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Intervention based on Transtheoretical Model promotes anthropometric and nutritional improvements — A randomized controlled trial

Mariana Carvalho de Menezes [a], Sueli Aparecida Mingoti [b], Clareci Silva Cardoso [c], Raquel de Deus Mendonça [a], Aline Cristine Souza Lopes [d,*]

[a] Postgraduate Program in Nursing, Universidade Federal de Minas Gerais, Research Group in Nutrition Interventions of University of Minas Gerais, 190 Alfredo Balena, Santa Efigênia, Belo Horizonte, MG 30190-100, Brazil
[b] Department of Statistics, Universidade Federal de Minas Gerais, 6627 Antônio Carlos ave. Campus Pampulha, Belo Horizonte, MG 30161-970, Brazil
[c] Department of Medicine, Universidade de São João Del Rei, Research Group in Epidemiology and Evaluation of New Technologies in Health, 400 Sebastião Gonçalves Coelho ave. Chanadour, Divinópolis, MG 35501-296, Brazil
[d] Department of Nutrition, Universidade Federal de Minas Gerais, Research Group in Nutrition Interventions of University of Minas Gerais, Brazil

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ABSTRACT

Objective: To analyze the effects of an intervention based on the Transtheoretical Model on anthropometric and dietetic profile among women in the Primary Health Care in Brazil.
Design and methods: Randomized controlled trial. The control group participated in physical activity and open group-education regarding nutrition of usual care. The intervention group participated in 10 workshops based on the Transtheoretical Model.
Results: Seventy-one women completed the study, with a mean age of 57.9 ± 11.7 years. Participants in the intervention group showed an improved body perception, reduced weight and body mass index post-intervention, and lower consumption of calories and foods high in fat. Significant weight reduction in the intervention group was associated with higher per capita income, reduced consumption of protein, reduced consumption of lipids, and the removal of visible fat from red meat and skin from chicken.
Conclusion: An intervention based on the Transtheoretical Model promoted reduction in consumption of foods high in calories and fat, with positive effects on weight and body perception. These results provide evidence of the applicability and benefit of the Transtheoretical Model within primary care.

What is already known about this subject?

- The scientific community has presented numerous nutritional interventions designed to promote healthy dietary practices. Although widely disseminated, individuals worldwide continue to lead unhealthy lifestyles, and obesity is becoming more prevalent.
- Traditional interventions do not account for an individual's attitudes and perceptions regarding nutrition, and they assume that the individual is ready to change his/her eating behavior.
- The Transtheoretical Model (TTM) facilitates greater understanding of an individual's behavior, which allows the development of interventions tailored to his/her readiness to change. TTM-based interventions have demonstrated positive impacts on populations exhibiting a variety of risky eating behaviors.

What this study adds?

- This is a pioneering study on the effects of TTM-based interventions on dietary fat consumption in Brazil. Application of TTM to date has been limited to developed countries, such as the United States, Canada, and England. It is important to test the model in other countries to replicate and validate findings.
- Intervention development based on the TTM within a Primary Health Care with universal access provides evidence of the applicability and effectiveness of TTM in different cultures and environments.
- A robust study methodology was employed to overcome gaps identified by the scientific community. Strengths of the study include a randomized clinical trial design, intervention development guided by the four pillars of TTM (stage of change, decisional balance, self-efficacy and processes of change), and use of a validated algorithm.

* Corresponding author at: 190 Alfredo Balena, Escola de Enfermagem, Santa Efigênia, Belo Horizonte, MG 30190-100, Brazil. Tel.: +55 31 3409 9179; fax: +55 31 3409 9860.
E-mail addresses: marysnut@gmail.com (M.C. Menezes), suelimngt@gmail.com (S.A. Mingoti), clarecicardoso@yahoo.com.br (C.S. Cardoso), alinelopesenf@gmail.com (A.C.S. Lopes).

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1. Introduction

According to the World Health Organization, unhealthy lifestyles, particularly suboptimal dietary habits, are a major factor in the increase in noncommunicable diseases (NCDs) (World Health Organization, 2011). Consumption of high-fat foods is problematic because these foods have high caloric density, promote less satiety than isocaloric portions of high carbohydrate or high protein food, and have pleasant taste and flavor that contribute to excessive consumption (Riccardi, Giacco, & Rivellese, 2004). Advances in nutritional science currently demonstrate that it is essential to consider the types of fats and dietary patterns consumed, not the proportion of calories from fat when the replacement nutrient is not specified (Willett, 2011). Excessive consumption of saturated and trans fat can contribute to weight gain, dyslipidemia and insulin resistance (World Health Organization, 2011). With this in mind, the scientific community has developed nutritional interventions aimed at reducing consumption of atherogenic foods and improving the quality of the diet. Despite these efforts, it is known that the majority of people worldwide have lifestyles incompatible with dietary recommendations (World Health Organization, 2011).

It is challenging to achieve changes in eating behavior among individuals and populations in our current obesogenic environment. There is heightened interest among the international research community in the use of theories and theoretical models (especially the Transtheoretical Model [TTM]) to better understand feeding behavior (Prochaska, Norcross, & Di Clemente, 2013). The TTM enables the development of differentiated interventions according to perception and motivation of individuals to make changes. The TTM has demonstrated positive impacts on populations with different risk behaviors related to NCDs (Prochaska et al., 2005), including strong evidence of reduced fat intake in short and long-term follow-up, showing results as reduction in calorie and fat intake, weight, waist circumference, serum concentrations of lipids, cholesterol and blood pressure of individuals (Elmer et al., 2006; Hoy et al., 2009; Van Sluijs, Van Poppel, & Van Mechelen, 2004). However, a review study showed that there is little evidence about the sustainable in weight loss, but that the TTM combined with nutritional and physical activity interventions can promote better changes in eating habits and physical activity. It highlights the need for randomized controlled trials and the proper use of TTM as a theoretical framework for intervention (Tuah et al., 2011).

Despite the promising nature of TTM and the positive results already verified, the studies are usually carried out in developed countries, for middle and high income populations. There is a lack of studies using the model within a population of low socioeconomic status and under real conditions such as public health services, particularly in primary care (Garrett, 2008). Thus, the purpose of this study was to analyze the effects of an intervention based on the TTM on anthropometric and dietetic status among women participating in a Primary Health Care in the context of the Brazilian national healthcare system.

2. Material and methods

2.1. Study site

The study was conducted in the *Academia da Saúde* Program. This program is integrated into the Primary Health Care of the national healthcare system that offers at no charge regular physical activity, nutritional counseling and healthy lifestyles to Brazilian community members. The supervised physical exercises included collective aerobic and anaerobic exercises, with a frequency of three times a week and 60 min per session. The service studied operates only in the morning and it is located in the city of Belo Horizonte, capital of Minas Gerais, which is the sixth most populous city in Brazil with 2,479,165 inhabitants (Instituto Brasileiro de Geografia e Estatística, 2013).

2.2. Study design and subjects

This randomized controlled trial was performed in two phases. In the first phase, the algorithm proposed by Greene & Rossi (1998) was validated. The individual's stage of change is identified by applying this algorithm that refers to a specific questionnaire based on the individual's perception and the assessment of fat consumption (Greene & Rossi, 1998).

In the second phase, group interventions were developed and implemented based on participant readiness to change consumption of fats.

The study was conducted on a sample of service users aged 20 years and over. Individuals were considered eligible for the study if they (A) had not participated in any previous nutritional intervention that addressed consumption of fats and (B) were regularly attending the collective exercise sessions of the service — 80.0% of attendance. The required sample size was calculated using the normal bilateral z-test to compare proportions of two independent groups (Lemeshow, Hosmer, Klar, & Lwanga, 1990) with 80% power to detect a 15% difference between groups (assuming 53% attrition due to high turnover of users in the service) at the 5% significance level. Of the 336 eligible individuals, 168 were randomly selected for the intervention study assuming that all 168 would take part in the first phase, i.e., algorithm validation. The algorithm validation phase and subsequent attrition are described in greater detail in Moreira, Santos, Menezes, & Lopes (2014) and Siqueira (2012), respectively. Loss of subjects from the study sample occurred due to the following reasons: participant refusals, disease, family problems, absence from service activities, and incomplete data (e.g., three complete 24-h dietary recalls [24DR]) (Fig. 1).

At the start of the intervention phase, 118 participants remained in the study; they were randomly assigned to a control group (CG) and an intervention group (IG) using a random number table. The researchers were blinded to the group assignment. Ninety-seven subjects completed the baseline questionnaire and initiated group activities (CG: 38, IG: 59) (Fig. 1). The uneven distribution between groups was to allow for higher attrition anticipated in the IG compared to the CG as occurred in previous studies (Johnson et al., 2008; Prochaska et al., 2005).

The Ethics Committee of the University of Minas Gerais and the City Hall of Belo Horizonte approved the study proposal, and a signed informed consent was obtained from all participants.

2.3. Measures

Data were collected in three phases: (1) assessment questionnaire, including the first 24DR; (2) subsequent anthropometric measurements and the second 24DR; and (3) the last of the three 24DRs. These data were again collected at post-intervention.

Food consumption was assessed using the three 24DRs and supplementary questions about eating habits related to fat. To enhance the accuracy and reliability of study participants' self-reported dietary recall, 24DRs were completed on alternate days including the weekend (Willett, 2013). The nutritional adequacy of subjects' diets was assessed in comparison with dietary recommendations by the Institute of Medicine (2006) and World Health Organization (2008).

Additional supplementary questions about eating habits addressed: methods of food preparation, including removal of visible fat from red meat and skin from chicken; types of vegetable oil and milk consumed; and consumption of fish and high-fat foods (Willett, 2013).

Readiness to change consumption of fats was verified by applying the algorithm proposed by Greene & Rossi (1998), and validated in Brazil by Moreira et al. (2014). A three-step process was used to determine an individual's stage of change (SOC). An initial classification was made based on each individual's perception of fat intake. For those classified as being in the action or maintenance stage, their average dietary fat intake entered in the three 24DRs was evaluated. Finally, if an individual's self-perception did not agree with their DR data (failed

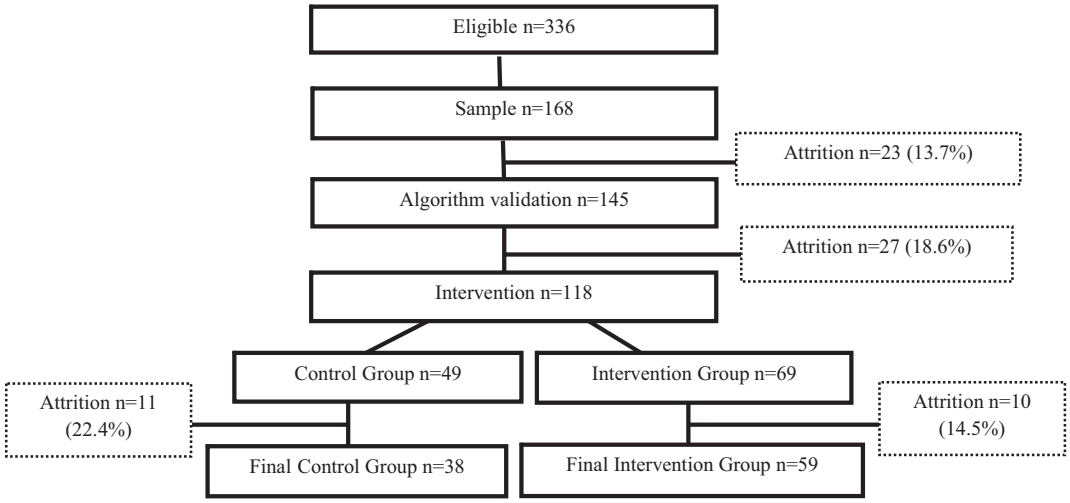

Fig. 1. Participant flow.

to meet the criterion of adequate fat intake ≤30%), then a new self-assessment was performed of readiness to change eating behavior.

Weight, body mass index (BMI = weight [kg]/height $[m]^2$) and waist circumference (WC) were measured pre- and post-intervention to detect changes in body composition. BMI data were interpreted based on recommendations by the World Health Organization (1995) and the Nutrition Screening Initiative (1992) for adults and seniors, respectively. WC data were interpreted based on WHO recommendations (World Health Organization, 2008).

All data were collected face-to-face by dietitians trained periodically.

2.4. Intervention planning

2.4.1. Control group (CG)

Individuals assigned to the CG maintained routine activities in the service that included aerobic and anaerobic exercise (3 exercise periods of 60 min each per week), open group-education regarding nutrition, and individual nutritional care for specific cases. The nutritional education groups occurred monthly on topics of interest to users and related to health promotion, prevention, and control of NCDs. During the study, dietary consumption of fats was not discussed during group education and the attendance of the participants was registered in all groups described. Individual attention (conducted in the *Academia da Saúde* Program) was provided only to overweight individuals with stabilized diseases. Individual attention aimed for prevention and health promotion. It consisted only of nutritional counseling, particularly focusing on positive reinforcement of the groups. Moreover, cases of greater disease severity were referred to the primary healthcare referral center for nutritional follow-up, due to risk of health complications. It is worth to emphasize that the Academia da Saúde program is integrated into the national healthcare system. All nutritional interventions in control group were conducted by dietitians for primary care.

2.4.2. Intervention group (IG)

In addition to the routine activities described above for the CG, specific interventions were implemented for the following 2 groups: (a) pre-action group (SOC: precontemplation, contemplation and preparation) and (b) action group (SOC: action and maintenance) (Siqueira, 2012). It should be noticed that, in the first workshop, the participants were told if they were in the pre-action or action stage of change, according to TTM.

SOC-specific interventions addressed the participants' nutritional and health needs guided by the four pillars of TTM: SOC, decisional balance, self-efficacy and processes of change. Based on a participatory teaching model, the intervention went beyond passive education to include challenging participant beliefs and attitudes regarding desired behavior changes (Siqueira, 2012). Rather than just providing nutrition education, each intervention group (pre-action and action) received a series of workshops that used play materials to facilitate autonomous decision-making and proactive problem-solving to overcome obstacles or barriers to change.

The interventions lasted for 6 months and consisted of 20 workshops, 10 for the pre-action group and 10 for those in the action group. Each 70-min workshop was limited to a maximum of 15 participants. A total of 54 meetings were held in order to ensure that users had access.

Individuals in the pre-action group were coached on cognitive and experiential processes of change; individuals in the action group were coached on behavioral processes of change. Interventions for both SOC groups aimed to (1) increase participants' confidence in their ability to overcome obstacles (self-efficacy) and achieve desired changes, and (2) increase awareness of the benefits of a healthy diet while minimizing/overcoming costs of (barriers to) the desired behavior change (decisional balance).

The pre-action group visualized success, reflected about their barriers and explored vicarious experiences/role modeling to increase self-confidence and readiness to change. Individuals in the action group, on the other hand, were given the opportunity to experiment with food preparation and new, healthy recipes. The group meetings also explored subjective matters, encouraging participants to express their values, feelings, experiences, and hedonic relationship with food (Siqueira, 2012). All nutritional interventions in intervention group were conducted by a multidisciplinary team that included dietitians and psychologists well versed in the TTM.

2.5. Statistical analysis

Demographic variables and self-reported morbidity were used to characterize the sample, while anthropometric measurements, body perception and satisfaction, food consumption, and SOC were use as indicators of participant progress. A descriptive analysis was performed, including the statistical test of Shapiro–Wilk to assess normality of the quantitative variables. The data were presented as mean and standard deviation for normally distributed variables, and as median and interquartile range (P25–P75) for not normally distributed variables.

Statistical tests for intergroup (Pearson's chi-square, Fisher's exact, Student *t* for independent samples, and Mann–Whitney) and

intragroup (McNemar, paired Student *t*, and Wilcoxon signaled posts) comparisons were performed.

Multiple linear regression was performed to identify independent variables that were associated with weight reduction observed in the IG. The outcome variable was the delta percentage of weight reduction:

$$([\textit{preintervention weight} - \textit{postintervention weight}]/\textit{preintervention weight}) * 100.$$

Multivariate analysis was performed by blocks of data (sociodemographic, health, food intake, anthropometry, and TTM). The backward method was used to build the model based on biological plausibility and a p value of ≤0.25 in the univariate analysis. All model assumptions were inspected and no violations were identified. Quality of the model fit was assessed by the significance of model parameters and analysis of residues. No violations were detected regarding the assumptions. The p value for all tests was 0.05. The adjusted determination coefficient was 64.2%.

3. Results

Of the 97 subjects in the study sample at the beginning of the intervention phase, 77 (79.4%) completed the study, with 34 subjects in the CG and 43 in the IG. Individuals were excluded from the analysis if they were unavailable for assessment due to being absent from the service (n = 8). In addition, 6 male subjects were excluded in order to obtain a homogeneous sample. Thus, the final analysis included 71 subjects, with 31 being in the CG and 40 in the IG.

IG participants were excluded if they attended less than 50% of workshops offered (n = 12) (World Health Organization, 2003). Including pre-action and action group interventions, the participants attended 8.1 (7.0–9.0) workshops. Pre-action participants attended 7.7 (6.2–8.4) workshops and action participants attended 8.7 (7.4–9.4) workshops (p > 0.05). The main reasons reported for absences in the workshops were illness (17.2%) or family member illness (8.7%), travel (7.0%), forgetfulness (7.0%), to have to work (4.6%) and other commitments as medical appointment, need to take care of grandson and personal problems.

Women who discontinued the study were younger and more likely to be under psychiatric care than women in the final study sample (48.6 ± 9.5 vs. 57.9 ± 11.7 with p = 0.003, and 52.9% vs. 19.7% with p = 0.011, respectively). There were no differences related to food consumption, SOC, anthropometry, or sociodemographic and health conditions.

As shown in Table 1, the majority of the 71 participants at baseline had low education and income per capita. The majority of women had excessive weight (including overweight and obesity status — CG: 58.1%; IG: 70.0%; p = 0.743). Among the characteristics evaluated, the only significant difference between the CG and IG was greater cholesterol intake among women in the IG. Finally, member participation in group education that occurred on the primary care service did not differ significantly between groups (CG: 1.7 ± 2.0 groups, IG: 2.1 ± 1.8 groups, p = 0.342). Regarding individual attention, just 2 individuals from CG and 2 individuals from IG were treated in the primary healthcare referral center for nutritional follow-up (CG: 6.5%; IG: 5.0%; p = 0.618).

At the end of the 6-month intervention period, women in the IG reported less frequent consumption of foods rich in fat (e.g., fried food, fried snacks, burgers, and others) and lower calorie consumption pre-intervention self-reported values (see Table 2). The mean difference of caloric reduction from pre-intervention to post-intervention was 215.6 kcal (95% CI: 95.0–373.0, p = 0.001).

Significant reductions in weight (−0.96 ± 2.45 kg) and BMI (−0.44 ± 1.06 kg/m^2) were achieved by IG participants over the 6-month intervention period as compared to pre-intervention measurements, and body perception likely improved as a result. The mean percentage of weight change was 1.37 ± 3.38%. In the control group there was no significant difference regarding weight, BMI and body perception (see Table 3).

Given these results, we carried out a post-hoc multiple linear regression analysis in order to identify the factors associated with weight reduction among IG women. The variables that remained significantly associated with weight reduction were family income, protein intake (percentage of daily caloric intake), appropriate dietary fat consumption (≤30% of daily caloric intake) and removing visible fat from red meat and skin from chicken (see Table 4). The assumptions for the model were carefully inspected.

4. Discussion

A 6-month TTM-based intervention among women in the Primary Health Care showed to be a strategy that may allow anthropometric and nutritional improvements. The results showed reduction of caloric intake, consumption of foods high in fat, body weight, and BMI, as well as an improvement in body perception. Participants in the CG did not show any changes.

Our findings are consistent with other studies that have reported positive effects of TTM-based interventions on caloric intake, consumption of foods high in fat, weight and BMI (Elmer et al., 2006; Johnson et al., 2008; Nasser, Cook, Dorsch, & Haennel, 2006; Raberg Kjollesdal, Hjellset, Bjørge, Holmboe-Ottesen, & Wandel, 2011). It is noteworthy that the median reduction of 215.6 kcal calories was similar to other studies (Elmer et al., 2006; Nasser et al., 2006). The effectiveness of TTM demonstrated in this and other studies is important and timely because we need an effective intervention to combat the increasing consumption of high-fat foods (World Health Organization, 2011).

The weight changes ranged from 1.0 to 6.5 kg and are consistent with other studies (Johnson et al., 2008; Nasser et al., 2006; Raberg Kjollesdal et al., 2011). The weight reduction is important since this was not the primary target of intervention. Moreover, the weight reduction identified is a relevant result considering that weight maintenance is already a challenge in our current obesogenic environment. Every day individuals are surrounded and affected by stimuli that encourage unhealthy lifestyles (i.e., excess consumption of calories and lipids) while discouraging energy expenditure (Chaput, Klingenberg, Astrup, & Sjödin, 2011).

However, a review study showed that there is little evidence about sustainable weight loss in TTM-interventions. On the other hand, TTM combined with nutrition and physical activity interventions tends to produce better health outcomes (Tuah et al., 2011). With this in mind, government programs as *Academia da Saúde* (that offers at no charge physical activity and nutritional counseling) should be prioritized to help population to promote consistent changes in eating habits and physical activity.

Given the weight loss observed in our IG, our study investigated which variables better explained these results. Investigation of factors involved in nutritional status allows for the identification of vulnerable individuals or groups that may be assisted by policies and programs. This study shows that the significant weight loss was associated with higher per capita income, a reduction in protein intake, reduced consumption of lipids (to ≤30% of daily caloric intake), and removing visible fat from red meat and skin from chicken.

Low income has been recognized as an important factor that limits a healthy diet. Foods high in calories, fats and sugar are generally more affordable (Drewnowski & Specter, 2004). The weight loss was also associated with reduced consumption of lipids from the pre-intervention assessment as verified by the average of three 24DRs. This positive relationship between weight loss and eating behavior related to the consumption of fats has also been observed in other studies (Howard et al., 2006; Murtaugh et al., 2007), with best results of weight reduction among those who decreased the percentage of calories from fat (Howard et al., 2006).

Table 1
Baseline characteristics of participants by intervention and control group.

Characteristics	Control group		Intervention group		p value
	n	Values	n	Values	
Sociodemographic					
Age (years)	31	60.4 ± 13.7	40	55.9 ± 9.7	0.110[a]
Family income per capita ($)	31	191.5 (83.8; 244.1)	38	159.5 (125.6; 291.2)	0.530[b]
Education (years)	31	4.0 (2.0; 8.0)	40	4.5 (4.0; 8.0)	0.184[b]
Occupancy (%)	31		40		0.332[c]
With fixed income	21	67.7	22	55.0	
Without fixed income	10	32.3	18	45.0	
Consumption					
Calories (kcal)	31	1592.3 (1269.3; 1868.7)	40	1672.0 (1474.7; 2268.3)	0.079[b]
Lipids (% kcal)	31	31.1 (28.2; 34.2)	40	30.6 (28.0; 35.1)	0.754[b]
SFA (% kcal)	31	8.2 (7.2; 9.7)	40	8.5 (7.5; 11.6)	0.217[b]
MFA (% kcal)	31	7.7 (7.3; 9.1)	40	7.9 (6.9; 9.9)	0.308[b]
PFA (% kcal)	31	10.1 ± 3.7	40	9.5 ± 2.7	0.424[a]
Cholesterol (mg)	31	139.0 (106.2; 185.2)	40	204.2 (134.3; 275.5)	0.005[b]
Stage groups (%)	31		40		0.686[c]
Pre-action	14	45.2	20	50.0	
Action	17	54.8	20	50.0	
Anthropometrics					
Weight (kg)	31	65.8 ± 13.4	40	68.3 ± 11.4	0.393[a]
BMI (kg/m^2)	31	27.7 ± 5.5	40	28.1 ± 4.0	0.746[a]
BMI classification (%)	31		40		0.743[c]
Underweight	2	6.4	2	5.0	
Normal weight	11	35.5	10	25.0	
Excessive weight (overweight and obesity)	18	58.1	28	70.0	
WC (cm)	31	85.4 ± 10.6	40	85.4 ± 9.7	0.998[a]
Body satisfaction (%)	31		40		0.163[c]
Satisfied	20	64.5	20	50.0	
Dissatisfied	11	35.5	20	50.0	
Body perception (%)			40		0.120[c]
Normal	9	29.0	8	20.0	
Thin or very thin	4	12.9	1	2.5	
Little fat. fat. too fat	18	58.1	31	77.5	
Foods high in fats[*] (%)	31		40		0.179[c]
Infrequent (monthly, rarely, never)	22	71.0	23	57.5%	
Frequent (daily, weekly)	9	29.0	17	42.5%	

Notes: n refers to the number of respondents. Symmetric variables — mean ± standard deviation; asymmetric — median (P25–P75). SFA — saturated fatty acid, MFA — monounsaturated fatty acid, PFA — polyunsaturated fatty acid. BMI — Body Mass Index. WC — waist circumference.
[a] Student *t* Test.
[b] Mann–Whitney Test.
[c] Pearson's chi-square Test.
[*] Foods high in fats: fried food, fried snacks, burgers, sausages, etc.

The weight reduction was inversely correlated with protein consumption, a finding consistent with other studies (Murtaugh et al., 2007). A study conducted in the United States of 1599 white women revealed that a higher proportion of calories from protein were associated with increased risk of overweight (OR: 1.81; 95% CI: 1.28–2.56) and obesity (OR: 3.55; 95% CI: 2.38–5.29). The association was even strong for animal protein (the odds ratios were 2.10 for overweight [95% CI: 1.47–2.98] and 2.28 for obesity [95% CI: 1.27–4.08]) (Murtaugh et al., 2007). However, a study with 72 overweight and obese subjects showed that the protein intake (0.8 g/kg) is important for maintaining

Table 2
Changes in consumption and dietary habits of intervention and control groups at pre- and post-intervention.

Characteristics	Control group (n = 31)			Intervention group (n = 40)		
	Pre-intervention	Post-intervention		Pre-intervention	Post-intervention	
	Values	Values	p value	Values	Values	p value
Calories (kcal)	1592.3 (1269.3; 1868.7)	1518.0 (1257.5; 1826.7)	0.245[a]	1672.0 (1474.7; 2268.3)	1569.3 (1300.1; 1912.7)	0.001[a]
Carbohydrate (% kcal)	54.5 (50.1; 57.9)	52.2 (47.1–56.7)	0.131[a]	52.1 (48.1; 56.8)	51.4 (47.7; 54.2)	0.288[a]
Protein (% kcal)	14.8 ± 2.5	15.7 ± 3.9	0.185[b]	15.6 ± 3.4	15.9 ± 2.9	0.621[b]
Lipids (% kcal)	31.1 (28.2; 34.2)	33.8 (29.9; 35.2)	0.239[a]	30.6 (28.0; 35.1)	32.6 (29.3; 36.2)	0.448[a]
SFA (% kcal)	8.2 (7.2; 9.7)	9.2 (7.0; 11.0)	0.165[a]	8.5 (7.5; 11.6)	9.7 (8.7; 11.6)	0.397[a]
MFA (% kcal)	7.7 (7.3; 9.1)	8.4 (7.2; 9.3)	0.210[a]	7.9 (6.9; 9.9)	8.6 (7.2; 10.5)	0.166[a]
PFA (% kcal)	10.1 ± 3.7	10.5 ± 2.9	0.524[b]	9.5 ± 2.7	9.9 ± 3.2	0.438[b]
Cholesterol (mg)	139.0 (106.1; 185.2)	157.3 (105.0; 203.7)	0.797[a]	204.2 (134.3; 275.5)	164.6 (112.8; 244.6)	0.188[a]
Foods high in fats[c] (%)			0.508[d]			0.022[d]
Infrequent (monthly, rarely, never)	70.0% (n = 21)	80.0% (n = 24)		57.5% (n = 23)	80.0% (n = 32)	
Frequent (daily, weekly)	30.0% (n = 9)	20.0% (n = 6)		42.5% (n = 17)	20.0% (n = 8)	

Notes: Symmetric variables — mean ± standard deviation; asymmetric — median (P25–P75). SFA — saturated fatty acid, MFA — monounsaturated fatty acid, PFA — polyunsaturated fatty acid. The test power to detect the difference between the frequency ratio of consumption of fat rich foods and median difference of calories was 90.67% and 98.26%, respectively.
[a] Wilcoxon signaled posts Test.
[b] Paired Student *t* Test.
[c] Foods high in fats: fried food, fried snacks, burgers, sausages, etc.
[d] McNemar Test.

Table 3
Changes of anthropometric measurements, body perception and body satisfaction of intervention and control groups at pre- and post-intervention.

Characteristics	Control group (n = 31)			Intervention group (n = 40)		
	Pre-intervention	Post-intervention		Pre-intervention	Post-intervention	
	Values	Values	p value	Values	Values	p value
Anthropometrics						
Weight (kg)	65.8 ± 13.4	66.2 ± 14.0	0.169[a]	68.3 ± 11.4	67.4 ± 11.4	0.018[a]
BMI (kg/m^2)	27.7 ± 5.5	27.9 ± 5.7	0.310[a]	28.1 ± 4.0	27.6 ± 4.0	0.011[a]
WC (cm)	85.4 ± 10.6	86.0 ± 9.9	0.334[a]	85,4 ± 9,7	84.3 ± 7.6	0.356[a]
Body satisfaction (%)			1.000[b]			0.180[b]
Satisfied	63.3 (n = 19)	60.0 (n = 18)		50.0 (n = 20)	62.5 (n = 25)	
Dissatisfied	36.7 (n = 11)	40.0 (n = 12)		50.0 (n = 20)	37.5 (n = 15)	
Body perception (%)			0.564[b]			0.034[b]
Normal	30.0 (n = 9)	26.7 (n = 8)		20.0 (n = 8)	35.0 (n = 14)	
Thin or very thin	10.0 (n = 3)	10.0 (n = 3)		2.5 (n = 1)	2.5 (n = 1)	
Little fat. fat. too fat	60.0 (n = 18)	63.3 (n = 19)		77.5 (n = 31)	62.5 (n = 25)	

Notes: Symmetric variables — mean ± standard deviation. BMI — Body Mass Index; WC — waist circumference.
Test power to identify differences mean of weight and BMI was 67.45% and 73.94%. respectively. In relation to body image, the test power was 71.35%.
[a] Paired Student *t* Test.
[b] McNemar Test.

weight and suggested that inadequate protein intake may contribute to a higher risk of weight regain after diet (Soenen, Martens, Waelen, Lemmens, & Plantenga, 2013). Indeed, a key feature when considering the total protein intake is the specific sources of dietary protein (Willett, 2013). In this study, participants demonstrated low consumption of fish and nuts and high consumption of red meat and whole milk (data not shown).

The weight reduction and consequent BMI reduction observed in IG were accompanied by improved body perception. It is valuable to note that we found no publications related to TTM that incorporated body perception. Body perception integrates the physical, mental and emotional aspects of an individual. A negative body perception can adversely affect one's health and quality of life and impede one's social and professional life. It has been associated with eating disorders, depression, and low self-esteem, among other emotional problems (Muenning, Jia, Lee, & Lubetkin, 2008).

Strengths of this study include the fact that it was a randomized clinical trial with rigorous study design conducted in a Primary Health Care. Although the literature presents different effective interventions based on TTM, only a few studies have been conducted in the context of health service. The development of interventions in this setting may allow us to extrapolate the actions to population groups and improve the actions proposed by the Primary Health Care for the population.

On the other hand, conducting a randomized trial in a Primary Health Care with universal access as recommended by the Brazilian national healthcare system imposes a challenge. Universal access contributes to a high turnover of users since they can leave and return to the service multiple times, making long-term follow-up difficult. Consequently, the participation was low in the group education regarding nutrition that occurred routinely on the primary care service. This open group-education method may be considered a limitation that contributes to the high attrition of participants, which might affect the continuity and deepening of themes worked. In addition, this method contributes to a lower awareness and empowerment of subjects.

Over the 6-month TTM-intervention period, study attrition amounted to 20.6% of eligible individuals. This level of attrition is close to the percentage (20%) considered to reflect strong adequacy in interventions lasting 6 months (Salmela, Poskiparta, Kasila, Vähäsarja, & Vanhala, 2009; Van Sluijs et al., 2004). When considering all three phases of the study, 54% of original subjects were lost, which is comparable to the allowance included in our sample size calculation (53%). These losses occurred especially among younger women, which may be because the service operates only in the morning, hindering the participation of those who started work during this shift.

Those who dropped out also reported greater participation in psychiatric treatment (anxiety, depression and others). These women may have experienced more difficulty using the service and their psychiatric conditions may have presented barriers to participating in the intervention. Further investigation is warranted on the applicability, clinical appropriateness, and safety of TTM-based interventions on individuals with psychiatric conditions (Cardoso & Galera, 2009).

It should be noted that sample size reduction due to study attrition might have harmed our ability to detect some positive results. However, when we analyzed the significant changes found, some statistical tests had sufficient power, ranging from 68% to 98%.

Another positive point of this study is the development of an intervention based on the four pillars of TTM in contrast to most studies that consider only the stages of change, thereby reducing the TTM to a single variable (Armitage, 2010). We specifically included validation of the algorithm used to identify the SOC as the first phase of our study because a common criticism/limitation of TTM studies to date has been the use of non-validated instruments (Van Sluijs et al., 2004). Furthermore, this study applied three 24DRs, before and after the intervention, in order to identify the usual intake of participants. It is noteworthy that the use of valid algorithms and careful execution of reclassification of SOC are crucial to the development of appropriate interventions. Besides the three 24DRs, objective measures such as anthropometric variables were also used. We emphasize that all data were collected by dietitians trained periodically. Data-collection procedures were standardized and it used protocols to minimize errors and biases inherent to 24DRs and anthropometric measurements (Institute of Medicine, 2006; Willett, 2013; World Health Organization, 1995, 2008). It is important to include objective measures as indicators of intervention effectiveness given the susceptibility to errors in self-

Table 4
Final model of multiple linear regression for the intervention group with the delta percentage of weight loss as the outcome variable.

Variable	Coefficient (β)	Standard error	Standardized beta	p value
Constant	11.392	2.209	–	<0.001
Family income per capita	2.732	0.714	0.434	0.001
Protein intake	−0.678	0.114	−0.666	<0.001
Adequate intake of lipids	2.139	0.718	0.322	0.006
Remove visible fat from red meat and skin from chicken	2.081	0.815	0.285	0.016

Notes: $R^2 = 0.687$; $R^2_{adjusted} = 0.642$. Backward method. Intervention group: n = 40. Categorical variables: family income per capita (category 0 and 1 = ≤1/>1 minimum wage on the date of collection. respectively). Adequate intake of fat (category 0 = >30%; category 1 = ≤30%) and removal of apparent fat from red meat and skin from chicken (category 0 = no/category 1 = yes). Quantitative variable: protein intake (percentage of daily caloric intake).

reported measures (Armitage, 2010). Other positive features of this intervention are:

a) All participants received the intervention as opposed to just those considered "at risk," which has been done in many studies using the TTM (Prochaska et al., 2005). (We believed that all individuals, including those in the action and maintenance stages, had room for improvement in eating habits.)
b) An interdisciplinary team planned and conducted the TTM-based intervention.
c) The intervention incorporates behavior change theories rather than relying solely on nutrition education (Prochaska et al., 2013).

The CG may be viewed as a study limitation since its members were exposed to some nutritional intervention; however, this "usual care" they received did not incorporate TTM. Similar "usual care" for control groups has been relatively common in other similar studies (Salmela et al., 2009). This limitation could not be circumvented considering that the intervention was performed in a public health service. It is noteworthy, however, that in the present study the activities performed by CG was described and compared to the activities completed by the IG, demonstrating similar participation. Furthermore, we highlight that there is a new perspective in Public Health Nutrition, related to the concept of Evidence-based public health. In addition to proving the efficacy of a specific intervention through studies performed under ideal conditions, it is also essential to prove that interventions are effective under routine conditions in health services (Garrett, 2008).

5. Conclusion

The results of a 6-month intervention period were positive, showing improvements in dietary behaviors, anthropometric measures, and body perception among women in the IG. The study confirmed the important need for interventions that have been proven effective at reducing consumption of dietary fat. In addition to a reduction in calories, factors associated with weight loss in our study included low protein intake and better economic condition. Our study results increase the evidence base for the effectiveness of TTM-based interventions at achieving desired behavior change in a wide variety of settings. We anticipate that this study and future research on TTM-based interventions will extend the reach of these beneficial interventions to additional population groups, and may encourage the development of public health policies and additional service activities targeted toward population health.

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Contributors

Mariana Carvalho de Menezes did the literature search, collected, analyzed and interpreted data. Sueli Aparecida Mingoti and Raquel de Deus Mendonça analyzed and interpreted data. Clareci Silva Cardoso and Aline Cristine Souza Lopes conceived study design. Aline Cristine Souza Lopes coordinated research. All authors were involved in writing the paper and had final approval of submitted and published versions.

Conflict of interest

All authors declare that they have no conflicts of interest.

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