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Transtheoretical model for change in obese adolescents: MERC randomized clinical trial

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Abstract

The randomized controlled trial evaluated the effectiveness of an intervention based on the Transtheoretical Model of Change on anthropometric, metabolic and motivational outcomes in obese adolescents. A total of 135 male and female adolescents were randomized to two groups: intervention group ($n = 65$) and control group ($n = 70$). The adolescents were evaluated 1 week before the interventions began and at the end of 12 weeks. There was no statistically significant difference between groups in the outcome variables. Intervention group reported magnitude of effect more expressive on body mass index percentile, waist circumference, waist-to-hip ratio, readiness to change diet and readiness to start exercise.

Keywords

adolescence, motivation, obesity, randomized clinical trial, treatment

The growing number of children and adolescents who are overweight and/or obese is considered to be a serious public health challenge in this century (Arnold et al., 2016; World Health Organization (WHO), 2016). The diagnosis of obesity is related to body fat mass and not to weight. The body mass index (BMI), defined by weight (kg) by height raised to the second power (m^2), is most widely used to make the diagnosis of obesity. For adolescents, there are graphs of BMI curves adjusted for age and gender that represent a trend, that is, a percentile. Adolescents with a BMI equal to or above the 85th percentile are classified as overweight, and those with a BMI equal to or above the 95th percentile are considered to be obese (De Onis et al., 2007). In Brazil, the prevalence of obesity in adolescents aged between 12 and 17 years is 8.4 per cent; it is even higher in the southern region (Bloch et al., 2016). It is known that this condition is associated with a series of chronic disorders, especially cardiovascular diseases (Simmonds et al., 2016).

While obesity can be partly addressed through interdisciplinary public policies and interventions, weight loss generally demands lifestyle changes, healthier eating habits and regular exercise at school, at home and in the

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general community (Boff et al., 2016; Lobstein et al., 2015; WHO, 2016; Yanovski, 2015). Adolescents' adherence to such regimens, however, is lower than that of both adults and children (França et al., 2013). Among the main causes of non-adherence are psychological and behavioural factors (De Miguel-Etayo et al., 2016) in addition to the type of communication typically used in interventions (Skelton et al., 2014; Smith et al., 2014; Steinbeck et al., 2009). Public health interventions for lifestyle change with this population are usually prescriptive, that is, health professionals try to impose which habits should be modified. This approach often heightens the subject's ambivalence and makes him or her abandon efforts to change (Finger and Potter, 2011). The Change Transtheoretical Model (TTM) is configured as an alternative to standard treatment formats. The model is designed to potentiate the effects of weight loss interventions by focusing on the ambivalence to behavioural change and increasing the person's internal motivation (Di Noia and Thompson, 2012; Han et al., 2015; Ott et al., 2015; Pirzadeh et al., 2015; Wu and Chu, 2015).

Thus, the Modification of Lifestyle and Cardiovascular Risk (MERC) project was proposed to evaluate an intervention based on TTM compared to a traditional intervention offered by the Brazilian public health service (Ribeiro et al., 2016). Standard Brazilian treatment programmes offer adolescents directive programmatic structures for accomplishment of desirable changes with little opportunity to participate in decisions regarding how those alterations are made. The intervention evaluated in the MERC project focuses on the individual's motivation to change his or her lifestyle, considering such elements as the stages of readiness to change, processes of change, personal decision-making and strengthening self-efficacy (Prochaska et al., 1992). One of the features of TTM, for example, is use of the principles of Motivational Interviews in interacting with the client. Such approaches provide the adolescent with a sense of autonomy and can be instrumental in evoking an intrinsic motivation to change (DiClemente et al., 2016). Clinical trials that have used the motivational approach with a focus on stages of readiness for change (Gourlan et al., 2013; Kong et al., 2013; MacDonell et al., 2012; Resnicow et al., 2015; Walpole et al., 2013) have found a significant reduction in BMI in obese adolescents. The literature also shows that interventions based on TTM cause modifications in dietary patterns and an increase in physical activity (see Di Noia and Thompson, 2012; Romain et al., 2016; Sanaeinasab et al., 2013). Despite these findings, there are few trials that test TTM with an obese adolescent population.

The main hypothesis in this study is that an intervention based on TTM will have the following effects on outcomes:

Primary – motivation for change. Increase of one point in the continuous variable of readiness to change for completion of physical exercise and food intake modification, increase in self-efficacy for eating habits, exercise and decisional balance for weight loss, anthropometric reduction of at least 0.5 per cent in BMI and BMI percentile, reduction of at least 5 per cent in abdominal circumference and improvement in the waist-to-hip circumference ratio (WHR).

Secondary – metabolic. Reduction of at least 20 per cent in triglycerides (BT), an increase of at least 5 per cent in high-density lipoprotein (HDL), reduction of 5 per cent in low-density lipoprotein (LDL), reduction of at least 5 per cent at the end of the intervention in insulin resistance (homeostasis model assessment–estimated insulin resistance (HOMA-IR)) and glycosylated haemoglobin (HbA1c) and improvement in systolic and diastolic blood pressure.

Psychological functioning. Reduction in points on the Binge Eating Scale (BES) and increase in satisfaction with one's body image.

The second hypothesis for this randomized clinical trial (RCT) is that the magnitude of the

effect of intervention based on TTM will be larger than the standard intervention for the above-mentioned outcomes.

Method

Study design

MERC is an RCT carried out in southern Brazil with approval of the Committee of Ethics in Research of the Pontifical Catholic University of Rio Grande do Sul (CAAE: 36209814.6.0000.5336). The study protocol is registered with the Brazilian Registry of Clinical Trials (RBR-234nb5) and the Clinical Trial Registry (NTC02455973).

Participants

Adolescents who were overweight or obese (BMI percentile = 85), female and male, and aged between 15 and 18 years participated in the study. Exclusion criteria were an absolute contraindication for physical activity, a diagnosis of psychiatric disorder, significant cognitive damage, a diagnosis of diabetes mellitus type I or pregnancy. Inclusion criteria were controlled blood pressure and availability to participate in the programme.

Recruitment

Recruitment of participants took place via digital media, radio and television. Those interested were offered mobile contact, WhatsApp and pages on social networks. After the initial contact was made, a meeting took place with parents or legal guardians along with the adolescents. In this initial meeting, the objectives of the research were explained. In addition, all eligibility criteria were evaluated. Those who met the eligibility criteria and were interested in participating were randomized. After randomization, a consent form was read to the caregiver(s) and a term of assent was read and signed by the adolescent. Participation in the study only occurred if both the parent(s)/guardian(s) and the adolescent agreed to it.

Randomization

The students were randomized into two groups: the Motivational Interdisciplinary Group (IG) and the Traditional Health Education Group (CG). To accomplish this randomization, Software Randomizer (version 4.0) was used (generating a single block of 156 numbers, which then was divided into two groups). A member of the research team was responsible for blind assignment of each participant to one of the two experimental groups. The study was single-blind, as the participants did not know what treatment they would receive. There were two versions of informed consent for the two participant groups (IG or CG). Only the consent form for the group to which the participant belonged was read. Thus, he or she was unaware that there were two treatment modalities.

Sample size calculation

The sample size calculation was based on the expectation of BMI variation from a similar study that found an average reduction of 1.1 kg/m^2 post intervention, implying a measure of effect of approximately 0.60 (initial BMI: 37.2 ± 6.0 vs final BMI: 36.1 ± 6.1). Taking into account that the effect size per group is higher with a margin of 40–60 per cent (with a difference of 0.4 in magnitude of effect measure between groups) and assuming a significance level of 5 per cent ($\alpha = 0.05$) and a sample power of 80 per cent ($1 - \beta$), it was determined that it would be necessary to have 60 adolescents per group (120 participants in all) to be able to detect an effect. Stata software, version 10.1 (StataCorp, 2011), was used to perform this calculation.

Interventions

Motivational Interdisciplinary Group (IG). The experimental group was composed of 12 meetings held once a week for 1.5 hours over 3 months. The meetings were conducted by an interdisciplinary team from the MERC project. The meetings were conducted by one professional from each

represented area: psychology, nutrition, physiotherapy, nursing and physical education.

The protocol of 12 sessions was based on TTM to engender motivation to change eating habits and initiate the practice of regular physical exercise through the stages of change, the processes of behavioural change, and enhanced decision-making and self-efficacy. All the sessions were structured and a digital resource was used to communicate in the adolescents' language. Two meetings were held with the teenagers' parents/guardians, one at the beginning of the intervention (first month) and another at the end, with the aim of helping the caregivers motivate their children towards adherence to a healthy lifestyle. The detailed content of the two meetings can be seen in the publication of this research protocol (Ribeiro et al., 2016). The intervention groups were distributed in five cycles, each having a duration of 3 months. In each cycle, a control group and an intervention group were conducted at the same time.

Traditional Health Education Group (CG). In this study, the group receiving traditional education in health was considered the control group. In the same manner as the experimental group, 12 group meetings lasting 1 hour were held once weekly for 3 months. This group was also guided by a multidisciplinary team composed of a psychologist, a nurse, a physiotherapist and a nutritionist. Unlike the IG team, however, these professionals had no TTM training, nor did they attend supervisory meetings. Two meetings with the parents were conducted at the beginning and the end of the intervention to guide them in changes to make in feeding their children and in the adolescents' physical activity habits.

As with the IG, the goal of the CG was to encourage participants to change both their dietary habits and physical exercise practices. In contrast to the experimental group, however, a directive and non-motivational approach was used in which the adolescents only received guidance regarding what they should do for food intake and physical exercise. Such a programme is part of primary health care as typically offered in the Brazilian public health system. The guidelines used to evaluate the health of CG participants were the same as those in the IG. The difference between the groups consisted of the TTM intervention in the IG, an offering that not only allowed greater interaction between health professionals and the adolescents but also encouraged the youngsters' active participation. More specifics on the CG sessions can also be seen in the MERC study protocol (Ribeiro et al., 2016).

Certification of interventionist treatment

The team that carried out the IG received 8 hours of training in Motivational Interviewing and 8 hours of TTM training. In addition, the team studied the sessions together step by step based on the techniques to stimulate the desired change processes and the change stages elaborated in the model. At the end of the meetings, the interdisciplinary IG team met with an experienced and expert supervisor of TTM to evaluate implementation of the protocol and use of the motivational approach (from listening to MP3 audio recordings made of the sessions).

Measurements

The evaluations were performed according to the study protocol (Ribeiro et al., 2016). The adolescents were assessed 1 week before the beginning of the groups (baseline) and after 3 months, at least until 2 weeks after the end of the meetings (follow-up). The evaluations were made by an interdisciplinary team composed of psychologists, nutritionists and nurses. Both baseline assessments and follow-up evaluations occurred over two encounters. The evaluators were properly trained and instrumented for the activities. During the evaluations, they did not know if the evaluated participant was in the control group or the intervention group.

Demographic variables. Socio-demographic variables were collected through an electronic

questionnaire using Qualtrics owned by the PUCRS.

Anthropometric variables. Body weight was checked with a Cauduro® scale with capacity up to 160 kg that was properly calibrated with the participant barefoot and wearing as little clothing as possible. A vertical anthropometer (Sunny®) was used to measure height.

BMI for age and height was calculated. This value, as noted above, is the ratio between the weight (in kilograms) and height (in metres) squared ($BMI = weight/height^2$). To calculate the BMI percentile, the WHO calculator Antroplus was used (2017 model) (WHO, 2006, 2007, 2008).

Waist circumference (WC) was measured with the participant standing up, and upon expiration, placing a tape measure through the middle point between the edge of the last costal arch and the edge of the anterior iliac crest (WHO, 2008).

Hip circumference (HC) was measured with the use of a tape measure at the highest point of the buttocks and the participant wearing as little clothing as possible (WHO, 2008).

The WHR was calculated by dividing the measurement of the WC in centimetres by the measurement of the HC in centimetres (WHO, 2008).

Blood pressure. For measuring blood pressure, the Omron 705-IT monitor was used. This device has been validated for use with adolescents, with values established according to recommendations by the Brazilian Society of Cardiology (Sociedade Brasileira de Cardiologia, 2010).

Metabolic variables. Analysis of metabolic variables was performed with the collected blood samples. The HDL, TC, TG and glucose analyses were performed by enzymatic reactions using kits manufactured by Johnson & Johnson (Ortho Clinical Diagnostics) and applying dry chemical methodology and the Vitros 750 self-tester. Fasting insulin and HbA1c were analysed by chemiluminescence. LDL was calculated as $LDL = ((TG/5) + HDL) - CT$, and HOMA-IR was fasting glycaemia $\times 0.0555 \times$ fasting insulin/22.5.

Motivational variables. The following instruments were used to evaluate participants' motivational levels:

Readiness to change diet and readiness to start exercise. This variable was assessed by means of an analogical scale that best represents how ready the participant was to alter his or her behaviour at that moment (Velasquez et al., 2001).

Decisional balance (DB). This variable was assessed through a self-report instrument that consisted of 20 questions to evaluate how important, for the subject, decision-making was in relation to losing weight (Prochaska et al., 1994).

The self-efficacy to diet and self-efficacy to exercise. Self-efficacy for healthy habits was evaluated by means of a question answered on an analogical scale from 0 to 10. The participant was asked to indicate how much he or she believed in his or her own ability to maintain a healthy diet and how much he or she believed in his or her own ability to maintain a routine of physical exercise.

Motivation to participate in MERC (MPM). Motivation to participate in the MERC project was measured on an analogical scale from 0 to 10 points, in which the adolescent marked the point that represented how much he or she was motivated at the time to participate in the study.

Psychological function. The following measures were used to assess the psychological status of the participants:

The Binge Eating Scale (BES). The BES was developed for screening and assessment of the severity of binge eating in obese individuals (Gormally et al., 1982). The BES is a Likert-type scale consisting of 16 items and

62 statements that score (from zero to three points) the severity and frequency of episodes, the quantity of food ingested and the degree of emotion involved in an episode of binge eating.

Body image satisfaction (STUNKART). The participant's satisfaction with body image was evaluated with the Figure Rating Scale designed by Stunkard et al. (1983) (see also Pereira et al., 2009).

Statistical analysis

Adolescents who completed 80 per cent of the intervention were included in the analysis. Presentation of the results involved the absolute and relative distributions as well as measures of central tendency and variability. Analysis of the data distribution was conducted using the Kolmogorov–Smirnov test still considering a maximum coefficient of variation of 30 per cent of the mean value.

For comparison of continuous variables, Student's *t*-tests for independent samples and Mann–Whitney *U*-tests were used. For the categorical variables, Pearson Chi-square tests and Fisher's exact tests were used.

For evaluation of interventions between groups over time, the sample that completed the follow-up evaluations ($n=65$) was considered. The analysis was conducted through generalized linear models (analysis of variance (ANOVA)) with repeated measures with homogeneity of variance estimated by the Levene test. The assumption of sphericity was calculated from the test of Mauchly. In cases of violation, the Greenhouse–Geisser correction and *F* ratio were used, as well as post hoc Bonferroni correction for multiple comparisons. The magnitude of the effect of interventions was assessed by means of Cohen's *d* and the variation between baseline and follow-up was assessed with Δ (Δ%).

Results

Figure 1 shows the diagram of MERC recruitment and adolescent participation. In Brazil, it is not permissible to remunerate research participants. As a consequence, participation in the study was voluntary (Menezes et al., 2015).

Study sample and retention

The predominant diagnosis in this sample of 135 adolescents was obesity (84.4%), which included 100 females (74.1%) and 35 males (25.9%). The mean age was 16.4 years (±1.09). The majority of the participants were white (69.6%) because data collection occurred in the southern region of Brazil, where Caucasians are the predominant ethnic group. In relation to socio-economic level, according to the Brazilian socio-economic classification, most fell into the predominant class B (51.1%), and 63 per cent were in high school at the time of evaluation. The characteristics of the 135 participants (IG=65; CG=70) are shown in Table 1.

There were significant differences between groups at baseline just in BMI percentile. This difference was because of the randomness in the division of the groups. In total, 92 teenagers (68% of the initial sample) attended 80 per cent of meetings of the intervention. However, only 65 participants completed the follow-up evaluations. These participants were included in the analyses. There was an overall sample loss of 48.8 per cent. In the IG group, 65 individuals were randomized and the dropout rate was 43.0 per cent ($n=28$). Of the CG participants, 70 were randomized and the dropout rate was 54.28 per cent ($n=38$). There was no statistical significance to losses comparing the IG and CG means ($p=0.351$).

Table 2 shows the results of primary and secondary outcomes at each time and between groups.

Changes in motivational measures

There was a statistically significant difference only in DB between groups over time ($F(1,63)=4.193$; $p=0.045$; Power=52.3%). The effect size for readiness to change diet in the IG was high (Cohen's $d=-0.87$) and 5.7 times higher than in the CG (Cohen's $d=-0.30$). MPM was statistically significantly different within groups over time ($F(1,63)=5.353$; $p=0.024$; Power=62.5%), but

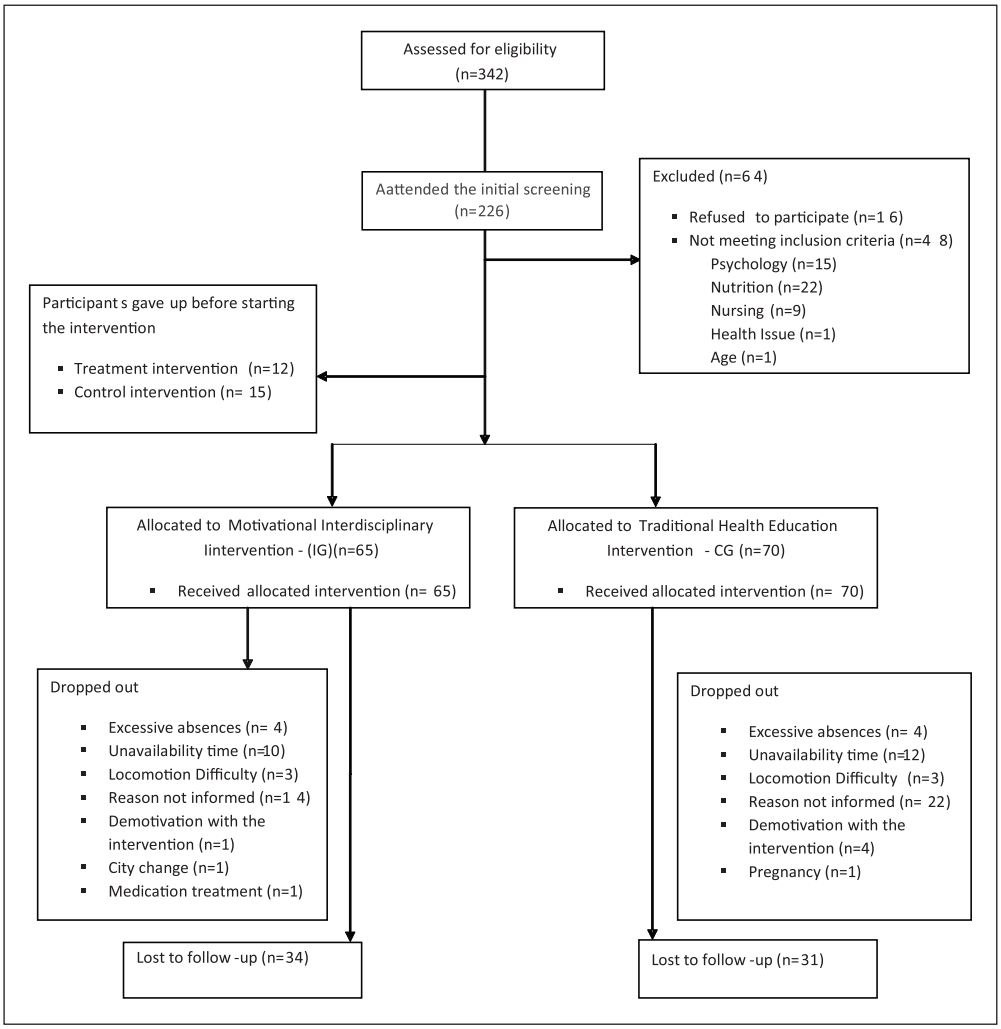

Figure 1. Consort diagram describing the flow of participants through each stage of the randomized trial.

was not significantly different between groups. The size of the effect of this variable in the IG was medium (Cohen's $d=-0.60$) and was 3.7 times higher than that in the CG (Cohen's $d=-0.17$). The self-efficacy to diet ($F(1,63)=34.530$; $p<0.001$; Power=100%) was statistically significantly different within groups over time but not between groups.

Changes in anthropometric measures

The BMI percentile was different between groups at baseline, but this result did not influence the variation in this variable when comparing baseline and follow-up ($F(1,63)=5.188$; $p=0.026$). Regarding the interaction effect between groups over time, statistically significant differences were not found for any anthropometric variables. Considering the effect of time within groups, there was a statistically significant mean reduction for BMI ($F(1,63)=23.539$; $p<0.001$; Power: 99.8%), WC ($F(1,63)=5.220$; $p<0.001$; Power: 99.9%), HC ($F(1,63)=5.188$; $p=0.026$; Power: 61.4%) and WHR ($F(1,63)=3.332$; $p<0.001$; Power: 43.6%). The estimates for the size of the

Table 1. Baseline characteristics of the study participants.

Variables	IG ($n=65$), mean (SD)	CG ($n=70$), mean (SD)	Statistical test	p-value
Demographic				
Age (years)	16.42 (1.17)	16.46 (1.01)	$t=-0.222$[a]	0.825
Gender (n, %)				
Male	21 (58.3%)	15 (41.7%)	$\chi^2=2.040$[b]	0.153
Female	44 (44.4%)	55 (55.6%)		
Ethnicity/white (n, %)	44 (65%)	52 (74.3%)	$\chi^2=4.586$[b]	0.281
Education/high school (n, %)	49 (75%)	46 (65.7%)	$\chi^2=0.758$[b]	0.709
Anthropometric measures				
Weight (kg)	95.90 (17.73)	97.04 (22.42)	$t=-0.330$[c]	0.742
Body mass index (BMI) (kg/m^2)	34.74 (4.71)	35.99 (6.51)	$t=-1.275$[c]	0.205
Body mass index (BMI) (percentile)	99.32 (0.87)	97.88 (2.74)	$t=2.443$[c]	0.020
Waist circumference (WC)	104.43 (12.18)	106.60 (16.43)	$t=-0.857$[c]	0.393
Hip circumference (HC)	119.84 (9.37)	118.99 (12.51)	$t=0.441$[c]	0.660
Waist to hip ratio (WHR)	0.87 (0.07)	0.89 (0.08)	$t=-1.611$[a]	0.110
Blood pressure (mm/Hg)				
Diastolic	83.19 (12.65)	83.67 (12.09)	$t=-0.222$[a]	0.825
Systolic	100.03 (27.29)	95.31 (25.81)	$t=1.033$[a]	0.303
Metabolic measures				
Triglycerides (TG) (mg/dL)	93.03 (45.61)	101.81 (43.42)	$t=-1.146$[a]	0.254
High-density lipoprotein cholesterol (HDL) (mg/dL)	48.50 (13.18)	49.74 (15.24)	$t=-0.500$[a]	0.618
Low-density lipoprotein cholesterol (LDL) (mg/dL)	94.202 (24.28)	95.87 (31.31)	$t=-0.380$[a]	0.704
Homeostasis model assessment insulin resistance (HOMA-IR)	72.23 (44.10)	85.36 (50.45)	$t=-1.605$[a]	0.111
Glycated Hemoglobin (GH)	5.11 (0.46)	5.23 (0.44)	$t=-1.349$[a]	0.180
Motivational measures				
Readiness to change diet	6.45 (1.91)	7.05 (1.73)	$t=-1.908$[a]	0.059
Readiness to start exercise	6.16 (2.47)	6.69 (2.02)	$t=-1.349$[a]	0.180
Decisional balance (DB)	2.90 (0.80)	1.53 (0.82)	$U=2132$[c]	0.537
Self-efficacy to exercise	7.38 (2.73)	7.50 (2.64)	$U=2266$[c]	0.970
Self-efficacy to diet	6.09 (2.33)	6.41 (2.62)	$U=2015$[c]	0.245
Motivation to participate in the MERC (MPM)	6.75 (2.79)	6.91 (2.94)	$U=2153$[c]	0.590
Psychological function				
The Binge Eating Scale (BES)	14.91 (8.13)	15.30 (8.55)	$U=2201$[a]	0.752
Body image satisfaction (STUNKART)	2.53 (1.10)	2.47 (1.18)	$t=0.339$[a]	0.735

IG: Motivational Interdisciplinary Group; CG: Traditional Health Education Group; SD: standard deviation; MERC: Modification of Lifestyle and Cardiovascular Risk.

[a]Student's t-test for independent samples assuming homogeneity (Levene test).

[b]Pearson Chi-square test (sex) and Fisher's exact test (race and schooling).

[c]Student's t-test for independent samples assuming heterogeneity of variances (Levene test).

[d]Mann–Whitney U-test.

Table 2. Effect of interventions in and between groups.

Variable	IG		CG		IG	CG	IG	CG	Test statistic	
	Baseline ($n = 34$), M ± SD	Follow-up ($n = 34$), M ± SD	Baseline ($n = 31$), M ± SD	Follow-up ($n = 34$), M ± SD	Mean Δ (Δ%)	Mean Δ (Δ%)	Effect size (Cohen's *d*)	Effect size (Cohen's *d*)	*p*-value (intragroups[a])	*p*-value (between groups[a])
Anthropometric measures[b]										
Weight (kg)	98.18 ± 15.78	96.77 ± 16.28	95.09 ± 21.83	94.00 ± 20.73	−1.41 (−1.54)	−1.08 (−0.91)	0.09	0.05	<0.001	0.870
Body mass index (BMI) (kg/m^2)	35.33 ± 4.29	34.55 ± 4.37	35.17 ± 5.88	34.67 ± 5.60	−0.77 (−2.24)	−0.49 (1.08)	0.18	0.09	<0.001	0.630
Body mass index (BMI) (percentile)	99.50 ± 0.79	99.17 ± 1.83	97.88 ± 3.63	98.48 ± 2.55	−0.33 (−0.34)	0.29 (0.34)	0.23	−0.41	0.911	0.102
Waist circumference (WC)	105.85 ± 11.99	100.51 ± 11.17	104.63 ± 16.01	101.96 ± 15.38	−5.34 (−4.88)	−2.70 (−2.30)	0.46	0.17	0.000	0.102
Hip circumference (HC)	121.09 ± 8.67	120.17 ± 8.64	117.37 ± 11.75	116.06 ± 10.93	−0.92 (−0.72)	−1.31 (−1.00)	0.10	0.07	0.026	0.692
Waist-to-hip ratio (WHR)	0.87 ± 0.08	0.83 ± 0.07	0.88 ± 0.08	0.086 ± 0.08	−0.44 (−4.88)	−0.20 (−2.28)	0.53	0.13	<0.001	0.073
Blood pressure (mm/Hg)[b]										
Diastolic	78.23 ± 10.53	72.61 ± 14.00	76.19 ± 9.29	73.22 ± 7.72	−5.61 (−5.36)	−2.96 (−3.25)	0.45	0.35	0.160	0.447
Systolic	124.12 ± 11.02	122.84 ± 10.37	122.69 ± 8.58	121.0 ± 11.08	−1.28 (−0.67)	−1.69 (−1.24)	0.12	0.17	0.228	0.866
Metabolic measures[b]										
Triglycerides (TG) (mg/dL)	96.85 ± 55.60	88.79 ± 39.74	100.45 ± 43.99	108.61 ± 56.17	−8.05 (3.56)	8.16 (9.85)	0.17	−0.16	0.991	0.086
High-density lipoprotein cholesterol (HDL) (mg/dL)[c]	48.88 ± 11.53	50.32 ± 13.83	52.10 ± 15.75	52.84 ± 20.50	1.44 (3.48)	0.74 (0.47)	−0.11	0.04	0.353	0.766
Low-density lipoprotein cholesterol (LDL) (mg/dL)	92.69 ± 25.13	86.85 ± 28.46	88.40 ± 27.61	80.28 ± 29.02	−5.83 (−5.04)	−8.11 (−6.35)	0.22	0.29	0.042	0.735
Homeostasis model assessment insulin resistance (HOMA-IR)	79.90 ± 47.87	79.30 ± 46.36	80.03 ± 43.62	69.32 ± 33.73	−0.60 (10.85)	−10.71 (−5.93)	0.01	0.27	0.156	0.204
Glycated haemoglobin (HbA1c)	5.08 ± 0.30	4.98 ± 0.33	5.08 ± 0.28	5.00 ± 0.33	−0.97 (−1.77)	−0.08 (−1.44)	0.32	0.26	0.025	0.833
Motivational measures[c]										
Readiness to change diet	6.52 ± 1.64	7.83 ± 1.40	7.31 ± 1.83	7.86 ± 1.78	1.30 (25.58)	0.72 (16.85)	−0.86	−0.30	<0.001	0.189
Readiness to start exercise	6.19 ± 2.46	8.19 ± 1.83	6.67 ± 2.21	8.11 ± 1.82	2.0 (93.88)	1.43 (33.97)	−0.92	−0.71	<0.001	0.288
Decisional balance (DB)	1.31 ± 0.82	1.35 ± 0.99	1.57 ± 0.86	1.87 ± 1.02	0.04 (25.58)	0.29 (30.08)	−0.04	−0.32	<0.001	0.045
Self-efficacy to exercise	7.24 ± 2.33	8.56 ± 2.0	6.74 ± 2.32	8.10 ± 1.7	1.32 (80.64)	0.00 (5.32)	−0.52	−0.67	0.061	0.061
Self-efficacy to diet	6.32 ± 2.92	7.88 ± 1.98	6.77 ± 1.96	8.55 ± 1.4	1.61 (32.95)	1.08 (59.39)	−0.62	−0.87	<0.001	0.747
Motivation to participate in the MERC (MPM)	7.76 ± 2.43	9.03 ± 1.71	8.45 ± 2.38	8.71 ± 1.5	1.26 (50.87)	0.25 (8.30)	−0.60	−0.13	0.024	0.131
Psychological function[b]										
The Binge Eating Scale (BES)	15.24 ± 7.26	11.94 ± 5.92	15.45 ± 8.46	11.81 ± 7.62	−3.29 (−15.66)	−3.64 (−3.43)	0.50	0.44	<0.001	0.848
Body image satisfaction (STUNKART)	2.47 ± 1.16	2.56 ± 1.24	2.83 ± 1.04	2.48 ± 1.22	−0.09 (−3.64)	0.35 (12.36)	−0.07	0.31	0.258	0.063

IG: Motivational Interdisciplinary Group; CG: Traditional Health Education Group; MERC: Modification of Lifestyle and Cardiovascular Risk.
Statistical analyses: Δ – change in gross score between baseline and follow-up; Δ% – variation between baseline and follow-up.
[a]Repeated measures ANOVA.
[b]Variable with an expected gross coefficient and negative variation at follow-up.
[c]Variables with an expected gross coefficient and positive variation at follow-up.

effect of BMI percentile in the groups were in opposite directions. In the IG, a small effect was detected (Cohen's $d=0.23$), whereas in the CG the estimate for the effect was negative (Cohen's $d=-0.41$), which indicates an increase in this variable in the follow-up. The estimated size of the effect of WC in the IG (Cohen's $d=0.46$) was medium and 2.7 times higher when compared to the CG (Cohen's $d=0.17$). IG had a medium effect on WHR (Cohen's $d=0.53$), which was four times greater than in CG (Cohen's $d=0.13$).

Change in blood pressure and metabolic measures

There were no statistically significant differences in blood pressure or metabolic variables between groups over time. There was a statistically significant effect of time on LDL ($F(1,63)=4.315$; $p=0.042$; Power=53.4%) and HbA1c ($F(1,63)=5.239$; $p=0.025$; Power=61.6%), pointing to lower means post intervention both in the IG and CG. The magnitude of effect on BT was small in the IG (Cohen's $d=0.17$), but in the CG it was negative (Cohen's $d=-0.16$), indicating that there was an increase in the levels of TG in the CG. The magnitude of the effect of HDL in the IG (Cohen's $d=-0:11$) was almost insignificant, but there was a variation of 3.48 per cent (increase) in HDL levels compared to baseline in the IG, while in the CG there was a smaller variation (0.47%). HOMA-IR was not affected in IG, and in CG there was a small effect (Cohen's $d=-0.27$).

Change in psychological function

There were no statistically significant differences between groups over time in psychological function variables. However, there was a significant intragroup difference over time in BES ($F(1,63)=14.408$; $p<0.01$; Power=96.2%) with a medium effect in the IG (0.50) and a small effect in CG (0.44). The effect on STUNKART in the CG was small (Cohen's $d=-0.31$), and it was not present in the IG.

Discussion

The most significant results in this study were related to motivation to change. The readiness for change, assessed in this study as a continuous variable, relates to how ready the person believes him or herself to be to modify his or her habits. The readiness for change in eating habits increased 1.61 points on the scale, showing a large effect size (Cohen's $d=0.86$), while the readiness to begin physical exercise also had an increase of 2 points on the scale and large effect size (Cohen's $d=-0.92$). Readiness for change represents points along a trajectory of change; the more advanced the individual is, the less prone he or she is to relapse (Brick et al., 2019). The movement between the stages occurs through stimulation of the processes of change (Prochaska et al., 2013), which was the central theme of the 12 meetings in the IG. Moreover, self-efficacy (SE) acts as an 'engine' that drives individual motivation insofar as it represents belief in success itself for both the SE for modification of diet (Cohen's $d=-0.62$) and the SE to physical exercise (Cohen's $d=0.71$). The decision to change was not negatively impacted by the IG, considering that at the beginning of the intervention the DB was already trending to the pros of weight loss (1.31 ± 0.82). The motivation for participation in MERC (MPM) also had a medium size effect, but its variation was high between baseline and follow-up ($\Delta\%=50.8$). One of the recommendations of the TTM is not to confront the adolescents' resistance to change but rather to respect their autonomy and focus on intrinsic motivators of change (DiClemente, 2015). This focus of the IG may have impacted MPM because the variation in this variable in the CG was considerably lower (8.3%), although it was not statistically significantly different between groups ($p=0.131$).

In the comparison between groups, there were statistically significant differences only for the DB ($p=0.045$), which increased in the pros to change in the CG. Because it is a typical intervention in health services in Brazil, our initial hypothesis was that this programme would

also have a positive impact on the outcomes in this study. According to TTM, any activity that the subject starts to modify the thoughts, feelings or behaviours is a process of change (Velasquez et al., 2013). Thus, the adolescents who participated in the CG also benefitted from the intervention with greater variation in the DB (30%) and a small effect size in relation to STUNKART (Cohen's $d = 0.31$) in the IG.

However, when considering the other variables in terms of magnitude of effect, gross differences and variation over time, it was observed that TTM in the IG leveraged the anthropometric results. This finding corroborates other findings in Brazilian adults (Romain et al., 2016) and adolescents (Gourlan et al., 2013; MacDonell et al., 2012; Resnicow et al., 2015). The difference in the magnitude of the effect of motivational variables also strengthened the clinical usefulness of TTM in this context. Motivation becomes different in relation to behavioural change because it prevents relapse and demonstrates adherence in the long term (DiClemente et al., 2016). However, for more consistent conclusions on the use of the TTM in the Brazilian population, more studies are necessary (Marshall et al., 2013) because RCTs with Brazilian adolescents have tested interventions for nutritional changes and aerobic exercise (Farah et al., 2014).

The Motivation Interdisciplinary Intervention Group (IG) resulted in a modest change in the participants' weight (−1.54%). However, the reduction in BMI was greater than that hypothesized in this RCT (−2.24%).

The results also confirmed the hypothesis of abdominal circumference reduction (−4.88%) and improvement in WHR (−4.88%). These findings agree with other RCT studies (e.g. Peirson et al., 2015) that examined behavioural interventions with a focus on weight loss in adolescents. The improvement in the habits caused a larger impact on the health of adolescents than directly on weight (Sbruzzi et al., 2013). As an example, in this study, there was a medium effect of IG on WHR (Cohen's $d = 0.53$). It is known that the WHR is the best indicator of visceral obesity and is widely used as an indicator of risk to health (WHO, 2008; Yoo, 2016). Reduction in this index may be better than that in weight on adolescent health (Ho et al., 2013). Another study confirmed that a reduction $\geqslant 0.5$ in BMI directly impacted the improvement in metabolic risk factors (Ford et al., 2010).

In this RCT, the metabolic outcomes improved less than expected. Only LDL (−6.35%) and HOMA-IR (−5.93%) reached variation above the expectation from baseline to follow-up. The TG (−3.56%) had low variation, while the HbA1c (−1.77%) also had low variation and a small effect (Cohen's $d = 0.32$). These metabolic alterations, even though modest, show that there was a change in eating habits and physical exercise (DiClemente, 2015; Prochaska et al., 2013). However, a change in blood pressure will only be found when exercising aerobically three times weekly over 12 weeks (García-Hermoso et al., 2013). The MERC's purpose was to encourage the practice of physical activity and therefore did not directly influence the adolescents' choices regarding the practice of physical activity.

The findings of this RCT could also be more consistent if there was no sample loss. Although the literature demonstrates that there is higher dropout in studies with adolescents (Boff et al., 2016), it was possible to keep a sample size with power to reject the null hypothesis. The young Brazilian dropouts can be better investigated in future studies, but an important aspect to consider is that Brazilian laws do not allow compensation of research participants (Menezes et al., 2015). Many participants may have given up due to lack of financial incentives for travel, given that the majority belonged to the low–medium social class.

TTM is already considered by the Ministry of Health to be a first choice approach for treatment of chemical dependence. Studies such as this can consolidate empirical evidence that the motivational approach potentiates the multidisciplinary standard interventions already existing in the treatment of obesity in Brazilian adolescents when given by qualified health professionals. This approach can be useful in devising more effective public policies.

Limitations

An RCT that proposes to test a behavioural intervention is vulnerable to certain biases. There is no possibility of carrying out a double-blind study because those who manage the intervention know that there will be a comparison and have knowledge of the group that they are conducting. Also, there is no control over the group coordinators, because despite the training on the TTM with the teams and a control for compliance with the protocol, the personality/style of the coordinators may have functioned as mediators of the results.

Gender was not considered as a mediating variable. Future studies may find more accurate results if they control for gender.

There were difficulties with sample retention, which resulted in a significant loss. Future Brazilian studies can focus on aspects that strengthen the retention of adolescents in interventions for weight loss.

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References

Arnold M, Leitzmann M, Freisling H, et al. (2016) Obesity and cancer: An update of the global impact. *Cancer Epidemiology* 41: 8–15.

Bloch KV, Klein CH, Szklo M, et al. (2016) ERICA: Prevalences of hypertension and obesity in Brazilian adolescents. *Revista de Saude Publica* 50(1): 1s–12s.

Boff RDM, Liboni RPA, Batista IPDA, et al. (2016) Weight loss interventions for overweight and obese adolescents: A systematic review. *Eating and Weight Disorders* 22(2): 211–229.

Brick LAD, Yang S, Harlow LL, et al. (2019) Longitudinal analysis of intervention effects on temptations and stages of change for dietary fat using parallel process latent growth modeling. *Journal of Health Psychology* 24(5): 572–585.

De Miguel-Etayo P, Muro C, Santabárbara J, et al. (2016) Behavioral predictors of attrition in adolescents participating in a multidisciplinary obesity treatment program: EVASYON study. *International Journal of Obesity* 40(1): 84–87.

De Onis M, Onyango AW, Borghi E, et al. (2007) Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization* 85(9): 660–667.

Di Noia J and Thompson D (2012) Processes of change for increasing fruit and vegetable consumption among economically disadvantaged African American adolescents. *Eating Behaviors* 13(1): 58–61.

DiClemente CC (2015) Change is a process not a product: Reflections on pieces to the puzzle. *Substance Use & Misuse* 50(8–9): 1225–1228.

DiClemente CC, Norwood AEQ, Gregory WH, et al. (2016) Consumer-centered, collaborative, and comprehensive care: The core essentials of recovery-oriented system of care. *Journal of Addictions Nursing* 27(2): 94–100.

Farah BQ, Ritti-Dias RM, Balagopal PB, et al. (2014) Does exercise intensity affect blood pressure and heart rate in obese adolescents? A 6-month multidisciplinary randomized intervention study. *Pediatric Obesity* 9(2): 111–120.

Finger IDR and Potter JR (2011) Entrevista motivacional no tratamento de sobrepeso/obesidade: uma revisão de literatura. *Revista Brasileira de Terapias Cognitivas* 7(2): 2–7.

Ford AL, Hunt LP, Cooper A, et al. (2010) What reduction in BMI SDS is required in obese adolescents to improve body composition and cardiometabolic health? *Archives of Disease in Childhood* 95(4): 256–261.

França SLG, Sahade V, Nunes M, et al. (2013) Adherence to nutritional therapy in obese

adolescents; a review. *Nutricion Hospitalaria* 28(4): 988–998.

García-Hermoso A, Saavedra JM and Escalante Y (2013) Effects of exercise on resting blood pressure in obese children: A meta-analysis of randomized controlled trials. *Obesity Reviews* 14(11): 919–928.

Gormally J, Black S, Daston S, et al. (1982) The assessment of binge eating severity among obese persons. *Addictive Behaviors* 7(1): 47–55.

Gourlan M, Sarrazin P and Trouilloud D (2013) Motivational interviewing as a way to promote physical activity in obese adolescents: A randomised-controlled trial using self-determination theory as an explanatory framework. *Psychology & Health* 28(11): 1265–1286.

Han H, Gabriel KP and Kohl HW (2015) Evaluations of validity and reliability of a transtheoretical model for sedentary behavior among college students. *American Journal of Health Behavior* 5: 601–609.

Ho M, Garnett SP, Baur LA, et al. (2013) Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: A systematic review and meta-analysis of randomized trials. *JAMA Pediatrics* 167(8): 759–768.

Kong AS, Sussman AL, Yahne C, et al. (2013) School-based health center intervention improves body mass index in overweight and obese adolescents. *Journal of Obesity* 2013: 575016.

Lobstein T, Jackson-Leach R, Moodie ML, et al. (2015) Child and adolescent obesity: Part of a bigger picture. *The Lancet* 385(9986): 2510–2520.

MacDonell K, Brogan K, Naar-King S, et al. (2012) A pilot study of motivational interviewing targeting weight-related behaviors in overweight or obese African American adolescents. *Journal of Adolescent Health* 50(2): 201–203.

Marshall SJ, Simoes EJ, Eisenberg CM, et al. (2013) Weight-related child behavioral interventions in Brazil: A systematic review. *American Journal of Preventive Medicine* 44(5): 543–549.

Menezes MC, Mingoti SA, Cardoso CS, et al. (2015) Intervention based on transtheoretical model promotes anthropometric and nutritional improvements – A randomized controlled trial. *Eating Behaviors* 17: 37–44.

Ott U, Stanford JB, Greenwood JL, et al. (2015) Stages of weight change among an occupational cohort. *Journal of Occupational and Environmental Medicine* 57(3): 270–276.

Peirson L, Fitzpatrick-Lewis D, Morrison K, et al. (2015) Treatment of overweight and obesity in children and youth: A systematic review and meta-analysis. *CMAJ Open* 3(1): E35–E46.

Pereira ÉF, Graup S, Lopes AS, et al. (2009) Percepção da imagem corporal de crianças e adolescentes com diferentes níveis socioeconômicos na cidade de Florianópolis, Santa Catarina, Brasil. *Revista Brasiliera de Saúde Materno Infantil* 9(3): 253–262.

Pirzadeh A, Feizi A, Mostafavi F, et al. (2015) Improving physical activity and metabolic syndrome indicators in women: A transtheoretical model-based intervention. *International Journal of Preventive Medicine* 6(1): 28.

Prochaska JO, DiClemente CC and Norcross JC (1992) In search of how people change: Applications to addictive behaviors. *American Psychologist* 47(9): 1102–1114.

Prochaska JO, Norcross JC and DiClemente CC (1994) *Changing for Good: The Revolutionary Program that Explains the Six Stages of Change and Teaches You How to Free Yourself from Bad Habits*. New York: William Morrow and Company.

Prochaska JO, Norcross JC and DiClemente CC (2013) Applying the stages of change. *Psychotherapy in Australia* 19(2): 10–15.

Resnicow K, McMaster F, Bocian A, et al. (2015) Motivational interviewing and dietary counseling for obesity in primary care: An RCT. *Pediatrics* 135(4): 649–657.

Ribeiro FA, Boff RM, Feoli AMP, et al. (2016) Randomized clinical trial of a motivational interdisciplinary intervention based on the transtheoretical model of change for lifestyle modification in overweight/obese adolescents: MERC study protocol. *International Journal of Clinical Trials* 3(4): 225–232.

Romain AJ, Bortolon C, Gourlan M, et al. (2016) Matched or nonmatched interventions based on the transtheoretical model to promote physical activity. A meta-analysis of randomized controlled trials. *Journal of Sport and Health Science* 7(1): 50–57.

Sanaeinasab H, Saffari M, Nazeri M, et al. (2013) Descriptive analysis of Iranian adolescents'

stages of change for physical activity behavior. *Nursing & Health Sciences* 15(3): 280–285.

Sbruzzi G, Eibel B, Barbiero SM, et al. (2013) Educational interventions in childhood obesity: A systematic review with meta-analysis of randomized clinical trials. *Preventive Medicine* 56(5): 254–264.

Simmonds M, Llewellyn A, Owen CG, et al. (2016) Predicting adult obesity from childhood obesity: A systematic review and meta-analysis. *Obesity Reviews* 17(2): 95–107.

Skelton JA, Irby MB and Geiger AM (2014) A systematic review of satisfaction and pediatric obesity treatment: New avenues for addressing attrition. *Journal for Healthcare Quality* 36(4): 5–22.

Smith KL, Kerr DA, Fenner AA, et al. (2014) Adolescents just do not know what they want: A qualitative study to describe obese adolescents' experiences of text messaging to support behavior change maintenance post intervention. *Journal of Medical Internet Research* 16(4): e103.

Sociedade Brasileira de Cardiologia (2010) VI Diretrizes Brasileiras de Hipertensão. *Arq Bras Cardiol* 95(1 supl.1): 1–51

StataCorp (2011) *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP.

Steinbeck K, Baur L, Cowell C, et al. (2009) Clinical research in adolescents: Challenges and opportunities using obesity as a model. *International Journal of Obesity* 33(1): 2–7.

Stunkard A, Sorensen T and Schlusinger F (1983) Use of the Danish Adoption Register for the study of obesity and thinness. *Research Publications – Association for Research in Nervous and Mental Disease* 60: 115–120.

Velasquez MM, Maurer GG, Crouch C, et al. (2001) *Group Treatment for Substance Abuse: A Stages-of-Change Therapy Manual*. New York: Guilford Press. Available at: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=psyc3&NEWS=N&AN=2001-18669-000

Velasquez MM, Maurer GG, Crouch C, et al. (2013) *Tratamento em Grupo para Usuários de Drogas*. São Paulo, Brazil: Editora Casa do Psicólogo.

Walpole B, Dettmer E, Morrongiello BA, et al. (2013) Motivational interviewing to enhance self-efficacy and promote weight loss in overweight and obese adolescents: A randomized controlled trial. *Journal of Pediatric Psychology* 38(9): 944–953.

World Health Organization (WHO) (2006) *Working together for health. The world health report*, WHO Press, Geneva. Available at: http://www.who.int/whr/2006/whr06_en.pdf

World Health Organization (WHO) (2007) Application tools: WHO AnthroPlus software. Available at: http://www.who.int/growthref/tools/en/

World Health Organization (WHO) (2008) *World health statistics 2008*. Report, WHO Press, Geneva. Available at: http://www.who.int/whosis/whostat/2008/en/

World Health Organization (WHO) (2016) Childhood overweight and obesity. Available at: http://www.who.int/dietphysicalactivity/childhood/en/

Wu YK and Chu NF (2015) Introduction of the transtheoretical model and organisational development theory in weight management: A narrative review. *Obesity Research & Clinical Practice* 9(3): 203–213.

Yanovski JA (2015) Pediatric obesity. An introduction. *Appetite* 93: 3–12.

Yoo EG (2016) Waist-to-height ratio as a screening tool for obesity and cardiometabolic risk. *Korean Journal of Pediatrics* 59(11): 425–431.