Nutrition, Metabolism & Cardiovascular Diseases (2022) **32**, 1990–1997

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

Lifestyle improvement reduces the consumption of ultra-processed foods in adults with metabolic syndrome☆

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Received 25 October 2021; received in revised form 18 April 2022; accepted 19 April 2022
Handling Editor: A. Siani
Available online 29 April 2022

KEYWORDS
Eating;
Industrialized food;
Metabolic syndrome;
Adult;
Fast food

Abstract *Background and aims::* The high consumption of ultra-processed products is a concern because it is positively associated with the incidence of chronic non-communicable diseases, as metabolic syndrome (MetS). The aim is to evaluate the effects of three different interventions to modify lifestyle on the consumption of ultra-processed foods in adults with MetS.
Methods and results:: This was a randomized clinical trial, in which the participants were divided into three groups: Standard Intervention (SI), Group Intervention (GI) and Individual Intervention (II). The interventions were carried out over a three-month period and the data was collected in a 24-h food record, taken at the beginning and end of the intervention. The food they ate was classified into four groups according to the degree of processing (unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods) in accordance with the NOVA food classification. Seventy adults took part in the study with a mean age of 51.2 ± 6.6 years old; most of whom were female (55.7%). The amount of ultra-processed food consumed by the three groups (SI, GI and II) was significantly reduced (46%, 34%, and 33%, respectively). The amount of processed food consumed only reduced in the II group. The Total Energy Value (TEV) consumed by the SI and II groups decreased.
Conclusions: The interventions that were intended to alter lifestyles were able to reduce the amount of ultra-processed food consumed, which can have an impact on the prevention and treatment of MetS.
Registration: registered in the Brazilian Registry of Clinical Trials, ReBEC, under number: RBR-9wz5fc.

1. Introduction

Metabolic Syndrome (MetS) is a clinical condition caused by a set of metabolic disorders. MetS can lead to increased risk factors for cardiovascular diseases, as a result of central fat deposition and insulin resistance [1]. An individual must have three of the following five decompensated criteria to be diagnosed with MetS: abdominal circumference (obesity), blood pressure, fasting blood glucose, triglycerides, and cholesterol [2].

☆ This study was financed by the Brazilian government through the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq). It also financed of the edict of Infrastructure of the Pontifical University of Rio Grande do Sul (PUCRS)/PRAIAS.
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https://doi.org/10.1016/j.numecd.2022.04.016

Currently, MetS is considered a worldwide public health issue [3]. It should be mentioned that its prevalence can vary significantly, as each institution may choose different diagnostic criteria. However, this clinical condition has become the greatest health risk in the modern world. It is more common in the urban population [3]. It is estimated that the prevalence of MetS in the United States is 34.2% [4]. In Brazil, the prevalence of MetS is 38.4% [5]. The increase in chronic non-communicable diseases (NCDs) over recent decades was associated with several factors that were the result of changing lifestyles. The most obvious risk factors are eating habits, physical inactivity and stress [6]. In addition to the genetic load, the lifestyle may lead to a greater demand and consumption of ultra-processed food because it is convenient and quicker to prepare. However, these nutritionally-unbalanced foods contain a large amount of sugar, sodium and trans fats [7]. The high consumption of ultra-processed products is concerning because it is positively associated with the incidence of NCDs. Meta-analysis studies have found that eating these increases the risk of being overweight, obese or having a high waist circumference by up to 34%, increases the risk of MetS by 79%, the risk of dyslipidemia by 102%, the risk of cardiovascular disease by up to 34%, and the mortality rate from all causes by 25% [8,9].

Therefore, as adults with MetS mainly eat ultra-processed food, it is essential to use preventive measures and propose a more appropriate diet. It is important to use tools that assess the quality of the food to monitor this. Carlos Augusto Monteiro and his team of researchers created the NOVA food classification [10,11] tool, which divides food into four groups, according to their degree of processing: 1) Unprocessed or Minimally Processed Foods, 2) Processed Culinary Ingredients, 3) Processed Foods and 4) Ultra-processed Foods. The biological, chemical, and physical techniques and methods used to alter the food after it is gathered, until it is consumed, determines the degree of processing. Therefore, NOVA can help to analyze an individuals' food consumption[9].

Although the NOVA classification is accepted worldwide [12–14], few studies have used this classification to assess the quality of food eaten by people/patients with MetS. Indeed, studies that have used the NOVA classification tool in interventions are rare; this is because this classification is still very new. This study is intended to enlarge on the amount of analysis on food consumption based on the degree of food processing and its implications for the health of the population under examination. Therefore, this study aims to evaluate the effect of three different interventions intended to alter lifestyles on the amount of ultra-processed food consumed by adults with MetS.

2. Methods

2.1. Population and sample

The sample studied originated from a secondary database for a principle study entitled "Effect of Lifestyle Modification on the Risk Factors for Heart Disease". This was a randomized clinical trial, in which the participants were recruited from the Rehabilitation Center of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil, in 2012. This convenient sample was recruited for through brief notices in newspapers, on radio, and on websites. The study included adults of both sex, between 30 and 59 years old, diagnosed with MetS, according to the National Cholesterol Education Program Adult Treatment Panel III (NCRPATP III)[2], which is based on the presence of three or more of the following criteria: abdominal circumference (AC) $>$ 88 cm for women and $>$ 102 cm for men; systolic blood pressure (SBP) $\geq$130 mmHg and diastolic blood pressure (DBP) $\geq$ 85 mmHg; fasting blood glucose $\geq$100 mg/dL; triglycerides $\geq$150 mg/dL; and HDL-cholesterol $<$40 mg/dL for men and $<$50 mg/dL for women. Similarly, patients with any of the following criteria were excluded from the study: contraindication for physical activity, pregnancy, severe psychiatric disorder or severe cognitive impairment, based on the Mini Mental State Exam [15](score $<$24), adapted and validated for Brazilian Portuguese.

After identifying the participants who could be included in the study, they were randomly divided into three types of intervention for lifestyle change, by simple randomization 1:1:1. The groups had a similar distribution of general characteristics and no statistically significant differences at the beginning of the study.

2.2. Intervention

The volunteers were allocated to three types of lifestyle intervention. All of the groups were assessed at the beginning and at the end of the interventions (after three months).

2.2.1. Standard Intervention (SI)

This format used treatments that did not involve drugs, in accordance with the recommendation for the clinical management of MetS in the main guidelines. For the purposes of this study, this was called Standard Lifestyle Modification Intervention, and therefore was considered the control group. The participants had two consultations with the nursing team; one for a baseline and the other after three months. At the first meeting, the participants were given instructions on food, looking after themselves and physical exercise [16]. At the second appointment they discussed how easy or difficult it was to follow the changes in lifestyle recommended during the first appointment.

2.2.2. Group Intervention (GI)

This format used group meetings to help motivate them to change their lifestyle, led by a multidisciplinary team of psychologists, nurses, physiotherapists and nutritionists. The meetings were held weekly for 1 h and 45 min. There were a total of 12 meetings (three months). The first 45 min focused on health education. The topics were on the main cardiovascular risk factors associated with MetS that could be changed. The final 60 min of each meeting

were dedicated to encouraging them to change behavior, based on the Transtheoretical Model of Change [17] (TMC), which allows us to understand, measure and intervene in stages to change behavior and to examine the degree of motivation an individual has to make such a change. The groups also discussed strategies to use to change their lifestyle in terms of eating habits and regular exercise and these were tried out, in accordance with the group's motivation.

2.2.3. Individual Intervention (II)

This format consisted of individual consultations, twice a week (once with the nutritionist and once with the psychologist), for three months (a total of 12 meetings with each). The intervention for these participants was based on the intrinsic and extrinsic needs of each, in the form of lifestyle changes through outpatient services. During the consultations with the nutrition team, each participant was given a food plan and instructed to develop a food development goal, relating to something that required changing. The nutritionist also monitored whether they were keeping to the diet plan, their body weight, and whether they were having any issues adjusting to the new routine. Issues relating to MetS were also addressed during these appointments. The weekly consultations with the psychologist were based on the TMC, adapted for individuals. The appointments followed a structured roadmap with pre-defined objectives based on the change processes and the motivation stages specific to the TMC. Finally, they exercised with the support of the physiotherapy team. Consultations took place three times a week, for a total of 36 sessions and lasted 60 min each. The exercise consisted of walking on a treadmill. The intensity of the exercise was adjusted for each participant, in order to reach a target heart rate of between 75% and 85% of the maximum heart rate, as recommended by the I Brazilian Guideline for the Diagnosis and Treatment of MetS [1].Blood pressure and heart rate were monitored during the exercise. The consultations were organized so that the participant had to meet the researchers three times a week. A multidisciplinary intervention, using a motivational approach based on the TMC was applied to Groups GI and II. This is a structure that allows you to understand, measure and intervene in behavioral change [17]. The model assumes that behavioral changes happen throughout a process, by which people go through different levels of motivation to change, which is represented by stages of motivation for change. The stages of change are pre-contemplation, contemplation, preparation, action, and maintenance. The initial sessions were based on the first stages of readiness for change (pre-contemplation and contemplation), while the sessions from the middle to the end of the intervention, covered the later stages of preparation, action and maintenance. All participants were allowed to miss two of the 12 meetings.

2.3. Data collection

The following information was collected during the screening of candidates: anthropometric measurements, blood pressure (BP), and current medication.

Abdominal circumference (AC) was measured with a non-extendible millimetric tape. The abdomen's maximum extension was measured after breathing out normally [18,19].The individuals were barefoot and lightly dressed and their body weight was measured using properly calibrated 160 kg Cauduro® scales. The Sunny® vertical anthropometer was used to measure their height. Their Body Mass Index (BMI) was calculated according to the formula - kilograms (kg) divided by height squared, where weight was measured in kg and height in meters (m^2) [20].

A mercury sphygmomanometer was used to take three consecutive BP measurements. The participants were sitting down and had been resting for 10 min, in accordance with the VI Brazilian Guidelines on Hypertension [21]. We used the mean of the three measurements.

The biochemical tests were performed on blood samples collected by venipuncture after 12-h fasting. Plasma glucose, total cholesterol (TC), serum triglyceride, and serum high-density lipoprotein cholesterol (HDL-C) levels were determined through enzymatic methods, carried out by a fully automated analyzer (VITROS 950 dry-chemistry system; Johnson & Johnson, Rochester, NY).

The sociodemographic data (name, age, ethnicity, education level, marital status), health data, medication, and lifestyle behavior were assessed a week before the interventions. Alcohol consumption was based on the Alcohol Use Disorders Identification Test (AUDIT) tool [22]. Participants who exercised at least once a week were considered physically active, compared with those who did not exercise at all (sedentary).

Individuals who presented at least three of the criteria defined by the revised NCEP ATP III; 2005 [23] were diagnosed with MetS: AC $\geq$102 cm for men and $\geq$88 cm for women (mandatory) [24]; SBP and DBP $\geq$130 and $\geq$ 85 mmHg, respectively, or using antihypertensive drugs; TG $\geq$ 150 mg/dL or using antihypertriglyceridemia drugs; fasting glucose $\geq$100 mg/dL or with a diabetes diagnosis; HDL-C $<$40 mg/dL for men and $<$50 mg/dL for women or receiving pharmacological treatment.

2.4. Dietary assessment

The data was collected through a 24-h recall, on a random day of the week, when the participants joined the study (T0) and after three months of intervention (T1). This tool allowed us to identify the food that the individual had eaten in the previous 24 h, including, for example: brands, preparation methods and quantities. The Multiple Pass Method [25] (MPM), which was developed in 1999 by the United States Department of Agriculture (USDA), was used

to reduce any possible errors when recording the food consumed or any measurement bias.,. This method has five steps for the 24-h recall: 1) quick list, 2) forgotten foods list, 3) list the time and meal, 4) detail cycle and 5) final review. The researchers were trained to use this technique.

The data collected did not include adding salt when preparing the meal or at the table, nor the sodium intake from pure water. The food consumed was converted into grams using the Table for the Assessment of Food Consumption Measures at Home [26]. The quantity, in grams, consumed by the participants was converted into calories using the Brazilian Food Composition Table (TACO) [27], or the label if the food was not included in the TACO.

Afterwards, the items listed in the 24-h recall were classified into one of the four groups in the NOVA food classification, which is based on the degree of food processing prior to consumption. We assessed he quantity in grams and the energy percentage of each food group in relation to the total energy in their diet. NOVA classifies food into four groups according to the degree and purpose of the processing it receives: Group 1: Unprocessed or Minimally Processed Foods; Group 2: Processed Culinary Ingredients; Group3: Processed Foods and Group 4: Ultra-processed Foods. More details on this food classification can be found in the original publication [11].

It is important to note that the NOVA food classification only takes into account industrial processing. Any preparation in kitchens at home is not treated as processing and therefore, it is not necessary to break down the recipes.

2.5. Statistical analysis

The data was listed in an Excel spreadsheet and submitted to double typing. Afterwards, it was analyzed using the Statistical Package for the Social Sciences - SPSS 21.0. The normality of the distribution of the quantitative data was verified using the Kolmogorov–Smirnov test. Data was described through its mean and standard deviation, and its absolute and relative frequency. ANOVA was used to compare the means and Pearson's Chi-square test was used to verify the association between the categorical measures. The Generalized Estimation Equations model was used to compare groups, before and after intervention. The following comparisons were made under the Generalized Estimation Equations model: in each group, the pre- and post-intervention times; in the pre-intervention time, as well as in the post-intervention time, the information from each group; and the interaction of the groups' behavior over time. For all analyses, results with $P < 0.05$ were considered significant. We used Hedge's D test for different samples and Cohen's D test for equal samples [28] to measure the effect size, which was followed by a power analysis of the comparison, in order to examine the statistical differences further. At least 80% was considered a reliable power analysis. These last analyses were performed on GPower [29] software version 3.1.9.7 for Windows (University of Düsseldorf, Düsseldorf, Germany).

2.6. Ethical aspects

After the groups were randomized, the participants were given individually, information on the procedures in the study, through the free and informed consent form, which was specific to each program. These were signed by the participants. In addition, the study was approved by the Ethics Committee of PUCRS under process number 10/05153 and registered in the Brazilian Registry of Clinical Trials (ReBEC), under number: RBR-9wz5fc.

3. Results

A total of 70 adults with a mean age of 51.2 ± 6.6 years were evaluated and most of them were female (55.7%).There were no significant differences in the characteristics of the sample between the SI, GI and II groups (Table 1 and Fig. 1).

After the intervention, the total energy value (TEV) consumed by the members of groups SI and II was reduced ($P < 0.001$) (SI $P < 0.05$; effect size: 3.978, huge effect, 100% of power. II $P < 0.05$; effect size: 3.942, huge effect, 100% of power)., The amount of processed food consumed by group II after the intervention, based on NOVA, was

Table 1 Characteristics of adults with metabolic syndrome (N = 70).

Features	Total sample n = 70	Groups			P
		SI n = 15	GI n = 26	II n = 29	
Age in years (mean ± SD)	51.2 ± 6.6	52.5 ± 6.6	50.0 ± 7.6	51.5 ± 5.7	0.490
Gender N (%)					
Male	31 (44.3)	10 (66.7)	12 (46.2)	9 (31.0)	0.076
Female	39 (55.7)	5 (33.3)	14 (53.8)	20 (69.0)	
Weight (mean ± SD)	93.2 ± 13.7	99.0 ± 13.8	93.1 ± 13.6	90.0 ± 13.1	0.118
Abdominal Circumference (mean ± SD)	111.67 ± 8.0	114.1 ± 9.2	111.9 ± 10.4	110.2 ± 6.9	0.426
Fasting Blood Sugar*	108.1 ± 35.6	120.4 ± 39.7	110.4 ± 45.0	99.4 ± 18.1	0.731
Triglycerides*	196.44 ± 83.6	166.60 ± 65.9	212.1 ± 90.9	198.9 ± 84.0	0.736
HDL*	48.1 ± 12.3	47.8 ± 9.9	47.8 ± 11.0	48.6 ± 14.7	0.863
Systolic Blood Pressure	134.1 ± 15.3	138.5 ± 18.2	131.5 ± 15.2	134.2 ± 13.7	0.776
Diastolic Blood Pressure	90.8 ± 13.3	96.1 ± 16.8	89.5 ± 12.6	89.2 ± 11.4	0,235

P: ANOVA for numerical variables and Chi-square test for categorical variables. Values in mean ± SD or number of patients with characteristics analyzed (%). *Fasting Blood Sugar and *HDL N = 69. *Triglycerides N = 68. SI: Standard Intervention; IG: Group Intervention; II: Individual Intervention.

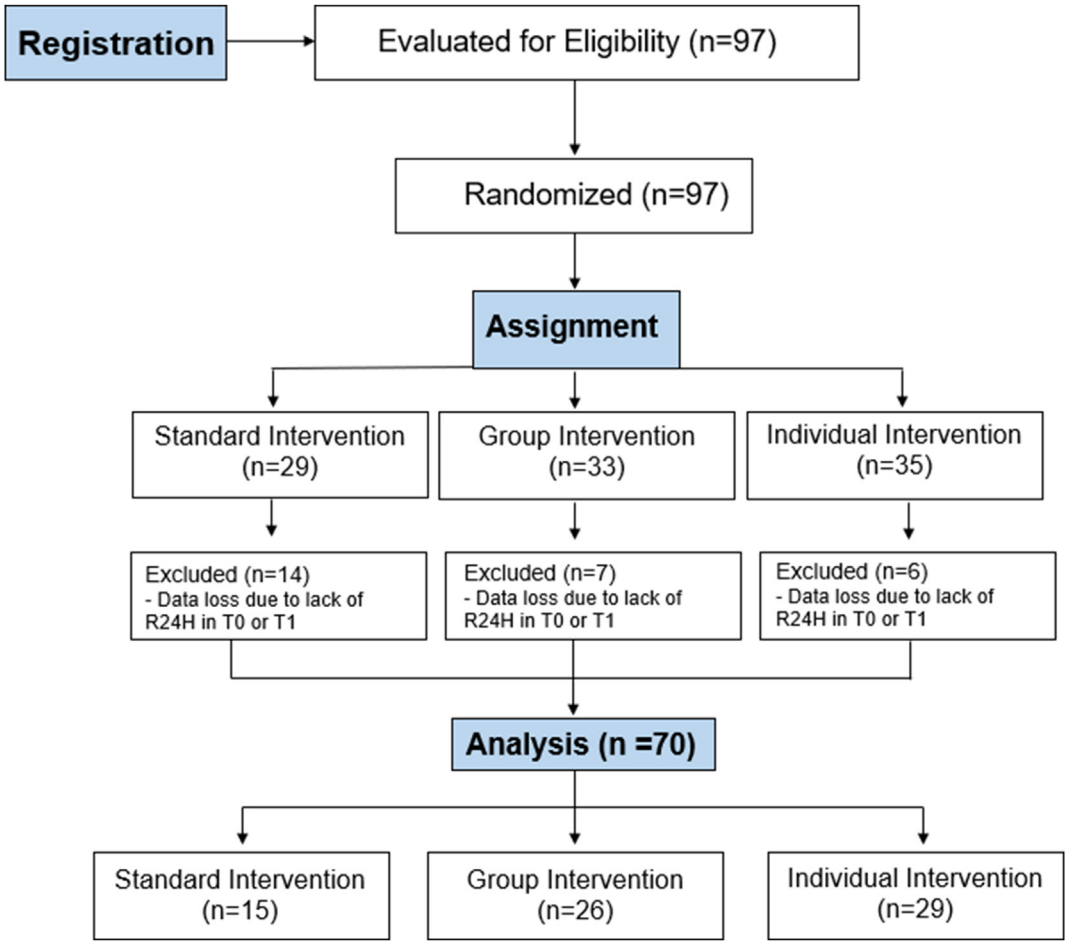

Figure 1 Flowchart of study participants.

reduced ($P = 0.018$) ($P < 0.05$; effect size:3.677, huge effect, 100% of power) and all three groups consumed less ultra-processed food ($P < 0.001$) (SI $P < 0.05$; effect size: 2.989, huge effect, 100% of power. GI $P < 0.05$; effect size: 2.952, huge effect, 100% of power. II $P < 0.05$; effect size: 3.515, huge effect, 100% of power). The amount of ultra-processed food consumed by the SI and the GI groups was statistically different before and after the intervention ($P = 0.011$) (before 668.6 ± 127.7 kcal vs. 1073.7 ± 156.7 kcal and after 361.3 ± 81.1 kcal vs. 705.8 ± 82.6 kcal). There was no significant difference between their consumption of unprocessed or minimally processed foods and processed culinary ingredients before or after the intervention (Table 2).

4. Discussion

The results of this study demonstrate that the three interventions studied had an impact on reducing the amount of ultra-processed food consumed between the set times (before and after the intervention), for each of the groups studied. However, only II was also able to reduce the amount of processed food consumed, based on analyses of this group before and after the intervention.

A systematic review of the effectiveness of using TMC in interventions to change eating habits and encourage exercise, demonstrated that this technique was effective at reducing the amount of fat consumed, increasing the amount of fruit and vegetables eaten and increasing the amount of physical activity [30]. These findings are in line with this study, which saw a decrease in the amount of ultra-processed food consumed and culminated in an improvement in the quality of the diet of those adults with MetS.

As MetS is so common and people with MetS do not adhere to the methods used to control it [31,32], the multidisciplinary intervention, using a motivational approach, as proposed by this study, is innovative. Most importantly, the interventions proposed in this study are recommended as a new approach for treating and preventing NCDs such as obesity, as well as ways to increase the likelihood that patients will adhere to treatment and achieving results that should be sustainable in the long term.

Another important aspect to highlight is that this intervention focuses on the behavior change process, especially on psychological aspects, using them as ways to affect change, rather than prescribing a restrictive diet. In

Table 2 Comparison between the averages of the total energy value and kilocalories of foods classified by NOVA, before and after intervention, in the analyzed groups and the behavior of the groups over time, in adults with metabolic syndrome (N = 70).

NOVA Groups Kilocalories	Groups			P		
	SI N = 15 Mean ± DP	IG N = 26 Mean ± DP	II N = 29 Mean ± DP	Group	Time	Group vs. Time
Total Energy Value of the diet (kcal)						
T0	2092,8[a]±184,5	2257,0 ± 144,2	2418,0[a]±201,1	0.107	<0.001	0.549
T1	1418,9[b] ± 118,1	1852,9 ± 122,6	1813,2[b] ± 93,3			
Unprocessed or minimally processed foods				0,552	0680	0,164
T0	746,9 ± 109,5	654,6 ± 70,8	669,5 ± 88,2			
T1	619,9 ± 59,2	619,4 ± 65,2	777,5 ± 62,8			
Processed culinary ingredients				0,487	0777	0,878
T0	37,1 ± 14,9	58,7 ± 12,8	79,3 ± 28,2			
T1	40,1 ± 14,2	57,6 ± 27,6	57,8 ± 33,8			
Processed foods				0,658	0018	0,075
T0	601,6 ± 99,4	434,3 ± 71,7	692,8[a]±117,0			
T1	477,2 ± 83,8	467,1 ± 72,8	329,5[b] ± 63,5			
Ultra-processed foods				0,011	<0,001	0801
T0	668,6[aA] ± 127,7	1073,7[aB] ± 156,7	939,4[a]±116,8			
T1	361,3[bA] ± 81,1	705,8[bB] ± 82,6	627,0[b] ± 84,7			

P: Model of Generalized Estimates Equations with Post Hoc of Significant Minimum Difference, adjusted for gender.SI: Standard Intervention; IG: Intervention: Group; II: Individual Intervention. Different lower-case letters mean statistically different mean for time analysis Different capital letters mean statistically different mean for group analysis.

addition, we believe that this intervention program can be easily applied in primary healthcare services, through training.

A recent clinical trial on the same population aimed to compare the effects of the three lifestyle change interventions on the number of diagnostic criteria and clinical parameters of MetS. The results showed that the number of diagnostic criteria for MetS decreased significantly within this population. In group II, the percentage of individuals with five criteria decreased by 83.5%[25]. In the SI group, the percentage of individuals with five criteria remained the same, but the number of individuals with four criteria decreased by 50.0% [33]. Although it was not the objective of this study, these results suggest that the proposed interventions, as well as being effective in reducing the amount of ultra-processed food consumed, were also effective in improving the clinical status of these patients.

The purpose of this study covered eating habits and physical activity, which are the main non-pharmacological approaches used to improve those risk factors for cardiovascular disease that can be modified [34]. Therefore, intervention programs that support changes in lifestyle should be encouraged. Furthermore, they can produce added benefits when combined with behavior change and motivation for change techniques, particularly in relation to how well the patient adheres to the proposed intervention [33,35].

A study carried out on adults from the United States [36], who were part of the National Health and Nutrition Examination Survey, showed that those whose diet contained more than 71% ultra-processed food were associated with a 28% prevalence of MetS, compared to an intake of under 40%. These findings suggest that eating more ultra-processed food is associated with developing NCDs, which can be the result of inadequate nutrition. In this study, the SI, GI and II groups reduced their consumption of ultra-processed food by 46%, 34% and 33%, respectively (Table 3). Therefore, one would expect that this decrease would have a positive impact on the participant's health. It is important to mention that another study into the lifestyle changes to prevent MetS in the same participants, carried out by the same research group [37], showed significant results for the Castelli Index I, which is a score for identifying cardiovascular risk.

Another study on [38] the participants of the Canadian Community Health Survey, found that the consumption of ultra-processed foods, represented a total of 48% of the TEV, in the Canadian diet. All socioeconomic groups consumed a high amount of this group of foods. In

Table 3 Ultra-processed consumption (in Kcal) in adults with MetS before and after the intervention.

Groups	Before Intervention (Kcal)	After intervention (Kcal)	Absolute value of the consumption difference (Kcal)	Percentage Variance (%)
SI (n = 15)	668.6 ± 127.7	361.3 ± 81.1	307.3	45.96%
GI (n = 26)	1073.7 ± 156.7	705.8 ± 82.6	367.9	34.26%
II (n = 29)	939.4 ± 116.8	627.0 ± 84.7	312.4	33.25%

SI: Standard Intervention; GI: Group Intervention; II: Individual Intervention.

addition, they also found a positive relationship between consuming ultra-processed foods and the intake of carbohydrates, free sugars, total and saturated fats and energy density, while an inverse relationship was observed with the content of protein, fiber, vitamins and mineral salts in the diet.

In regard to the food consumption data of the Brazilian population, a study [39] examined data from the Household Budget Survey (HBS) from 2008 to 2009, which was designed to analyze the relationship between the availability of processed and ultra-processed products in a household and the prevalence of residents being overweight or obese in Brazil. It showed that the availability of ultra-processed products in a home was positively associated with the average Body Mass Index (BMI) and the prevalence of overweight or obese residents, while processed products were not associated with these results. In this study, the consumption of ultra-processed food in relation to TEV reduced from 32%, 47.6% and 38.9%–25.5%, 38% and 34.5%, respectively, in the SI, GI and II groups.

Furthermore, another study involving the Brazilian population [40] showed that ultra-processed foods are frequently consumed by the adult Brazilian population in the 27 state capitals. These foods were consumed more by those who were, independently, male, younger, and had less than a college education. Another study [41] also showed that those who consume more ultra-processed food, also do not eat enough fiber.

In addition, another result from this study was that the TEV decreased significantly in the members of the SI and II groups. In the SI group it reduced by 32.2% (673.9 kcal) while in group II it reduced by 26% (604.9 kcal). The amount of processed food only reduced in Group II, 52.4% (363.3.3 kcal). Taken together, these results suggest that the quality of food the studied population were eating after the proposed intervention improved. Although the amount of ultra-processed food being consumed by all groups significantly decreased, the intake of unprocessed foods did not change, which also means that the participants did not eat more of these foods. This finding suggests that new interventions to encourage people to eat foods from Group 1of the NOVA food classification.

Among the limitations of this study are, most particularly, the difficulty in quantifying food intake accurately, due to the use of food records, tables of the nutritional composition of foods and underestimating food consumption. In addition, as the 24-h recall was only used at the beginning of the intervention and the end, it does not indicate what the participant's usual diet would be. However, the data was collected using the MPM [25] technique, in order to minimize possible measurement bias. Another limitation is in relation to preparing food, which are scored in the unprocessed foods group. Therefore, when some ultra-processed ingredients are included during preparation the amount of ultra-processed food consumed could be underestimated, for example.

Overall, an important factor has been the use of the NOVA food classification as a tool to assess the food consumption and the nutritional quality of diets. The NOVA classification also makes it possible to developing an approach around food education, in order to encourage healthy eating habits.

5. Conclusion

The results of this study demonstrate that all the proposed interventions were effective in reducing the amount of ultra-processed food consumed, which suggests that they improved the quality of the diets of those in the population studied. Furthermore, the TEV in groups SI and II was reduced, but the amount of ultra-processed food consumed, the TEV, and the amount of processed food consumed was only all reduced in the II Group. Therefore, these findings may indicate that an intervention using a motivational approach, conducted by an interdisciplinary team, could be a successful alternative in treating MetS.

Author contributions

Marthina Streda Walker and Francine Specht Tarasiuk contributed to the concept, the methodology, the formal analysis, the investigation, the data curation and the original drafting, reviewing and editing. Andreia da Silva Gustavo, Margareth da Silva Oliveira, Márcio Vinícius Fagundes Donadio contributed to the concept, the methodology and the reviews. Ana Maria Pandolfo Feoli was involved in all stages of preparing the manuscript.

Declaration of competing interest

The authors state that there are no conflicts of interest in this work.

Acknowledgments

This study was financed by the Brazilian government through the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). They also financed the edict of infrastructure of the Pontifical University of Rio Grande do Sul (PUCRS)/PRAIAS.

References

[1] Brasileira Sociedade, Cardiologia de. I diretriz brasileira de diagnóstico E tratamento da síndrome metabólica. Arq Bras Cardiol 2005.
[2] Lorenzo C, Williams K, Hunt KJ, Haffner SM. The national cholesterol education program-adult treatment Panel III, international diabetes federation, and world health organization definitions of the metabolic syndrome as predictors of incident cardiovascular disease and diabetes. Diabetes Care 2007. https://doi.org/10.2337/dc06-1414.
[3] Saklayen MG. The global epidemic of the metabolic syndrome. Curr Hypertens Rep 2018. https://doi.org/10.1007/s11906-018-0812-z.
[4] Moore JX, Chaudhary N, Akinyemiju T. Metabolic syndrome prevalence by race/ethnicity and sex in the United States, national health and nutrition examination Survey, 1988–2012. Prev Chronic Dis 2017;14:160287. https://doi.org/10.5888/pcd14.160287.

[5] Oliveira LVA, dos Santos BNS, Machado ÍE, Malta DC, Velasquez-Melendez G, Felisbino-Mendes MS. Prevalence of the metabolic syndrome and its components in the Brazilian adult population. Ciência Saúde Coletiva 2020;25:4269–80. https://doi.org/10.1590/1413-812320202511.31202020.
[6] Organization WH (WHO). Obesity and overweight. 2018. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
[7] Monteiro C, Cannon G, Levy R, Moubarac J-C, Lc Louzada M, Rauber F, et al. Ultra-processed foods: what they are and how to identify them. 2019. https://doi.org/10.1017/S1368980018003762.
[8] Pagliai G, Dinu M, Madarena MP, Bonaccio M, Iacoviello L, Sofi F. Consumption of ultra-processed foods and health status: a systematic review and meta-analysis. Br J Nutr 2020. https://doi.org/10.1017/S0007114520002688.
[9] Askari M, Heshmati J, Shahinfar H, Tripathi N, Daneshzad E. Ultra-processed food and the risk of overweight and obesity: a systematic review and meta-analysis of observational studies. Int J Obes 2020. https://doi.org/10.1038/s41366-020-00650-z.
[10] Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada MLC, Jaime PC. The un Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Publ Health Nutr 2018. https://doi.org/10.1017/S1368980017000234.
[11] Monteiro CA, Cannon G, Levy R, Moubarac J-C, Jaime P, Martins AP, et al. NOVA. The star shines bright. World Nutrition; 2016.
[12] Steele EM, Baraldi LG, Da Costa Louzada ML, Moubarac JC, Mozaffarian D, Monteiro CA. Ultra-processed foods and added sugars in the US diet: evidence from a nationally representative cross-sectional study. BMJ Open 2016. https://doi.org/10.1136/bmjopen-2015-009892.
[13] Moubarac JC, Batal M, Martins APB, Claro R, Levy RB, Cannon G, et al. Processed and ultra-processed food products: consumption trends in Canada from 1938 to 2011. Can J Diet Pract Res 2014. https://doi.org/10.3148/75.1.2014.15.
[14] Moreira PVL, Baraldi LG, Moubarac J-C, Monteiro CA, Newton A, Capewell S, et al. Comparing different policy scenarios to reduce the consumption of ultra-processed foods in UK: impact on cardiovascular disease mortality using a modelling approach. PLoS One 2015;10:e0118353. https://doi.org/10.1371/journal.pone.0118353.
[15] Folstein M, Folstein S. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975.
[16] Amine EK, Baba NH, Belhadj M, Deurenberg-Yap M, Djazayery A, Forrestre T, et al. Diet, nutrition and the prevention of chronic diseases. World Health Organization - Technical Report Series; 2003. https://doi.org/10.1093/ajcn/60.4.644a.
[17] Velasquez MM, Crouch C, Stephens NS, DiClemente CC. Group treatment for substance abuse: a stages-of-change therapy manual. 2016.
[18] Timothy G Lohman, Alex F Roche, Reynaldo Martorell. Anthropometric standardization reference manual. [n.d].
[19] Marfell-Jones M, Olds TSA. International standards for anthropometric assessment. North-West University. South Africa: International Society for the Advancement of Kinanthropometry. School of Biokinetics, Recreation and Sport; 2006.
[20] Garrow JS, Webster J. Quetelet's index (W/H2) as a measure of fatness. Int J Obes 1985;9:147–53.
[21] Weber MA, Schiffrin EL, White WB, Mann S, Lindholm LH, Kenerson JG, et al. Clinical practice Guidelines for the management of hypertension in the community. J Clin Hypertens 2014;16:14–26. https://doi.org/10.1111/jch.12237.
[22] Babor TF, Higgins-Biddle J, Saunders JB. AUDIT: the Alcohol use disorders identification test: Guidelines for use in primary health care [n.d].
[23] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome. Circulation 2005;112:2735–52. https://doi.org/10.1161/CIRCULATIONAHA.105.169404.
[24] Kadakia MB, Fox CS, Scirica BM, Murphy SA, Bonaca MP, Morrow DA. Central obesity and cardiovascular outcomes in patients with acute coronary syndrome: observations from the MERLIN-TIMI 36 trial. Heart 2011;97:1782–7. https://doi.org/10.1136/heartjnl-2011-300231.
[25] Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler WV, et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. Am J Clin Nutr 2008;88:324–32. https://doi.org/10.1093/ajcn/88.2.324.
[26] Abv P. Tabela para Avaliação de Consumo Alimentar em Medidas Caseiras. Atheneu 2004.
[27] Universidade Estadual de Campinas. Tabela brasileira de composição de alimentos-TACO. 2011.
[28] Wassertheil S, Cohen J. Statistical power analysis for the behavioral sciences. Biometrics 2006;26:588. https://doi.org/10.2307/2529115.
[29] Faul F, Erdfelder E, Lang A-G, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175–91. https://doi.org/10.3758/BF03193146.
[30] De Menezes MC, Bedeschi LB, Dos Santos LC, Lopes ACS. Interventions directed at eating habits and physical activity using the transtheoretical model: a systematic review. Nutr Hosp 2016. https://doi.org/10.20960/nh.586.
[31] Miller BML, Brennan L. Measuring and reporting attrition from obesity treatment programs: a call to action! Obes Res Clin Pract 2015. https://doi.org/10.1016/j.orcp.2014.08.007.
[32] Burgess E, Hassmén P, Pumpa KL. Determinants of adherence to lifestyle intervention in adults with obesity: a systematic review. Clinical Obesity 2017. https://doi.org/10.1111/cob.12183.
[33] Piovesan CH, Gustavo A, Macagnan FE, Saboya PP, Oliveira M da S, Bodanese LC, et al. The effect of different interventions for lifestyle modifications on the number of diagnostic criteria and clinical aspects of metabolic syndrome. Metab Syndr Relat Disord 2020. https://doi.org/10.1089/met.2019.0132. met.2019.0132.
[34] Lin Y-H, Chu L-L, Kao C-C, Chen T-B, Lee I, Li H-C. The effects of a diet and exercise program for older adults with metabolic syndrome. J Nurs Res 2015;23:197–205. https://doi.org/10.1097/jnr.0000000000000078.
[35] Tran VD, James AP, Lee AH, Jancey J, Howat PA, Thi Phuong Mai L. Effectiveness of a community-based physical activity and nutrition behavior intervention on features of the metabolic syndrome: a cluster-randomized controlled trial. Metab Syndr Relat Disord 2017. https://doi.org/10.1089/met.2016.0113.
[36] Martínez Steele E, Juul F, Neri D, Rauber F, Monteiro CA. Dietary share of ultra-processed foods and metabolic syndrome in the US adult population. Prev Med 2019. https://doi.org/10.1016/j.ypmed.2019.05.004.
[37] Feoli AMP, Ribeiro ÉCT, Piovesan CH, Macagnan FE, Oliveira M, Gustavo A da S. MELHORA do estilo de vida reduz O índice de castelli 1 em indivíduos com síndrome metabólica. Saúde e Pesquisa 2018;11:467. https://doi.org/10.17765/1983–1870.2018v11n3p467-474.
[38] Moubarac J-C, Batal M, Louzada ML, Martinez Steele E, Monteiro CA. Consumption of ultra-processed foods predicts diet quality in Canada. Appetite 2017;108:512–20. https://doi.org/10.1016/j.appet.2016.11.006.
[39] Canella DS, Levy RB, Martins APB, Claro RM, Moubarac J-C, Baraldi LG, et al. Ultra-processed food products and obesity in Brazilian households (2008–2009). PLoS One 2014;9:e92752. https://doi.org/10.1371/journal.pone.0092752.
[40] Costa C dos S, Sattamini IF, Steele EM, Louzada ML da C, Claro RM, Monteiro CA. Consumo de alimentos ultraprocessados e associação com fatores sociodemográficos na população adulta das 27 capitais brasileiras (2019). Rev Saude Publica 2021;55:47. https://doi.org/10.11606/s1518-8787.2021055002833.
[41] Cruz GL da, Machado PP, Andrade GC, Louzada ML da C. Alimentos ultraprocessados e o consumo de fibras alimentares no Brasil. Ciência Saúde Coletiva 2021;26:4153–61. https://doi.org/10.1590/1413-81232021269.15462020.