered as the culprit contributing to the development of metabolic syndrome, providing insight into mechanisms that bridge the link between ultra-processed foods and chronic diseases. We found that higher carbohydrates percentage from ultra-processed foods consumption was associated with greater waist adiposity accumulation (class II-III obesity group). In general, this can be explained by some features of industrial processing, such as increase of energy density by adding sugar and use of additives amplifying sensory properties, that might lead to an increased eating rate and delayed satiety signaling (Konieczna J et al., 2021).

Monounsaturated fat (MUFA) found in plant and animal sources, present several health benefits, including the prevention of metabolic syndrome and its complications (Sheashea M et al., 2021). As our study shows that MUFA (%) from in nature foods was lower in group with the highest BMI, it is strongly suggested that dietary intervention adding MUFA can lead to anti-inflammatory effects and can decrease chronic inflammation ameliorating the general metabolic profile (Ravaut G et al., 2020).

The high refined carbohydrate, fat, sugar and salt content of this group of foods may produce changes in gut-brain signaling, leading to addictive-like eating behaviors and over consumption. Furthermore, the nutritional quality decreases with processing grade, that's why ultra-processed foods have a poor nutritional profile, contributing with personal, population, and planetary health problems (Small DM, et al., 2019; Hall KD et al., 2019; Lawrence M. 2021).

The excess of consumption of fat is associated with dyslipidemia and cardiovascular diseases, such as atherosclerosis, which are the main cause of mortality in the world's population. Ultra-processed foods are rich in saturated and trans fats, which make food more attractive and palatable. Corroborating this statement, a study carried out by Santana GJ et al., 2020, confirms the relationship between high consumption of foods rich in trans and saturated fats, and increased cardiometabolic risk in a population of Brazilian young adults. Food additives within ultra-processed foods, were demonstrated to promote inflammation, liver dysfunction and metabolic syndrome, that arises from changes in the microbiome (Santana GJ, et al., 2020).

In this sense, interventions aiming health promotion, nutrition education, limiting consumption of ultra-processed foods, decreasing the consumption of sugar-sweetened beverage and foods rich in saturated fats, stimulating for healthy living, may be an effective strategy for obesity prevention and treatment having a strong impact on reducing the obesity epidemic. The consumption of in natura or minimally processed foods, including fruits and vegetables plays a prominent role in cardiometabolic protective effects and prevent of metabolic syndrome (Downer S, et a., 2020).

According to the dietary guidelines of healthy eating for the population, must be considerate the cultural and social food patterns of each state, city and country (Guia Alimentar para a População Brasileira, 2014). In this way, an alternative or a complementary strategy to improve the national diet is to target processed foods for reformulation. This is supported by the World Health Organization (WHO) and The Food and Agriculture Organization (FAO) and represents a driving policy in many countries (Cediel, G. et al., 2021).

Despite the limitations present in a cross-sectional study by analysing data in a single moment, it was possible to observe results with a good prognosis for the clinical treatment of obesity aiming a healthy weight loss. As major finding, it was observed that higher BMI are related to higher consumption of nutrients from ultra-processed foods, however, with no significant difference in the amount of total calories per day. This result demonstrates that using a nutritional strategy for the weight loss process preserving nutritional quality is more important than counting calories.

5 CONCLUSION

Evidence suggests that ultra-processed foods may be associated with greater accumulation of body fat, increasing risks for the development of obesity and related diseases such as metabolic syndrome. Corroborating this, the present investigation shows that highest consumption of ultra-processed foods was observed among individuals with higher BMI and percentage of fat mass. Obesity being one of the main public health problems, this investigation can stimulate public health programs to reinforce guidelines regarding the type of food procedure, giving priority to taking care of the population's health by improving nutritional quality and preventing, and treating obesity in a multidisciplinary way.

ACKNOWLEDGEMENTS

This study was supported by the Foundation of São Paulo Research - FAPESP (grant nos.: 2017/07372-1, Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP), the National Council for Scientific and Technological Development - CNPq (grant nos.: 301322/2017-1; 305240/2021-8) and the Coordination of Higher Educational Personnel Training – CAPES.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Table 1. Anthropometric and body composition parameters

variáveis	BMI I (n= 83)	BMI II-III (n= 56)	Wald	df	p
body weight (kg)	87.74 ± 7.55	104.96 ± 13.67	93.184	1	**<0.01**
BMI (kg/m²)	32.57 ± 1.38	39.3 ± 3.52	250.712	1	**<0.01**
neck circumference (cm)	35.68 ± 1.8	39.03 ± 5.02	41.826	1	**<0.01**
abdominal circumference (cm)	106.08 ± 6.99	119.18 ± 11.15	73.552	1	**<0.01**
waist circumference (cm)	92.93 ± 6.44	104.65 ± 9.34	77.536	1	**<0.01**
hip circumference (cm)	118.44 ± 5.17	128.58 ± 8.66	76.479	1	**<0.01**
fat mass (%)	38.49 ± 2.65	41.51 ± 3.77	31.119	1	**<0.01**
fat free mass (kg)	60.48 ± 5.67	62.14 ± 6.94	2.441	1	0.11

BMI: body mass index; df: degree of freedom

Generalized linear model (GzLM) post hoc Sidak. Statistical significance p≤ 0.05

Table 2. Dietary evaluation.

variáveis	BMI I (n= 83)	BMI II-III (n= 56)	Wald	df	p
Total energy (kcal)	1699.02 ± 566.08	1674.59 ± 464.93	0.073	1	0.80
Carbohydrate (g)	203.94 ± 79.68	208.52 ± 68.68	0.113	1	0.74
Carbohydrate (% kcal)	11.99 ± 2.62	12.38 ± 1.36	1.113	1	0.29
Carbohydrate (% kcal in nature)	152.54 ± 966.54	53.88 ± 56.52	0.589	1	0.44
Carbohydrate (% kcal processed)	69.49 ± 67.91	76.43 ± 197.21	0.89	1	0.77
Carbohydrate (% kcal ultra-processed)	40.73 ± 29.57	76.71 ± 148.44	4.685	1	**0.03**
Protein (g)	80.84 ± 24.23	80.24 ± 25.54	0.019	1	0.89
Protein (% kcal)	4.98 ± 1.46	4.91 ± 1.22	0.101	1	0.75
Protein (% kcal in nature)	41.53 ± 219.54	18.78 ± 15.39	0.607	1	0.44
Protein (% kcal processed)	29.22 ± 30.24	32.98 ± 98.77	0.107	1	0.74
Protein (% kcal ultra-processed)	18.69 ± 17.24	32.99 ± 65.76	3.623	1	0.06
Lipids (g)	63.64 ± 28.1	58.32 ± 19.47	1.555	1	0.21
Lipids (% kcal)	3.68 ± 0.79	3.45 ± 0.57	3.599	1	**0.058**
Lipids (% kcal in nature)	39.77 ± 230.42	15.62 ± 17.23	0.62	1	0.43
Lipids (% kcal processed)	21.68 ± 23.73	24.18 ± 74.97	0.082	1	0.78
Lipids (% kcal ultra-processed)	12.46 ± 8.98	18.28 ± 25.12	3.813	1	**0.051**
Saturated fat (g)	20.51 ± 10.11	18.31 ± 7.25	2.01	1	0.16
Saturated fat (% kcal)	1.18 ± 0.35	1.09 ± 0.37	2.32	1	0.13
Saturated fat (% kcal in nature)	10.09 ± 50.4	4.77 ± 5.05	0.627	1	0.43
Saturated fat (% kcal processed)	7.22 ± 9.13	7.7 ± 23.82	0.028	1	0.88
Saturated fat (% kcal ultra-processed)	4.09 ± 3.43	5.81 ± 7.31	3.509	1	0.06
Monounsaturated fat (g)	16.38 ± 8.99	14.65 ± 5.41	1.908	1	0.17
Monounsaturated fat (% kcal)	0.95 ± 0.34	0.88 ± 0.27	1.619	1	0.20
Monounsaturated fat (% kcal in nature)	6.59 ± 26.75	3.71 ± 3.45	0.64	1	**0.001**
Monounsaturated fat (% kcal processed)	5.65 ± 6.22	7.26 ± 27.56	0.266	1	0.61
Monounsaturated fat (% kcal ultra-processed)	3.38 ± 2.8	5.06 ± 7.21	3.79	1	**0.052**
Polyunsaturated fat (g)	10.7 ± 9.53	9.37 ± 4.73	1.735	1	0.19
Polyunsaturated fat (% kcal)	0.6 ± 0.38	0.55 ± 0.2	1.272	1	0.26
Polyunsaturated fat (% kcal in nature)	9.35 ± 62.96	2.66 ± 4.12	0.639	1	0.42
Polyunsaturated fat (% kcal processed)	3.51 ± 3.88	3.44 ± 9.15	0.004	1	0.95
Polyunsaturated fat (% kcal ultra-processed)	2.01 ± 1.73	3.3 ± 6.49	3.028	1	0.08

Fibers (g)	14.39	±	6.52	16.56	±	9.32	2.653	1	0.10
Fibers (% kcal)	0.88	±	0.38	1.003	±	0.51	2.291	1	0.13
total in nature (kcal)	568.22	±	290.4	556.54	±	316.41	0.051	1	0.82
total processed (kcal)	449.35	±	338.32	453.91	±	264.56	0.007	1	0.93
total ultra-processed (kcal)	664.32	±	411.72	608.19	±	442.99	0.593	1	0.44

df: degree of freedom

Generalized linear model (GzLM) post hoc Sidak. Statistical significance p≤ 0.05

Table 3. Association among waist circumference and macronutrients originated from ultra-processed foods

	β value	**Wald**	**Exp(B)**	**(95% CI)**	**p**
Carbohydrate (% kcal ultra-processed)	0.001	4.022	1.001	(1.000 - 1.001)	**0.04**
Protein (% kcal ultra-processed)	-0.001	2.219	0.999	(0.997 - 1.000)	0.13
Lipids (% kcal ultra-processed)	-0.001	0.128	0.999	(0.996 - 1.002)	0.72

dependent variable: waist circumference

REFERENCES

[1] Lin X, Li H. Obesity: Epidemiology, Pathophysiology, and Therapeutics. Front Endocrinol (Lausanne). 2021 Sep 6;12:706978. doi: 10.3389/fendo.2021.706978. PMID: 34552557; PMCID: PMC8450866.

[2] World Health Organization. WHO. March 2020; Available from: http://bvsms.saude.gov.br/

[3] World Health Organization. WHO. March 2022. Available from : https://www.paho.org/

[4] Ministério da Saúde, 2021. Available from: https://aps.saude.gov.br/.

[5] Camacho S, Ruppel A. Is the calorie concept a real solution to the obesity epidemic?. Glob Health Action. 2017;10(1):1289650. doi:10.1080/16549716.2017.1289650.

[6] Srour B, Fezeu LK, Kesse-Guyot E, Allès B, Méjean C, Andrianasolo RM, Chazelas E, Deschasaux M, Hercberg S, Galan P, Monteiro CA, Julia C, Touvier M. Ultra-processed food intake and risk of cardiovascular disease: prospective cohort study (NutriNet-Santé). BMJ. 2019 May 29;365:l1451. doi: 10.1136/bmj.l1451. PMID: 31142457; PMCID: PMC6538975.

[7] Nardocci M, Leclerc BS, Louzada ML, Monteiro CA, Batal M, Moubarac JC. Correction to: Consumption of ultra-processed foods and obesity in Canada. Can J Public Health. 2019 Feb;110(1):15-16. doi: 10.17269/s41997-018-0142-6. Erratum for: Can J Public Health. 2019 Feb;110(1):4-14. PMID: 30353503; PMCID: PMC6964566.

[8] Monteiro CA, Levy RB, Claro RM, Castro IR, Cannon G. A new classification of foods based on the extent and purpose of their processing. Cad Saude Publica. 2010;26:2039–49. Doi: 10.1590/s0102-311x2010001100005. PubMed

[9] Monteiro CA, Cannon G, Levy RB, Moubarac JC, Louzada ML, Rauber F, Khandpur N, Cediel G, Neri D, Martinez-Steele E, Baraldi LG, Jaime PC. Ultra-processed foods: what they are and how to identify them. Public Health Nutr. 2019 Apr;22(5):936-941. doi: 10.1017/S1368980018003762. Epub 2019 Feb 12. PMID: 30744710.

[10] Juul F, Martinez-Steele E, Parekh N, Monteiro CA, Chang VW. Ultra-processed food consumption and excess weight among US adults. Br J Nutr. 2018 Jul;120(1):90-100. doi: 10.1017/S0007114518001046. Epub 2018 May 6. PMID: 29729673.

[11] Harrison S, Couture P, Lamarche B. Diet Quality, Saturated Fat and Metabolic Syndrome. Nutrients. 2020 Oct 22;12(11):3232. doi: 10.3390/nu12113232. PMID: 33105691; PMCID: PMC7690379.

[12] Balani R, Herrington H, Bryant E, Lucas C, Kim SC. Nutrition knowledge, attitudes, and self-regulation as predictors of overweight and obesity. J Am Assoc Nurse Pract. 2019 Sep;31(9):502-510. doi: 10.1097/JXX.0000000000000169. PMID: 30829975.

[13] de Carvalho CM, Dias Mendonça D, Haas Piovesan C, Edler Macagnan F, Pandolfo Feoli AM. Nutritional adequacy in subjects with metabolic syndrome. Nutr Hosp. 2014 Nov 16;31(3):1147-53. doi: 10.3305/nh.2015.31.3.8086. PMID: 25726206.

[14] Ministry of Health of Brazil, Secretariat of Health Care, Primary Health Care Department. Dietary guidelines for the Brazilian population 2014 [Internet]. Available from:http://189.28.128.100/dab/docs/portaldab/publicacoes/guia_alimentar_populacao_ingles.pdf.

[15] Monteiro CA, Cannon G, Moubarac J-C et al. (2018) The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutr 21, 5–17.

[16] Konieczna J, Morey M, Abete I, Bes-Rastrollo M, Ruiz-Canela M, Vioque J, Gonzalez-Palacios S, Daimiel L, Salas-Salvadó J, Fiol M, Martín V, Estruch R, Vidal J, Martínez-González MA, Canudas S, Jover AJ, Fernández-Villa T, Casas R, Olbeyra R, Buil-Cosiales P, Babio N, Schröder H, Martínez JA,

Romaguera D; PREDIMED-Plus investigators. Contribution of ultra-processed foods in visceral fat deposition and other adiposity indicators: Prospective analysis nested in the PREDIMED-Plus trial. Clin Nutr. 2021 Jun;40(6):4290-4300. doi: 10.1016/j.clnu.2021.01.019. Epub 2021 Jan 28. PMID: 33610419.

[17] Sheashea M, Xiao J, Farag MA. MUFA in metabolic syndrome and associated risk factors: is MUFA the opposite side of the PUFA coin? Food Funct. 2021 Dec 13;12(24):12221-12234. doi: 10.1039/d1fo00979f. PMID: 34779464.

[18] Ravaut G, Légiot A, Bergeron KF, Mounier C. Monounsaturated Fatty Acids in Obesity-Related Inflammation. Int J Mol Sci. 2020 Dec 30;22(1):330. doi: 10.3390/ijms22010330. PMID: 33396940; PMCID: PMC7795523.

[19] Small DM, DiFeliceantonio AG. Processed foods and food reward. Science. 2019 Jan 25;363(6425):346-347. doi: 10.1126/science.aav0556. PMID: 30679360.

[20] Hall KD, Ayuketah A, Brychta R, Cai H, Cassimatis T, Chen KY, Chung ST, Costa E, Courville A, Darcey V, Fletcher LA, Forde CG, Gharib AM, Guo J, Howard R, Joseph PV, McGehee S, Ouwerkerk R, Raisinger K, Rozga I, Stagliano M, Walter M, Walter PJ, Yang S, Zhou M. Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. Cell Metab. 2019 Jul 2;30(1):67-77.e3. doi: 10.1016/j.cmet.2019.05.008. Epub 2019 May 16. Erratum in: Cell Metab. 2019 Jul 2;30(1):226. Erratum in: Cell Metab. 2020 Oct 6;32(4):690. PMID: 31105044; PMCID: PMC7946062.

[21] Lawrence M. Ultraprocessed foods and cardiovascular health: it's not just about the nutrients. Am J Clin Nutr. 2021 Feb 2;113(2):257-258. doi: 10.1093/ajcn/nqaa333. PMID: 33300033.

[22] Santana GJ, Silva NJ, Costa JO, Vásquez CMP, Vila-Nova TMS, Vieira DADS, Pires LV, Fagundes AA, Barbosa KBF. Contribution of minimally processed and ultra-processed foods to the cardiometabolic risk of Brazilian young adults: a cross-sectional study. Nutr Hosp. 2021 Apr 19;38(2):328-336. English. doi: 10.20960/nh.03183. PMID: 33586992.

[23] Downer S, Berkowitz SA, Harlan TS, Olstad DL, Mozaffarian D. Food is medicine: actions to integrate food and nutrition into healthcare. BMJ. 2020 Jun 29;369:m2482. doi: 10.1136/bmj.m2482. PMID: 32601089; PMCID: PMC7322667.

[24] Cediel, G., Reyes, M., Corvalán, C., Levy, R., Uauy, R., & Monteiro, C. (2021). Ultra-processed foods drive to unhealthy diets: Evidence from Chile. Public Health Nutrition, 24(7), 1698-1707. doi:10.1017/S1368980019004737