



## Trabajo Original

### Interventions directed at eating habits and physical activity using the Transtheoretical Model: a systematic review

#### *Intervenciones dirigidas a los hábitos alimenticios y la actividad física mediante el Modelo Transteórico: una revisión sistemática*

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### Abstract

**Introduction:** The multi-behavioral Transtheoretical Model (TTM) addresses multiple behaviors and it is a promising strategy to control multifactorial morbidities, such as chronic diseases. The results obtained using the TTM are positive, but are not consistently methodical.

**Objectives:** The aim of this study was to systematically review the effectiveness of the Transtheoretical Model in multi-behavioral interventions for changing eating habits and levels of physical activity.

**Methods:** A search on PubMed and SciELO databases was performed with inclusion criteria set for intervention studies before 2016 using the Transtheoretical Model for more than one behavior, including eating habits and/or engaging in physical activity.

**Results and conclusion:** Eighteen studies were identified; there was a predominance of randomized clinical trials, studies conducted in the United States, and the use of the Internet and/or telephone. The selected studies were aimed at changing eating behaviors; five of the studies did not address physical activity. The main results were reduction of fat consumption, an increase in the consumption of fruit and vegetables, and increases in physical activity, which are progressions in the stages of change and weight loss identified by the Transtheoretical Model. However, the studies showed methodological weaknesses, including high participant loss and the omission of information about randomization and blinding.

#### Key words:

Theoretical models.  
Food habits. Exercise.  
Intervention studies.  
Review.

### Resumen

**Introducción:** el Modelo Transteórico multiconductual aborda distintas conductas y es una estrategia prometedora para el abordaje de patologías multifactoriales, sobre todo en las enfermedades crónicas. Los resultados iniciales de su empleo han sido favorables, pero no han sido probados con rigor.

**Objetivos:** el objetivo de este estudio fue realizar una revisión sistemática de la eficacia del Modelo Transteórico en el cambio de hábitos dietéticos y en el grado de actividad física con intervenciones en varias áreas de la conducta.

**Métodos:** se realizó una búsqueda en PubMed y SciELO utilizando como criterios de búsqueda estudios de intervención realizados antes de 2016 y que incluyeran más de un hábito, incluyendo hábitos alimentarios y/o actividad física.

**Resultados y conclusión:** se identificaron 18 estudios, con un predominio de ensayos clínicos aleatorizados, estudios realizados en Estados Unidos de Norteamérica, y uso de Internet y/o teléfono. Los estudios seleccionados tenían como meta el cambio en los hábitos dietéticos. En 5 de los estudios no se incluía la actividad física. El principal resultado de la intervención fue la disminución en el consumo de grasa y el aumento en la ingestión de frutas y verduras, así como un aumento en la actividad física. Estos cambios supusieron progresos en la pérdida de peso. Sin embargo, los trabajos eran metodológicamente débiles, incluyendo una alta tasa de abandonos, y falta de información sobre la aleatorización y cómo se realizó el estudio ciego.

#### Palabras clave:

Modelos Teóricos.  
Hábitos alimenticios.  
Ejercicio. Estudios  
de intervención.  
Revisión.

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## INTRODUCTION

The Transtheoretical Model (TTM) is used in developing and monitoring the effectiveness of health interventions in research and health service contexts. This study focused on the multi-behavioral TTM because it addresses multiple behaviors, which makes it a promising strategy to control multifactorial morbidities, such as chronic diseases (1).

The main pillars of TTM encompass the stages of change (SC), decisional balance, self-efficacy, and processes of change. The SC represents the motivation and promptness of change (2), and progression is mediated by the other components. Decisional balance involves the individual's perception of the advantages and disadvantages of modifying the targeted behaviors and self-efficacy, which is defined as the confidence in the ability to adopt new behaviors. The processes of change comprise cognitive, experimental, and behavioral strategies that encourage the progression across stages (3).

The results obtained using the TTM are positive, but are not consistently methodical. The present work systematically reviewed the effectiveness of the TTM in multi-behavioral interventions for changing eating habits and levels of physical activity.

## METHODS

This review was conducted based on the recommendations of the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guide. The following steps were undertaken in this study: The hypothesis and aims of the study were defined, the criteria for inclusion and exclusion of articles was established, bibliographical research was conducted, the material was carefully read, the information to be obtained from the articles was defined, and the methods of analyzing and presenting the results were established.

The bibliographical research was performed with the purpose of answering the following question: *Has the multi-behavioral change-eating habits and physical activity- using the TTM been effective?* The databases of the United States National Library of Medicine (PubMed) and The Scientific Electronic Library Online (SciELO) were used. The keywords used (in Portuguese and in English) included (1) use of the Transtheoretical Model ("stages of change", "stage of change", "transtheoretical model", "transtheoretical model of change"); (2) addressing more than one behavior: Multi-behavioral Transtheoretical Model ("multiple behavior interventions", "multiple behavior changes"); and (3) inclusion of the eating behaviors and/or physical activity in the intervention ("dietary therapy", "eating habits", "physical activity", "diet and exercise").

All articles published before 2016 were identified, followed by an analysis of their titles, and an analysis of abstracts and full texts. When the title and the abstract met the established criteria, the selected articles were read in full (Table I) (4). Moreover, the articles referenced in this work and additional available publications were recovered using the same inclusion criteria.

To verify agreement on the selection of articles to be analyzed in this review, two authors applied the proposed inclusion criteria in an independent and blinded manner. The *kappa* test was used to measure the concordance between the evaluators. In case of discordance, there was a discussion and a consensus was proposed and, when necessary, the other authors of this work were consulted. The articles associated with an unique study were analyzed separately, but referenced in the text according to the first publication.

## RESULTS

### STUDY SELECTION

The database SciELO did not have any articles containing the multi-behavioral TTM; therefore, only articles found in the PubMed database were analyzed.

The independent evaluators reached an initial consensus over the selection of 78.8% of the articles (*kappa* test: 0.697). The discordance generated resulted mainly from the incomplete description of the methodology in the abstracts.

Figure 1 presents the flowchart used to select the articles. Eighteen studies met the eligibility criteria and were included in this review. The 18 studies evaluated generated 23 publications: Johnson et al. (5); Cook et al. (6), Prochaska et al. (7-9), Logue et al. (10), Jones et al. (11), Svetkey et al. (12) and Elmer et al. (13) (*Premier* Study), Block et al. (14) and Sternfeld et al. (15) (*Alive!* Study), Clark et al. (1), Greaney et al. (16) and Greene et al. (17) (*SENIOR* study), Riebe et al. (18,19), Steptoe et al. (20,21), Van Wier et al. (22,23) (*ALIFE@Work* study), Niederhauser et al. (24) (*Building Strong and Ready Families Program*), Mauriello et al. (25), Velicer et al. (26), Armitage et al. (27), Menezes et al. (28) (Table II).

### METHODOLOGICAL CHARACTERISTICS OF THE STUDIES

From the 18 analyzed studies, 14 were conducted in the United States of America, two in the United Kingdom (20,27), one in Brazil (28) and one in Canada (11).

The sample size in the studies varied from 71 to 5,407 (average = 1,349) participants, and included male and female participants. The average age ranged from 25, 8 to 75 years, with the exception of two studies which samples were composed by preadolescents (26) and adolescents (25) (Table II).

The main inclusion criterion for the studies was the presence of an aggravating factor, such as overweight (9,10,18,20,22,27), high blood pressure (12), increased risk of cardiovascular diseases (20), and diabetes mellitus (11).

The predominant design was the randomized clinical trial (5-12,14,20,22,26,28), but studies of interventions without a control group (CG) (18,26), an experimental (1) and quasi-experimental (24) group were also identified. Only 8 studies clearly described the randomization method used (10,12,14,20,22,26-28).

**Table I.** Information extracted from the studies

<b>Methodological characteristics</b>	
Design	<ul style="list-style-type: none"> <li>– Realization and description of randomization</li> <li>– Presence of a control group</li> <li>– Presence of intervention in the control group</li> </ul>
Population	<ul style="list-style-type: none"> <li>– Statistical comparison of control and intervention groups</li> <li>– Percentage of acceptable abandonment: Acceptable value &lt; 20% in short-term follow-up (≤ 6 months) or &lt; 30% long-term (&gt; 6 months)</li> </ul>
Measurement quality	<ul style="list-style-type: none"> <li>– Realization of blinding in the studies</li> <li>– Comparable time measurements between intervention and control groups</li> <li>– Follow up time acceptable (&gt; 6 months)</li> </ul>
Statistical analysis	<ul style="list-style-type: none"> <li>– Analysis controlled for confounders</li> <li>– Analysis by intention-to-treat</li> </ul>
<b>Outcome variables</b>	
Primary outcome	<ul style="list-style-type: none"> <li>– Consumption and feeding behavior</li> <li>– Physical activity</li> </ul>
Other outcomes	<ul style="list-style-type: none"> <li>– Anthropometric measures: weight, body mass index, waist circumference; and body composition</li> <li>– Pillars of the Transtheoretical Model (TTM)</li> </ul>
<b>Other variables extracted</b>	
Participants	<ul style="list-style-type: none"> <li>– Number</li> <li>– Profile: age, sex, nutritional status and health conditions</li> </ul>
Location and year	<ul style="list-style-type: none"> <li>– Country of conducting the study</li> <li>– Year of publication</li> </ul>
Intervention	<ul style="list-style-type: none"> <li>– Using TTM</li> <li>– Professionals involved</li> <li>– Method of application: Internet, face to face (individual and group) and telephone</li> </ul>

From the 16 studies that had a CG, 31 % (n = 5) did not conduct an intervention. The treatment of the CG was generally defined as “usual care” (1,6,7,10-12,20,22, 8), and only five studies (7,10,12,27,28) described the intensity and type of care.

In the majority of the studies, the comparability of the control and intervention groups (IG) was tested on the baseline values (1,6-12,14,20,24,25,27,28) for demographical and socio-economic variables, among others, with the exception of two studies (5,22). In the study of Van Wier et al. (22,23), the groups were not statistically compared before the intervention, although all the analyses were adjusted by baseline values, which created an adjusted follow-up score.

Most of the trials had a follow-up period of six months or longer (4), varying between one (27) and 36 months (26). Some studies presented participant losses considered acceptable over the short- (≤ 6 months) (6,12,27) and long-term (> 6 months) (5,8,11,12,26); one study did not give the loss information. We found losses ranging between 11,1% (27) and 63% (24) in the short-term studies and between 17,3% (26) and 46% (5) in the long-term studies. In general, these losses were lower in the CG.

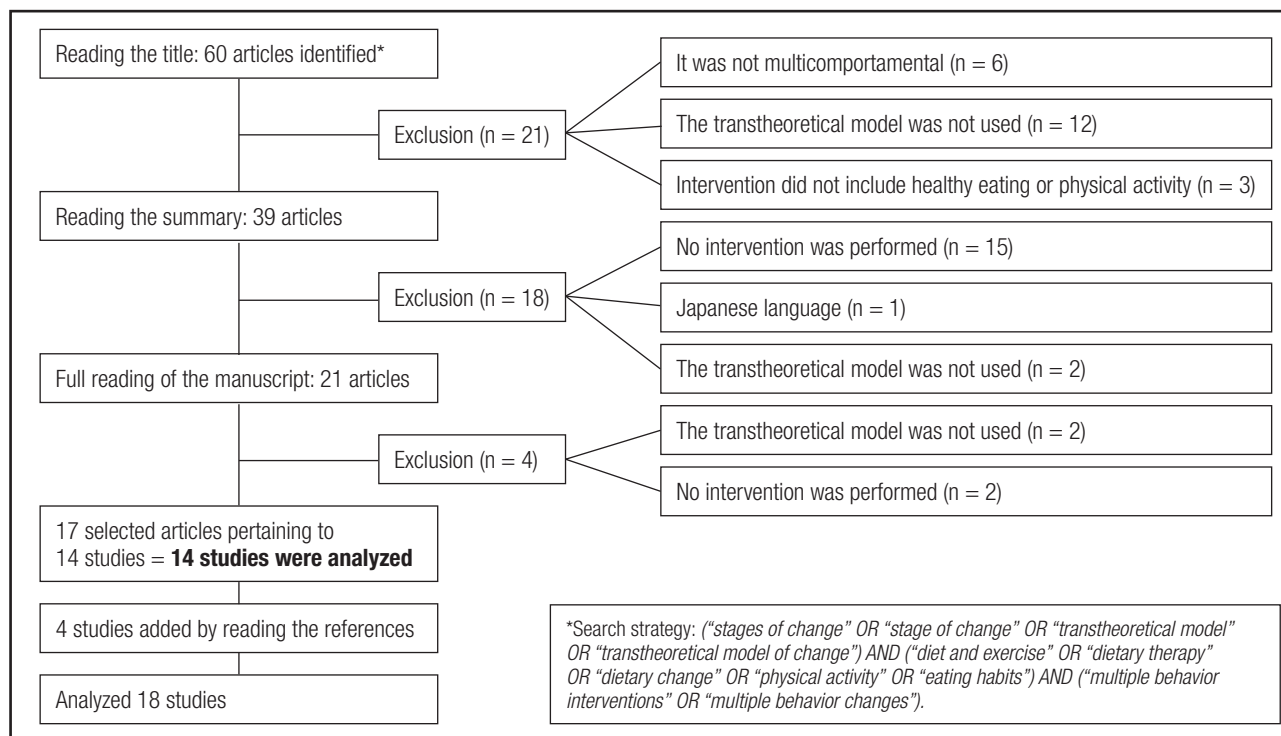
All studies evaluated the CG and IG (intervention group) at comparable time points, and additional analyses were performed

only with the IG; in some studies, this was done for supporting the intervention (8,11).

Seven investigations (39%) did not mention whether the researchers or the participants were blind to status (1,5,7,11,20,22,24), and the reason given was the nature of the interventions (18,20) or the presence of research assistants, who were not blind to the group assignment, during assessments (25,26). The remaining studies explained how blind analyses were performed or the data collection was carried out using self-report questionnaires without the involvement of the researcher (6,8,10,12,14,27,28).

Regarding the statistical analysis of the data, the majority of the studies controlled by potential confounding factors in intention-to-treat analyses (1,5,10-12,14,20,22,25,26). In addition, Prochaska et al. (7,8) used the Generalized Linear Model, a method that allows the evaluation of a changing pattern across time, in addition to performing modeling and evaluation of missing data.

For the evaluation of the main outcomes, the studies used Food Frequency Questionnaires (11,14,17,22), 24 hours Food Records (R24) (10,13,17,18,28) and general questionnaires concerning eating habits and behaviors (6-8,14,25,26,28) to evaluate food consumption. R24 were administered face-to-face, via telephone or computer, two (13) or three (10,17,18,28) times at



**Figure 1.**  
Flowchart of the study selection process.

each evaluation time-point. However, only one study included the consumption of micronutrients (13), while the others limited the analysis to the consumption of calories, lipids, and food groups, including fruit and vegetables (FV).

Concerning the practice of physical activity (PA), the studies applied distinct questionnaires in which the participants reported the duration and/or frequency of the activity (14,16,19,20,22,24-26). A seven-day PA (physical activity) Recall to estimate the daily energy expenditure (10,13), an ergometric test to evaluate the cardiac frequency or maximum oxygen consumption (13,19), a measure of the functional mobility in the elderly (16), monitoring of PA with a pedometer (23) were among the measures used.

Regarding other outcomes investigated, thirteen studies obtained anthropometric data (10,12,18,20,22,27,28) or used self-reported anthropometric information (5,6,9,11,22,24,25). Weight was the most frequently used measurement, and some studies also included Body Mass Index (BMI) (18,19,24,25,27,28), waist circumference (WC) (10,22,28), and body fat percentage (BF %) (19).

Some studies failed to report which questionnaire was used for evaluating the TTM pillar stages of change (6,14) and only a few described the validation of this tool (5,25,26,28). The remaining TTM pillars (processes of change, decisional balance and self-efficacy) were used to monitor the results in only a few interventions (1,6,14,19,22).

## INTERVENTIONS AND THE TRANSTHEORETICAL MODEL

The application methods for the intervention included online platforms, e-mails, phone calls (1,5-11, 14,22,25,26) and group (12,18,28) and individual (9,20) face-to-face meetings.

The professionals engaged in the development and execution of the interventions included nutritionists (10,12,18,22,28), health educators (12,20), health coaches (9), psychologists (10,18,20,28), nurses (20,24), chaplains (24), and physical education teachers (22), or advisors (10,11); seven studies did not report who developed or performed the intervention (1,5,7,8, 25-27). The training of these professionals was mentioned in six of the studies (9,10,12,20,22,28).

The TTM was used as an aid to classify the SC of the participants and assess the intervention (22), as an intervention tool (10,12), or both (1,5-9,11,14,18,20,24-26,28). As an example, in the ALIFE@Work study (22) (performed with overweight workers) the advice related to PA was based on the stages of change, while the advice related to healthy eating habits was based on self-reports of food consumption.

Some interventions were exclusively based on the TTM (1,5,7,8,10,11,18,20,25-28), while others (6,12,14,22) used it in combination with other elements derived from behavioral and cognitive psychology or other theories (9,24).

Table II. Description of the studies included in the review and main results

Studies	Target audience (n) and design	Modality, frequency of intervention, and use of the Trans-theoretical Model (TTM)	Intervention	Significant results - eating habits and physical activity
<i>Premier Study</i> (12,13)	<ul style="list-style-type: none"> <li>Adults with blood pressure above optimal (n = 810)</li> <li>A randomized clinical trial (RCT) multicenter</li> </ul>	<ul style="list-style-type: none"> <li>Modality: Individual and collective intervention</li> <li>Duration and frequency: 18 months, with 14 weeks: weekly; and for 14 weeks, biweekly; monthly rest</li> <li>TTM: Construction of action together with other theories</li> </ul>	<ul style="list-style-type: none"> <li>Control Group (CG): Advice on sodium, alcohol and physical activity - PA (2 visits of 30 minutes)- Intervention Group - IG (1 e 2): CG: intervention and behavioral counseling based on social cognitive theory, techniques motivational and TTM</li> <li>IG 2: DASH diet (↓ total and saturated fat; ↑ fruits and vegetables - FV - and low fat dairy products)</li> </ul>	<ul style="list-style-type: none"> <li>IG 1 and 2: ↓ Consumption of calories, sodium, total and saturated fat; ↑ cardiorespiratory fitness (6m); ↓ weight</li> <li>IG 2: ↑ Consumption of cholesterol and calcium, magnesium, fiber and folate; ↑ number of portions of FV and dairy products</li> </ul>
<i>Alive! Study</i> (14,15)	<ul style="list-style-type: none"> <li>Non medical professionals of business health plan (n = 787)</li> <li>RCT</li> </ul>	<ul style="list-style-type: none"> <li>Modality: E-mail</li> <li>Duration and frequency: 3 months (25 contacts)</li> <li>TTM: Construction of intervention, together with other theories, and evaluation of effectiveness</li> </ul>	<ul style="list-style-type: none"> <li>CG: Untreated</li> <li>IG: Participant chooses a behavior (PA, FV intake, fats and sugar) for sending e-mails tailored to their characteristics, with goals and guidelines for achieving them and overcome barriers, etc.</li> </ul>	<ul style="list-style-type: none"> <li>IG: ↓ Consumption of saturated and trans fats and ↑ FV; ↑ confidence in the ability to improve diet and PA; ↑ time of moderate PA and total; ↑ chance to advance in stages of change (SC) of FV</li> <li>Individuals in pre-action and action: ↑ chance to advance in SC (sugar consumption and PA)</li> </ul>
<i>SENIOR Study</i> (1,16,17)	<ul style="list-style-type: none"> <li>Old-aged people (n = 1,277)</li> <li>Experimental study</li> </ul>	<ul style="list-style-type: none"> <li>Modality: E-mail and telephone</li> <li>Duration and frequency: 12 months (monthly)</li> <li>TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>CG: Prevention materials without description</li> <li>IG: GI-PE (physical exercise), -IG-FV, IG-PE-FV, to approach the 4 pillars of TTM</li> </ul>	<ul style="list-style-type: none"> <li>IG -FV: ↑ FV consumption</li> <li>IG -FV: Maintenance (M) greater use of self-efficacy and processes of change</li> <li>IG - EP: Higher score for pros to adopt or maintain PE. Individuals in pre-action and action: ↑ progression to higher SC</li> </ul>
Cook et al. (6)	<ul style="list-style-type: none"> <li>Officials from staffing firm (n = 419)</li> <li>RCT</li> </ul>	<ul style="list-style-type: none"> <li>Modality: Internet program</li> <li>Duration and frequency: 3 months (free use of the program)</li> <li>TTM: Construction of intervention, together with other theories and assessment of effectiveness</li> </ul>	<ul style="list-style-type: none"> <li>CG: Printed materials containing topics IG</li> <li>IG: Interactive program for the workplace, based on social cognitive theory and MT, addressing healthy eating habits (HEH), PA and stress management</li> </ul>	<ul style="list-style-type: none"> <li>GI and Control Group (CG): ↑ Attitude towards HEH, frequency of healthy eating practices, ↑ motivation to improve diet, intends to practice HEH; improves the SC to PA and HEH; ↑ self-efficacy for diet; ↓ self-reported weight</li> <li>GI: Improved to SC to weight control</li> <li>GC: ↑ Self-efficacy for practicing PA</li> </ul>
Johnson et al. (5)	<ul style="list-style-type: none"> <li>Adults with overweight (Body Mass Index - BMI: 25 to 39.9)</li> <li>(n = 1,277)</li> <li>RCT</li> </ul>	<ul style="list-style-type: none"> <li>Modality: E-mail</li> <li>Duration and frequency: 9 months (quarterly reports)</li> <li>TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>CG: Untreated</li> <li>IG: 4 sets of reports, tailored by 4 dimensions to the TTM for consumption of calories and fat, moderate PE (minimum of 30 minutes, 5 times/week) and individual stress management</li> <li>OBS.: Individuals in maintenance without intervention</li> </ul>	<ul style="list-style-type: none"> <li>IG progressed further stages of action and maintenance (A / M) for PE, HEH and consumption of FV</li> <li>IG for HEH and PE ↓ self-reported weight</li> </ul>

(Continue in the next page)

**Table II (Cont.). Description of the studies included in the review and main results**

Studies	Target audience (n) and design	Modality, frequency of intervention, and use of the Transtheoretical Model (TTM)	Intervention	Significant results - eating habits and physical activity
DISC Study Jones et al. (11)	<ul style="list-style-type: none"> <li>- Individuals with diabetes (n = 1029)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: E-mail and telephone</li> <li>- Duration and frequency: 12 months (bimonthly)</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Usual care, with regular visits from family doctor or endocrinologist and/or groups of diabetes education</li> <li>- IG: Individual reports based on stages of change-SC. Individual counseling by phone to answer questions and facilitate achievement of goals for fat intake, smoking, and blood glucose self-monitoring</li> <li>OBS: <i>Individuals in action/maintenance without intervention</i></li> </ul>	<ul style="list-style-type: none"> <li>- IG: ↓ Total fat intake, ↑ FV intake, progression to higher stages of A/M for glucose monitoring and HEH</li> </ul>
Logue et al. (10)	<ul style="list-style-type: none"> <li>- Adults with overweight (BMI &gt; 27 kg/m<sup>2</sup> or waist / hip ratio &gt; 0.95-men and &gt; 0.80-women) from 15 Primary Care Services (PCS) (n = 665)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: E-mail and telephone</li> <li>- Duration and frequency: two years (monthly)</li> <li>- TTM: Construction of intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: 10 minutes semiannual advice on HEH and PE based on the food pyramid and the American Food Guide</li> <li>- IG: Intervention for fat intake and FV, control food portions, PE and habitual PA, based in SC and calls for weight loss.</li> <li>OBS.: Physicians were trained on use of SC and change processes</li> </ul>	<ul style="list-style-type: none"> <li>- CG and IG: ↓ Calorie intake, ↑ energy expenditure, ↓ weight (6 to 12 m), ↓ waist circumference (WC)</li> <li>- IG: ↑ Minutes of PE weekly</li> </ul>
Prochaska et al. (7)	<ul style="list-style-type: none"> <li>- Parents of teens (n = 2,460)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: E-mail</li> <li>- Duration and frequency: 12 months (reports with 0, 6 and 12 months)</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Received evaluation result of behaviors and SC (with 0, 12 and 24 months)</li> <li>- IG: Reports for each risk behavior – fat intake, sun exposure and smoking, based on TTM</li> </ul>	<ul style="list-style-type: none"> <li>- IG: ↑ FV consumption and behaviors like <i>replacement</i> (food with high fat content underneath), <i>avoid</i> (reduce frequency and amount of foods high in fat) and <i>modification</i> (food preparation)</li> <li>- IG: Progressed further stages of A/M to HEH</li> </ul>
Prochaska et al. (8)	<ul style="list-style-type: none"> <li>- Patients from PCS (n = 5,407)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: E-mail</li> <li>- Duration and frequency: 12 months (reports with 0, 6 and 12 months)</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Received no intervention, but as members of PCS may have participated in actions</li> <li>- IG: Reports for each risk behavior - fat intake, sun exposure, smoking and regular mammograms, based on TTM</li> </ul>	<ul style="list-style-type: none"> <li>- IG: ↑ FV consumption, grains and foods rich in fiber; ↑ modification; progressed further stages of A/M to HEH</li> <li>- GI and GL: ↑ <i>Replacement</i> and <i>avoid</i></li> </ul>

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**Table II (Cont.). Description of the studies included in the review and main results**

Studies	Target audience (n) and design	Modality, frequency of intervention, and use of the Transtheoretical Model (TTM)	Intervention	Significant results - eating habits and physical activity
Riebe et al. (18) Riebe et al. (19)	<ul style="list-style-type: none"> <li>- Participants with BMI between 27-40 kg/m<sup>2</sup> (n = 144)</li> <li>- Intervention without control group (CG)</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: Collective intervention</li> <li>- Duration and frequency: 6 months (4 months: weekly, biweekly rest)</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Untreated</li> <li>- IG: Counseling based on the four pillars of TTM, supervised biweekly treatment of PE and PE stimulus to practice 2 times / week outside the program. Food records in order to reach goal of fat intake, FV and whole grains; balance, variety and moderation</li> </ul>	<ul style="list-style-type: none"> <li>- IG: ↓ Consumption calories, saturated fat and FV; ↓ total fat and carbohydrates (6 months); ↑ VO2 max (3 months) and PE weekly minutes; ↓ weight, BMI and % body fat; progression stages of A/M for the consumption of fat and PE (6 months)</li> <li>- Individuals who kept feeding behavior (&lt; 25% of caloric intake from fat): less temptation to eat fatty foods and greater use of change processes</li> </ul>
Steptoe et al. (20) Steptoe et al. (21)	<ul style="list-style-type: none"> <li>- Patients with increased risk of cardiovascular disease from 20 PCS (n = 883)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: Individual counseling</li> <li>- Duration and frequency: "Brief intervention" (2 or 3 meetings of 20 minutes for those who had 1 or 2 risk factors, respectively)</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Usual care to promote health</li> <li>- IG: Brief behavioral counseling based on SC, interspersed with 1 or 2 phone calls for consolidation and encouraging behavioral change</li> <li>* Patients with elevated serum cholesterol: reduce dietary fat and increase consumption of FV</li> <li>* Patients with high BMI and no regular PA: PA practice</li> </ul>	<ul style="list-style-type: none"> <li>- IG: ↓ Fat consumption; ↑ regular PE; showed greater chance of switching to A/M to fat intake and PE</li> <li>- GI and CG progressed to A/M to fat intake and PE</li> </ul>
ALIFE@ Work Study (22,23)	<ul style="list-style-type: none"> <li>- Workers of 7 companies with overweight (BMI ≥ 25 kg/m<sup>2</sup>) (n = 1,386)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: Telephone or internet (e-mail and site)</li> <li>- Duration and frequency: 6 months (10 biweekly counseling sessions)</li> <li>- TTM: Measured at baseline and used for intervention physical activity together with other theories</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Self-help materials</li> <li>- IG PA: consumption of calories, fat, sugar and alcohol</li> <li>- IG-phone: Advice and lessons guided by principles of behavioral therapy</li> <li>- IG -internet: Interactive site with individual pages and lessons; and contacts with a counselor by email</li> </ul>	<ul style="list-style-type: none"> <li>- IG (phone): ↓ Fat intake; ↑ PA (MET / min) and likely to adhere to the guidance of PA</li> <li>- IG (telephone and internet): ↓ Weight and WC</li> </ul>
Building Strong and Ready Families Program, Niederhauser et al. (24)	<ul style="list-style-type: none"> <li>- Active duty infantry soldiers and their spouses (n = 245)</li> <li>- Quasi-experimental study</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: Collective intervention</li> <li>- Duration and frequency: 3 to 6 week (two day-long sessions)</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- CG: Untreated</li> <li>- IG: Building Strong and Ready Families (BSRF) Program (healthy lifestyle promotion and risk behavior elimination – tobacco, nutrition, PE, safety, spirituality, communication skills, and stress)</li> </ul>	<ul style="list-style-type: none"> <li>- IG: &gt; stage progression in PE</li> </ul>
Prochaska et al. (9)	<ul style="list-style-type: none"> <li>- Adults at risk for at least one risk behavior (exercise, stress, BMI, smoking) (n = 1,400)</li> <li>- RCT</li> </ul>	<ul style="list-style-type: none"> <li>- Modality: Face-to-face, telephonically or online</li> <li>- Duration and frequency: 6 months</li> <li>- TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>- Health Risk Intervention (HRI) group: provide a single step to begin progressing the SC at risk</li> <li>- Motivational Interviewing (MI group): three sessions of health coaching</li> <li>- TTM group: HRI + TTM online with up to four programs (stress, exercise, smoking, and weight management)</li> </ul>	<ul style="list-style-type: none"> <li>- MI and TTM groups: &gt; % of participants in to A/M regarding exercise compared to HRI group</li> </ul>

(Continue in the next page)

**Table II (Cont.).** Description of the studies included in the review and main results

Studies	Target audience (n) and design	Modality, frequency of intervention, and use of the Transtheoretical Model (TTM)	Intervention	Significant results - eating habits and physical activity
Mauriello et al. (25)	<ul style="list-style-type: none"> <li>English-speaking high school students between 9<sup>th</sup> and 11<sup>th</sup> grade (n = 1,800)</li> <li>Effectiveness trial</li> </ul>	<ul style="list-style-type: none"> <li>Modality: Online</li> <li>Duration and frequency: 14 months</li> <li>TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>CG: Untreated</li> <li>IG: online TTM-based program including stage-matched and tailored feedback messages aimed at physical activity, FV consumption and TV time</li> </ul>	<ul style="list-style-type: none"> <li>IG: &gt; number of days doing PA (2 months), more servings of FV (2, 6 and 12 months); progression to A/M for PA (2 months) and FV consumption (2 and 6 months); &gt; stability in A/M for PA (2 months), and FV (6 and 12 months)</li> </ul>
Veicer et al. (26)	<ul style="list-style-type: none"> <li>English speaking sixth grade students (n = 4,158)</li> <li>Randomized two-arm comparison trial</li> </ul>	<ul style="list-style-type: none"> <li>Modality: Online</li> <li>Duration and frequency: 3 years</li> <li>TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>Substance prevention (SP) intervention: TTM-tailored intervention sessions aimed to reduce tobacco and alcohol use</li> <li>Energy balance (EB) intervention: TTM-tailored intervention sessions focused on physical activity, TV time and FV consumption</li> </ul>	<ul style="list-style-type: none"> <li>EB: &gt; relapse prevention and progression to A/M for PA and FV consumption, compared to SP group</li> </ul>
Armitage et al. (27)	<ul style="list-style-type: none"> <li>People already enrolled on a commercial weight loss program in the north of England (n = 72)</li> <li>RCT</li> </ul>	<ul style="list-style-type: none"> <li>Modality: self-administered volitional help sheet</li> <li>Duration and frequency: 1 month (1 session)</li> <li>TTM: Construction of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>CG: Commercial weight loss program and a distracter task</li> <li>IG: Commercial weight loss program and volitional help sheet linking critical situations (temptations) and appropriate responses (processes of change) related to eat</li> </ul>	<ul style="list-style-type: none"> <li>IG: &gt; weight loss at 1 month compared to CG</li> </ul>
Menezes et al. (28)	<ul style="list-style-type: none"> <li>Women in primary health care (n = 71)</li> <li>RCT</li> </ul>	<ul style="list-style-type: none"> <li>Modality: Collective intervention</li> <li>Duration and frequency: 6 months (biweekly)</li> <li>TTM: Construction and effectiveness of the intervention</li> </ul>	<ul style="list-style-type: none"> <li>CG: Usual care (physical activity and open group-education).</li> <li>IG: Usual care and TTM-based workshops aimed at changing the anthropometric and dietetic profile of participants</li> </ul>	<ul style="list-style-type: none"> <li>IG: improved body perception, ↓ weight and BMI, ↓ consumption of calories and foods high in fat</li> </ul>

Note: Preference was given to the findings in the larger follow up described by the study; Results for those that reached significance in only part of the study, the time at which the change was verified were described in parentheses. ↓ - decrease; ↑ - increase; > greater. Pre-action: Name used for the first three stages of change; pre-contemplation, contemplation and decision; Action: Change the last stages of action and maintenance.



## INTERVENTION EVOLUTION: EATING HABITS AND PHYSICAL ACTIVITY

Almost all the studies addressed healthy eating habits (HEH), and thirteen studies included advice on the increasing PA (1,5,6,9,10,12,14,18,20,22,24-26). Interventions focusing on eating habits were particularly aimed at reducing the ingestion of fat and increasing the consumption of FV, which was explicitly addressed in 72% and 38% of the studies, respectively. Others monitored behaviors, including controlling the size of food portions (10), and reducing calories (5,22,28), sodium (13), alcohol (13, 22) and sugar (14, 22) (Table II).

Among the changes in eating habits, significant reductions were observed in the consumption of total fat (11,13,20,22), saturated fat (13,14,19) trans fat (14), calories (10,13,19,28), sodium (13) and cholesterol (12); there was an increase in the ingestion of FV (7,8,11,13,14,17,25,26), vitamins, minerals and fibers (13) (Table II). Positive changes in behavior, such as increased intention, motivation and attitudes to achieve HEH (6), and increased substitution of food with high-fat content for low-fat content, were reported. Reduction in the frequency and quantity of high-fat products and changes in the way the food is prepared (7,8,28) were also observed (Table II).

Some studies documented negative changes in eating habits, such as reduced consumption of FV after 24 months (13) or no alterations after the intervention in the ingestion of sugar (14) and FV (23) (Table II).

The evolution of physical activity was evaluated primarily by the increase in frequency or duration (9,10,14,19,20,22,25,26), whereas the type and intensity of the activities were less explored. The work of Johnson et al. (5) and Cook et al. (6), although including interventions for PA and HEH, did not include the analyses of the evolution in PA frequency and duration (5,6) or in consumption or eating habits (5) (Table II).

As a consequence of alterations in the eating habits and in the practice of physical activity, eight short- and long-term studies showed weight reduction among members of the IG (5,13,19,22,27,28) and CG (6,9, 27), as well as reductions in their WC (10,22), BF % and BMI (19,28) (Table II).

All the studies that evaluated the evolution of the SC reported positive results, and the patients progressed to the stages of action and maintenance (5-8,11,14,16,19,21,24-26) (Table II). Block et al. (14) was the only study that did not find an evolution in the ingestion of fat, despite the positive results for other eating habits.

## DISCUSSION

The multi-behavioral TTM is a promising strategy for the promotion of healthy lifestyles, and positive results for multiple behaviors in various scenarios have been reported (1,7,29,30). However, methodological differences among the studies persist, which hinders the demonstration of their effectiveness and their use in theoretical and practical applications.

The positive points of the analyzed studies include the use of randomized clinical trials, which is an appropriate methodology to assess the effects of an intervention; large sample sizes; long-term follow-up; and suitability of the statistical analyses. Consequently, the majority of the studies found a significant evolution in the stages of action and maintenance in the participants, in addition to changes in the behaviors associated with HEH and PA, with significant differences among the intervention and control groups.

Nevertheless, the studies also had methodological weaknesses, such as participant loss and omission of information concerning randomization and blinding. Most of the studies reported the intervention delivered to the CG participants, although the intensity of the intervention was not reported. Logue et al. (10) verified that, at baseline, 83% of the CG participants reported being advised by a physician to lose weight and 48% had previous experience with commercial programs for weight loss. In some studies, individuals of the CG evolved positively in their eating habits, levels of physical activity, and body weight, possibly due to CG group characteristics similar to those found in Logue et al. (6,10).

The positive changes observed for the CG could also result from recruiting highly motivated volunteers or the financial support given to the participants (6,10). The selection processes used may have attracted individuals more likely to undergo lifestyle changes, who, therefore, were not representative of the general population (12).

Similar methodological weaknesses were also identified in a review that aimed to evaluate the effectiveness of TTM-based interventions on sustainable weight reduction. Besides pointing out the insufficient information related to randomization and blinding, the authors indicate others limitations such as wide use of self-reported measures and lack of post-intervention assessments that could allow verifying long-term weight loss sustainability (31).

It should be highlighted that the use of multi-behavioral TTM is justified considering the complexity of the behaviors associated with people's lifestyles. It is estimated that 15% of the population account for 60% of health care costs due to multiple health-risk behaviors (1). Considering the relevance of maximized cost-effectiveness interventions, multi-behavioral TTM is promising for promoting coaction or paired actions, in which the change on one behavior can have a potential to change another behavior (29,30). The interventions evaluated in this review were included because they were multi-behavioral. However, sometimes the studies did not conduct simultaneous interventions for multiple health risks because some individuals were already at the action and/or maintenance stages for a certain behavior or individuals' choice of a particular type of intervention. Nonetheless, although at advanced stages of change, these individuals could have relapses, which support the multi-behavioral approach.

The interventions used had a heterogeneous set of methods, with different combinations of intensities, follow-up periods, technologies, theoretical models, uses of the TTM, target behaviors, target populations, and variables analyzed. Such heterogeneity makes it difficult to compare or reproduce the studies, in addition to limit the applicability of the discoveries to clinical practice (31).

The use of technological tools was a predominant method of intervention application. This is likely a consequence the complex logis-

tics of face-to-face interventions, which require a large number of professional staff, substantial amounts of time, elevated cost, and other difficulties associated with reaching a large number of participants (6-8,22). On the other hand, the use of technologies may present some difficulties, like assessing the intensity of the intervention, actual participation of the individuals (14), creation of bonds between the educators and the participants, and the sensitization and motivation achieved through virtual communication.

In addition, when evaluated by e-mail, the engagement of the participants was low. In one study, only 30% answered to the evaluation questionnaires sent six and twelve months after the study began (7). The participation in such technological interventions also imposes certain requirements, such as knowing how to read and write and having access to a computer, Internet (1,5-11,14,22), or telephone (1,10,11,22). It also requires that the participants have the basic informatics skills to use interactive platforms, dynamic simulations, and access links (6,14,25,26). Concerning the use of the TTM, although it comprises four pillars, most of the studies explored solely the stages of change, despite the fact that the authors of the studies highlighted the importance of the other TTM mediators. The importance of evaluating all the pillars is evidenced in the work of Greaney et al. and Greene et al. (The SENIOR study) (16,17), in which the participants that received advice on diet and were at the maintenance stage had higher self-efficacy and use of the processes of change (17), whereas those who received intervention for the promotion of physical activity (PA) had a higher score in starting or maintaining activity (16).

Given the heterogeneous methodology observed, we suggest that CG members do not receive treatment or are exposed to interventions comparable in intensity to those received by IG members in future studies; therefore, the only distinction between the groups is the intervention content. Future studies of interventions should be detailed regarding the nature and magnitude of TTM dimensions that are used and carried out with methods applicable to the population in general. Potential limitations of this review include those linked to bibliographical research, such as the possible omission of studies related to the theme (32). On the other hand, to minimize this bias, several strategies were employed; these included using a large number of keywords, determining the search strategies in advance, defining inclusion and exclusion criteria, having two independent researchers select the articles, reviewing any additional references in the selected articles, and contacting the authors of the articles when necessary.

The obtained results reveal a growing interest in the international use of interventions based on the TTM for multiple health-related behaviors, especially using technological tools (computer and telephone), which has not yet been seen in Brazil. They provide evidence of the need for national studies and publications.

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