Transtheoretical model-based nutritional interventions in adolescents: a systematic review

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Abstract

Background: Literature has shown a tendency of inadequate dietary intake among youth, consequently, nutritional interventions are required. The transtheoretical model (TTM) classifies individuals based on their readiness to change. This model is widely used for health education interventions with proven efficacy.

Purpose: This review aimed to weigh the strength of evidence about the TTM usage in nutritional interventions for adolescents and its effectiveness regarding dietary intake.

Methods: This study followed the PRISMA guidelines. Eligible studies were input into Mendeley software. The Adolec, Google Scholar, LILACS, PsycINFO, PubMed, Science Direct and Web of Science databases were searched. Only full original articles written in English, Spanish or Portuguese on randomized controlled trials and quasi-experimental designs that applied the TTM in the design of nutritional interventions targeting adolescents were included, with no restrictions on publication date. The quality and risk of bias was evaluated with the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies.

Results: The initial search yielded 3779 results. Three studies were rated as strong, six as moderate and five as weak. The final sample of 14 articles included adolescents that were mostly recruited from schools, with interventions ranging from one month to three years. The TTM was used alone or combined with other behavior-change theories and most of the interventions involved digital technology. The nutritional topics covered included fruit and vegetable consumption, low-fat diet, and cooking skills. Four studies presented improvement in fruit and vegetable consumption and four progressed through stages of change. Participants from two interventions reduced fat intake. At the end of one intervention, all the participants were in action and maintenance stages.

Conclusion: The TTM seems to be a successful strategy for nutritional intervention aiming at improving dietary intake in adolescents. Its application in different contexts shows that the TTM is flexible and possible to be implemented in many settings. The use of the model is shown to be restricted to the stage of change’ construct. Further studies should use all constructs of the TTM in the design and compare the TTM with other behavior-change theories to better understand its effectiveness.

Background

Adolescence is a period of intense biopsychosocial changes and involves specific nutritional needs [1, 2]. Healthy eating habits are essential to appropriate growth and development in this age group and serve as a protective factor against non-communicable diseases [1, 2]. A tendency toward inadequate eating habits among youth has been documented in the literature, including high intake of sugary drinks [3], skipping breakfast [4] and low consumption of fruits and vegetables [5]. Thus, nutritional intervention is required to ensure healthy growth and prevent the development of chronic diseases while still young [6].
The Transtheoretical Model (TTM) describes change not as an individual event but rather as a series of steps that take place according to a person's degree of motivation. The four constructs of TTM are the stages of change, the processes of change, self-efficacy and decisional balance [7]. Five stages of change have been determined based on motivation level. Individuals in the precontemplation stage are unaware that their behavior is harmful and are not well informed about how to change, so their motivation is low or nonexistent. Individuals in the contemplation stage are less reluctant to change and they may be aware that there is something wrong with their behavior but are unwilling to act. Individuals in the decision stage feel more prepared to act and plan to change according to short-term goals. In the action stage meaningful changes in behavior occur, while in the final stage, maintenance, the new behavior persists for at least six months [7].

Different processes are involved in progression through the stages of change. For example, to cross from precontemplation into contemplation, consciousness raising must occur, and this process mostly applies to initial stages. As individuals progress through the stages, their self-efficacy is expected to increase, i.e. how capable they feel of changing, including recognition that there are more pros than cons to changing, as stated in decisional balance [7].

This model is widely used for health education interventions, such as physical activity [8], fruit and vegetable consumption [9] and weight control [10], with proven efficacy. Some positive aspects of using the TTM include its low-cost, its adaptability to a number of problems [8], and the fact that the intervention can be tailored for participants according to their level of readiness for change [7]. It is known that tailored interventions are more effective for changing health behaviors [11, 12].

There has not yet been a systematic review of adolescent nutritional interventions that adopted the TTM as a theoretical model in the design of the intervention. Moreover, this model consists of many constructs, so it is applied in different ways by different authors. Therefore, this review aimed to weigh the strength of evidence about the TTM usage in nutritional interventions for adolescents, by describing how the TTM (any construct mentioned above or all) is applied to nutritional interventions for adolescents and evaluate its effectiveness.

Methods

This study followed the PRISMA guidelines [13] and is registered on the PROSPERO Website (#CRD42018096819).

Data sources and search strategy

The following databases were searched for articles in English, Portuguese or Spanish: Adeolec, Google Scholar, LILACS, PsycINFO, PubMed, Science Direct and Web of Science. The search was updated twice, once after thirty days and again about a year later to find recently published articles. A librarian from the University of Brasilia assessed the quality of the primary search by filling out the Peer Review of Electronic Search Strategy form. Figure 1 describes the primary search strategy for PubMed, which was
then adapted for the other databases. MeSH Terms were applied, such as “adolescent”, “food intake”, and “health education”. Since transtheoretical model was not a MeSH term, and because the stages of change are described differently in nutritional intervention studies, the following free text words were searched: “transtheoretical model”, “stages of change” and “stages of behavioral change”.

**Eligibility criteria**

Only randomized controlled trials and quasi-experimental studies that included adolescents between ten and nineteen years who had been exposed to any type of nutritional intervention that used at least one TTM construct in the design were eligible. When the original article mentioned about the use exclusively of self-efficacy, it was reviewed only if there was a statement that the TTM was used in the design of the intervention or if another construct of the model was applied, since self-efficacy is a construct of other behavioral change theories as well. No other restrictions were applied, including publication date. Studies involving children and adolescents or young adults and adolescents were included. The exclusion criteria were an unhealthy population, studies that only classified participants according to stages of change as a variable (i.e., without implementing the TTM as a theoretical basis in the design of the intervention), or studies in which the intervention had not yet been implemented. Individuals with obesity were not classified as unhealthy.

**Selection process**

The titles and abstracts found in the database search were input into Mendeley software. Duplicates were removed and assessed manually by the first reviewer. Two reviewers performed the study analysis, which included reading the titles and abstracts and discarding those that did not match the inclusion criteria. Each full paper was read separately by both reviewers. Disagreements between reviewers were resolved by an expert. One reviewer assessed the reference lists of the included studies to find other related articles. An updated search was performed in the databases by one reviewer, and both reviewers assessed the eligible studies for inclusion. Figure 2 shows the entire selection process, including dates.

**Data extraction and Study Quality Assessment**

The data were extracted using a table based on the Centre for Reviews and Dissemination for Undertaking Reviews in Healthcare instructions [14]. Data were extracted on the publication type, country, funding, main purpose, study design, intervention characteristics (time, frequency of exposure, inclusion/exclusion criteria, methods of delivery) and outcomes follow-up, dropout rate, and main results), population characteristics (age, gender, ethnicity), and TTM construct measures. Two reviewers performed this process separately, assessing the quality and risk of bias in each study using the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies [15]. This questionnaire was designed primarily to assess the quality of interventional studies designed for public health purposes, which is the case of the included studies. According to Olivo et al., the questionnaire provides
"excellent agreement for the final grade" of included studies [16]. It extracts information on selection bias, study design, blinding, data collection methods, withdrawals and dropouts, intervention integrity, and analyses performed. The articles were rated for each component and a final global categorical rating was assigned (strong, moderate or weak), as recommended by the Effective Public Health Practice Project. A meta-analysis could not be performed due to heterogeneity of the included studies.

Results

The initial search returned 3779 results, from which 119 duplicates were removed. Of the remaining abstracts, 3572 did not meet the selection criteria and were excluded. Thus, the full texts of 88 articles were read. Of these, 77 did not meet the eligibility criteria for reasons described in Figure 2. The final sample of 11 articles was published between 2003 and 2018 [18, 19, 20, 21, 23, 24, 26, 27, 28, 29, 30, 32, 33]. Two of the articles were assessed jointly because they covered the same intervention [20, 21]. Two articles on interventions that had already been covered in the review were included through a reference list search. Both of these articles were analyzed with the other studies on the same intervention [19, 30]. After the updated search, four more papers were included [17, 22, 25, 31], totaling 17 articles and 14 interventions. All but two of the studies received funding [22, 25], although this was not considered a potential added bias.

Methodological quality of the studies

Five interventions were classified as weak [17, 23, 28, 29, 31], six as moderate [22, 24, 25, 26, 27, 33] and three as strong [18, 20, 32]. Most of the studies were rated as weak due to having a non-representative sample [17, 23, 28, 29] and because blinding was not mentioned in the paper [28, 29]. Further information about the articles’ scores and classifications is available in the supplementary material.

Sampling and recruitment

One study recruited adolescents from youth service agencies [20], another recruited adolescents in search of nutritional counselling [22] and a third recruited adolescents through digital media, radio and television [17]. The remaining studies recruited adolescents from schools [18, 23, 24, 25, 26, 27, 28, 29, 31, 32, 33]. The participants’ age ranged from 7 to 19 years old, with two studies including preteens [25, 33]. The majority of the studies targeted low-income populations [20, 22, 23, 24, 26, 28, 32], with three focusing on middle-income adolescents [18, 27, 29], one on African Americans [20] and two exclusively on girls [26, 27]. Four studies focused on adolescents with obesity [17, 22, 27, 33].

Study design characteristics

The sample sizes varied from 16 to 2983 participants. A total of eight randomized controlled trials [17, 18, 26, 28, 29, 31, 32, 33] and six quasi-experimental studies [20, 22, 23, 24, 25, 27] were included. All but six of the studies had at least two follow-up measurements [18, 22, 25, 29, 31, 33]. The study duration
(including pre-test and post-test measurements) ranged from one month to three years, with many lasting six months or more [18, 22, 26, 27, 28, 29, 32, 33].

**Intervention strategies and measured variables**

The majority of the interventions involved digital technology [18, 20, 23, 26, 28, 29, 32]. Their strategies included the use of websites [18, 29], videos [23] and CD-ROMs [20, 26] as means of providing information and assessment. One intervention involved SMS (Short Messages Service) messages [28]. Two interventions mailed printed materials, such as magazines, letters to families and newsletters [25, 32]. Most of the interventions occurred at schools facilities [18, 23, 24, 25, 26, 27, 29, 31, 32]. Some studies involved dietary assessment methods, such as food frequency questionnaires, 3-day food records, self-reported consumption and food diary [20, 23, 24, 31, 32]. Only one study assessed previous nutritional guidance [32]. Excluding outcomes related to dietary intake, some studies also analyzed anthropometric measures [17, 22, 28, 31] and nutritional knowledge [27]. Other characteristics of the intervention can be found in Table 1.

**Nutritional topic covered in the intervention**

Six aimed at improving fruit and vegetable consumption [18, 20, 25, 28, 29, 32], three promoted a low-fat diet [23, 24, 26], three focused on healthy dietary intake in general [17, 22, 33], one focused in improving food choices and cooking skills [31], and one focused on the reduction of fast food intake and improvement of nutritional knowledge [27].

**Application of the TTM**

All studies but one used the stages of change in the development of the intervention [26]. The majority of them used the stages of change to create a tailored intervention, with the exception of one study that used the stages to direct the content of the intervention to all five stages of change progressively [31]. Six studies exclusively used the stages of change's construct [18, 22, 28, 29, 31, 33]. Seven used the processes of change in accordance with the stages of change to create a tailored intervention [17, 20, 23, 24, 25, 27, 32]. Five studies included decisional balance and self-efficacy as a measure [17, 20, 25, 27, 32] and one used these two constructs in the development of the intervention [26].

Boff et al. scheduled 12 meetings conducted by professionals in different areas, such as psychology, nutrition, physical therapy, and physical education. The meetings were based on the stage of the intervention group [17]. Brick et al. provided tailored TTM-based computer intervention sessions for three groups according to their grade [18]. The TTM-based intervention program of Di Noia et al. included an introductory session and a stage of change assessment, which was followed by three stage-based sessions involving the most suitable change strategies. For those in the precontemplation stage, consciousness raising, dramatic relief and environmental reevaluation were used. For the contemplation/preparation sessions, self-reevaluation and self-liberation were incorporated. For the action/maintenance stages, change reinforcement management, helping relationships,
counterconditioning, and stimulus control were used [20]. Filgueiras et al. provided nutritional counseling that set specific stage-based behavioral change goals, as well as nutritional education workshops [22]. The intervention in Frenn et al. was designed for the whole class, focusing on processes of change appropriate for those only in the precontemplation and contemplation stages. Individual stage-based computer-generated feedback on dietary fat was provided. The processes of change used for the whole class were self-reevaluation and consciousness raising. Decisional balance was explored in half of the intervention sessions, whose topics were reducing barriers to healthy foods and emphasizing its benefits [23]. Frenn et al. provided four class sessions based on processes of change, consciousness raising and self-reevaluation, because the majority of their participants were in the precontemplation or contemplation stages. Separate smaller group sessions took place for those in the preparation, action and maintenance stages [24]. Intervention from Gur et al. presented different components in order to address every stage. Examples of the strategies included a card game to promote the pros of eating F&V and explain their various features [25]. Haerens et al. used concepts of self-efficacy and the benefits and barriers to define the content of and feedback about a fat consumption intervention [26]. Jalambadani et al. provided lessons on identifying and overcoming barriers related to the reduction of fast food consumption and methods for staying motivated. The curriculum also included information on processes of change and self-efficacy [27]. The participants in Lana et al. developed a website based on attitude, social influence and self-efficacy theory and TTM, sending SMS messages to increase self-efficacy [28]. In the study by Mauriello et al., the intervention group received stage-matched, tailored feedback messages based on their TTM assessments, which included all TTM constructs [29]. The non-tailored intervention of Muzaffar et al. provided 12 weekly meetings that included small group discussions led by the educators, hands-on and food preparation activities, and facilitated group decision-making and problem-solving experiences for participants. All content was developed based on all stages of change of the TTM [31]. Toral et al. developed and mailed printed educational materials promoting healthy dietary habits according to their stage of change to the intervention group [32]. Yusop et al. included nutritional counseling in an intervention that was tailored to the participants’ current stage of change. The nutritional counseling topic was based on the participant's current stage of change [33].

**Other theoretical basis**

The TTM was used in all included interventions, although some of them were based on other theories as well. Two studies used a combination of Health Promotion and TTM [23, 24], one used determinants from social cognitive theory [31], another study used a combination of the social cognitive theory and the theory of planned behavior [26], and one article used the Attitudes Social influence Self-efficacy model [28].

**Intervention duration and frequency of exposure**

In one study the participants were exposed to the intervention only once [26], while five interventions had weekly sessions [17, 20, 22, 25, 27, 31, 33], and another sent magazines and newsletters once a month [32]. One study enabled access to a website for nine months, including teacher support [28].
**Main outcomes**

**Fruit and vegetable intake**

There was an improvement in fruit and vegetable consumption in the intervention groups of four studies [20, 25, 28, 29] and four also progressed through stages of change [18, 25, 28, 29]. Participants of intervention of Di Noia et al. increased fruit and vegetable consumption more than controls. Besides, more participants of the intervention group progressed to later stages and maintained recommended intake levels [20]. In the intervention from Gur et al., students in the action and maintenance stages increased, while the students in the other stages decreased [25]. In the study of Lana et al., the number of students who did not consume enough fruit decreased by more than 70% [28]. The intervention group of Mauriello et al. reported eating significantly more servings of fruits and vegetables than the control group [29]. Toral et al. found no differences in the participants’ fruit and vegetable intake or in perceived self-efficacy or benefits and barriers compared to baseline [32].

**Dietary Fat Intake**

There were positive results in intervention groups of Haerens et al. and Freen et al. regarding fat intake reduction [23, 26]. Nevertheless, the percentage of fat increased in Freen et al.’s intervention group, although it was significantly less than the control group [24].

**Other outcomes**

Boff et al. found no significant changes in Body Mass Index and dietary intake when compared to baseline [17]. All the participants in Filgueiras et al. were in the action or maintenance stages by the end of the intervention [22]. Jalambadani et al. found significantly greater weight loss in the experimental group than the control group at the final follow-up [27]. In the intervention of Muzaffar et al. there were no significant differences found between the adult-led and peer-led groups for change in Body Mass Index percentile. All participants significantly reduced kcals/day from baseline to 6-months post-intervention. For the peer-led group, self-reported intake of whole grains (servings/day) increased from baseline to 6-months post-intervention [31]. In Yusop et al. study, weight and waist circumference increased in both groups, but it was more expressive in the control group and no significant differences between groups for dietary intake were found [33].

**Discussion**

This is the first systematic review to collect data on how the TTM has been applied to design nutritional interventions for adolescents. This review also showed the effectiveness of each intervention. The majority of studies used the TTM, most specifically the stages of change, to develop a tailored intervention program. According to Celis-Moralez et al., tailored interventions that incorporate behavior change techniques are more effective than conventional interventions for dietary behavior change [12]. This shows the TTM is a well-known method of tailored interventions [34].
At all times the processes of change were used in combination with the stages of change and also with the aim of tailoring the content of the intervention, except for Jalambadani et al. [27], which included process of change as a variable. In addition, this construct was not found to be used exclusively. According to Velicer et al., using the TTM in interventions can result in higher retention rates, because the participants’ motivation level is adequate for the objectives of the intervention program [35]. One recent intervention [31] used the stages of change to gradually organize the content of the intervention, ensuring that individuals of all stages could receive at least one content matched to their corresponding stage. This study found positive results in the intervention and opens the way for an alternative to a tailored intervention, demanding less time and logistics.

This review points out the fact that decisional balance and self-efficacy are mostly used as a measure of outcome, rather than a tool for the development of interventions. Only one study [26] used these constructs to define the content of and feedback of a nutritional intervention, showing that most studies that claim to be based on theoretical models use, in fact, a part of the model in the design of the intervention, which increases the possibility of variability of results from one intervention to another and decreases the possibility of replication. This statement can be confirmed by the fact that none study used all constructs in the development of the intervention, and only six used all four constructs of the TTM, even as a measure of outcome. Finally, the stages of change show to be the most well-known construct of the TTM, since all interventions, but one, used it, and, of these, six studies used exclusively this construct.

Using the constructs as a measure shows to be positive for interventions. The literature shows TTM as a more sensitive measure of progress for a dietary intake change, and even when the food consumption is not altered, an increase in decisional balance or self-efficacy, or progress through the stages of change can represent a positive outcome [35].

Many studies recruited adolescents from schools, a normal setting for health programs [36], and nine of them also implemented the intervention at the school's facility [18, 23, 24, 25, 26, 27, 29, 31, 32]. Implementing healthy eating programs at schools is recommended by the World Health Organization [37]. In addition, school health programs tend to be more cost-effective [37], a finding also found in this review, since only one of these mentioned above did not obtain positive significant results. [32].

All the studies focusing on low income populations had positive significant results. Targeting this group is extremely important because they are more likely to develop health problems, and these odds can be reduced by changing dietary habits [38].

Two interventions focused only on girls, and both had positive results [26, 27]. A study exploring food preferences by gender and age found some differences: boys preferred more meat and fish, and girls preferred more vegetables and sweets [39]. Besides, girls tend to be more concerned than boys about weight loss, engaging in dieting, and present more guilt over eating too much [40]. These findings suggest that gender preferences should be considered when developing nutritional interventions. When the topic
is specifically tailored to the study population in terms of stages of change, gender and other characteristics, the intervention tends to become more effective [34, 41].

Guerra et al. found that interventions with longer durations have more positive results [42]. According to the TTM, at least six months are required to maintain a behavior. Few studies continued six months or more [18, 22, 28, 32, 33], so the time period is a positive aspect of their design [42]. On the other hand, there were only two follow up assessments in most of the studies, which is a weakness [17, 20, 23, 24, 26, 27, 28, 32].

Some of the studies used a combination of the TTM and other behavioral change theories. To provide a more detailed explanation of health behavior and to reduce complexity, researchers have been trying to integrate diverse theories [43]. Combining theories is useful when their constructs are complementary, since their strengths can be kept and their weaknesses removed, thus a broader range of factors can be explored [44]. For instance, social cognitive theory analyzes the social effects on behavior in a more representative way than TTM, so if these models are combined, gaps are filled in the latter. In a recent meta-analysis, Gourlan et al. found that physical activity interventions based on a single theory presented better outcomes than interventions based on a combination of theories [45]. However, it is unclear whether this conclusion is also valid for nutritional interventions.

This review reinforced the flexibility of the model, since it was applied in different contexts and in a variety of ways: the interventions occurred at schools, dietetic clinics, youth service agencies and online, and the strategies included printed materials, nutritional counseling, group meetings, classroom lessons and digital technology. Many studies used information and communication technologies in their interventions, including strategies involving websites, videos, and CD-ROMs. This is a positive point because these media are highly acceptable among adolescents. Moreover, using digital media facilitates stage-based tailored interventions [11].

Although the effectiveness of the TTM was addressed in the included studies, they had significant methodological differences, such as the outcome of interest, setting, forms of delivering the intervention, and other characteristics. Moreover, no studies compared the effectiveness of different theoretical models for changing dietary intake or even whether it is better not to use them [46]. In addition, a wide range of factors make it difficult to determine whether behavior-change techniques are actually effective: many studies used a combination of two or more theories and effectiveness depends on the way a theory is used, as well as on the study population and design [11, 47]. It is suggested that future studies compare the effects of different behavioral change theories in this age group, so that the effectiveness of the TTM can be more clearly determined.

A meta-analysis could not be performed due to the heterogeneity of the studies. Non-representative samples, low frequency and exposure to the content of the intervention, and short length of follow-up assessment, that were aspects related to the poor quality of the articles included, were the main limitations of the selected studies. The non-inclusion of gray literature in the search is a limitation of this review. Another limitation is the fact this present study was aimed at evaluating effects only on dietary
intake. However, an individual's eating behavior involves several determinants, which were not considered in this review.

This review showed most authors use mainly stages of change when developing nutritional interventions. These interventions are presented as TTM based, although according to Mastellos et al. [48] it is better to categorize these interventions as being based in stages of change construct. Future research in this field should consider usage of all constructs of TTM in development of these interventions.

**Conclusion**

The TTM seems to be a successful strategy for nutritional intervention aiming at improving dietary intake in adolescents. Besides, its application in different contexts shows that the TTM is flexible and possible to be implemented in many settings. The use of the model in the development of the intervention is shown to be restricted to the stage of change' construct and focusing on promoting a tailored intervention. Further studies comparing the TTM with other behavior-change theories should be conducted to better understand its effectiveness.

**Declarations**

**Ethics approval and consent to participate**

Not applicable.

**Consent for publication**

Not applicable.

**Availability of data and materials**

All data and materials are available.

**Competing interests**

The authors declare that they have no competing interests.

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**Authors' contributions**

JN: Data curation, Investigation, Formal analysis, Methodology, Validation, Writing – original draft.

GM: Formal analysis, Methodology, Validation, Writing – review & editing.
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Table

Table 1: Main results of the included studies
| Study and Purpose | Participants’ Characteristics | Intervention | Duration of exposure, follow-up and frequency | Main Results |
|------------------|------------------------------|--------------|-----------------------------------------------|--------------|
| Boff et al. [17] (2018) | Sample: 65 | Who delivered: A multidisciplinary team from the MERC project | Duration: 3 months | Outcome analyzed: Dietary intake and anthropometric variables. |
| To evaluate the effectiveness of a TTM-based intervention on anthropometric, metabolic, and motivational outcomes in obese adolescents. | Age: 15 - 18 y | To whom: Adolescents who were with overweight or obesity | Follow-up: Baseline and after 12 weeks | TTM constructs used: Processes of change |
| | Gender: Male: 57% Female: 43% | Format: Motivational Interdisciplinary Group (IG) and the Traditional Health Education Group (CG) | Frequency: 12 weekly meetings for 1h30min | Decisional balance |
| | Country: Brazil | Context: Online | Self-efficacy | Main results: There was a statistically significant difference only in decisional balance between groups over time. Regarding the interaction effect between groups over time, statistically significant differences were not found for any anthropometric variables. Intervention group reported magnitude of effect more expressive on body mass index percentile, waist circumference, waist-to-hip ratio |
| Brick et al. [18, 19] (2017) | Sample: 2983 | Who delivered: Research assistants | Duration: 3 years | Outcome analyzed: Dietary intake |
| | Age: | To whom: | Follow-up: Baseline, | TTM constructs used: Stages of change |
To evaluate stage progression in a large computer-based, TTM-tailored intervention involving physical activity, fruit and vegetable consumption, TV viewing, and substance abuse prevention.

| 10 - 15 y (mean 11.4 y) | Students |
|-------------------------|----------|
| **Gender:**              | Energy balance intervention and alternate intervention groups |
| Male: 52.2%              | **Context:** The intervention was delivered in school computer laboratories using laptops provided by the study |
| Female: 47.8%            | **Content:** The energy balance group received an intervention to increase fruit and vegetable consumption. The alternate group received an intervention to prevent/cessate smoking and alcohol use. Both groups received TTM-tailored intervention, and feedback |
| **Country:**             | **Follow up assessment every year for 3 years** |
| United States            | **Frequency:** 5 sessions |

**Main Results:** Regarding fruit and vegetable intake, the energy balance group had greater percentages of consumption than the substance use prevention group, progressing to the action or maintenance at 12, 24, and 36 months.

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Di Noia et al. [20, 21] (2008)

To examine the efficacy of a TTM-based computer-mediated intervention to increase fruit and vegetable consumption among economically disadvantaged African American adolescents.

| Sample: 507 | Who delivered: Research staff |
|-------------|------------------------------|
| **Age:** 11 - 14 y (mean 12.4 y) | To whom: African American adolescents from Youth services agencies |
| **Gender:** | **Format:** Computer intervention (CIN) and Control |
| Male: 39% | **Context:** CD-ROM mediated intervention content in Youth services agencies |
| Female: 61% | **Outcome analyzed:** Dietary intake |
| **Country:** United States | **TTM constructs used:** Processes of change, Stages of change, Decisional balance, Self-efficacy |

**Main Results:** The fruit and vegetable intake of those involved in the program increased about 38% more than the control group, an average increase of 0.9 daily servings of fruits and vegetables.
The intervention addressed the health benefits of consuming five or more daily servings of fruits and vegetables. The CIN received stage-tailored sessions.

More youths in the intervention than in the control group progressed to later stages.

| Study | Sample | Who delivered | Duration | Outcome analyzed | TTM constructs used |
|-------|--------|---------------|----------|------------------|---------------------|
| Filgueiras et al. [22] (2018) | 16 | Health professionals | 13 months | Dietary intake and weight change | Stages of change |
| | 11-17 y | Adolescents with obesity | | | |
| | Male: 57% | | Baseline, 6 and 13 months | | |
| | Female: 43% | | | | |
| | Brazil | | | | |
| | Country | | | | |
| | | Format: Individual nutritional counseling and nutritional education workshops | | | |
| | Content: The nutritional education workshops were conducted in the Center of Nutritional Recovery and Education (CREN) | | | | |
| | | Content: All participants went through individual nutritional counseling, according to their stage, in a CREN office, to help them overcome the difficulties and barriers involved in changing dietary habits, reinforcing the positive aspects of the changes that had already been made. | | | |
| Freen et al. [23] (2005) | 103 | Research staff | 1 month | Dietary intake | Processes of change |
| | 11-17 y | Adolescents with obesity | | | |
| | Male: 57% | | Baseline, 6 and 13 months | | |
| | Female: 43% | | | | |
| | Brazil | | | | |
| | Country | | | | |
| | | Format: Individual nutritional counseling and nutritional education workshops | | | |
| | Content: All participants went through individual nutritional counseling, according to their stage, in a CREN office, to help them overcome the difficulties and barriers involved in changing dietary habits, reinforcing the positive aspects of the changes that had already been made. | | | |
To examine the effectiveness of 8 sessions of a TTM/Health promotion intervention (Internet/video-based) to increase physical activity and reduce dietary fat among 7th graders.

| Sample: | Who delivered: |
|---------|----------------|
| 74      | Graduate nursing students in pediatric nursing |
| Age:    | To whom: |
| 12 - 17 y (mean 13.82 y) | Students |
| Gender: | Format: |
| Male: 47% | Control group and Stages of change intervention group |
| Female: 52% | Context: |
| Country: | All classroom interventions took place during the Family and Consumer Education class |
| United States | Content: |
|           | Classroom interventions incorporated processes appropriate for the stages of change |

**Gender:**
- Male: 40.6%
- Female: 59.4%

**Country:**
- United States

**Format:**
- Control group and Intervention group

**Context:**
- The intervention was conducted in a computer laboratory where each student had a computer

**Content:**
- The focus of the intervention was on reducing dietary fat with strategies appropriate for all stages of change, particularly for those in precontemplation and contemplation stages

**1 week before and after intervention**

**Frequency:**
- 8 sessions of 40 min (1 class period)

**Main Results:**
Among those who participated in more than half the sessions, dietary fat decreased from 30.7% to 29.9% of the total calorie intake. The diet of those who participated in less than half of the sessions was not significantly different than the control group.

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Freen et al. [24] (2003)

A stage-based intervention to reduce fat consumption in middle school students.

| Sample: | Who delivered: |
|---------|----------------|
| 74      | Graduate nursing students in pediatric nursing |
| Age:    | To whom: |
| 12 - 17 y (mean 13.82 y) | Students |
| Gender: | Format: |
| Male: 47% | Control group and Stages of change intervention group |
| Female: 52% | Context: |
| Country: | All classroom interventions took place during the Family and Consumer Education class |
| United States | Content: |
|           | Classroom interventions incorporated processes appropriate for the stages of change |

**Format:**
- Control group and Intervention group

**Context:**
- The intervention was conducted in a computer laboratory where each student had a computer

**Content:**
- The focus of the intervention was on reducing dietary fat with strategies appropriate for all stages of change, particularly for those in precontemplation and contemplation stages

**Duration:**
- 4 class periods

**Follow-up:**
- Pre-test, and post-test

**Frequency:**
- 4 sessions of 45min

**Outcome analyzed:**
- Dietary intake

**TTM constructs used:**
- Processes of change
- Stages of change
- Decisional balance
- Self-efficacy

**Main Results:**
The average percentage of fat in dietary intake ranged from 30.7% to 32.8%; the percentage of fat increased less in the intervention group than the control group.
precontemplation and contemplation stages of change by using multiple instructional methods appropriate to middle school students, content to increase knowledge, and peer modeling of skills

| Sample: | Who delivered: | Duration: | Outcome analyzed: |
|---------|----------------|-----------|-------------------|
| Gur et al. [25] (2019) | Sample: 702 | Research team | 8 weeks | Dietary intake |
| Age: 9 - 15 y (mean 12.02 y) | Age: 9 - 15 y (mean 12.02 y) | Research team | 8 weeks | Dietary intake |
| Gender: Male: 45.2% Female: 54.8% | Gender: Male: 45.2% Female: 54.8% | Research team | 8 weeks | Dietary intake |
| Country: Turkey | Country: Turkey | Research team | 8 weeks | Dietary intake |
| Who: Students and their families | Who: Students and their families | Research team | 8 weeks | Dietary intake |
| To whom: Students and their families | To whom: Students and their families | Research team | 8 weeks | Dietary intake |
| Format: Single group | Format: Single group | Research team | 8 weeks | Dietary intake |
| Context: The intervention took place in the classroom | Context: The intervention took place in the classroom | Research team | 8 weeks | Dietary intake |
| Content: The intervention presented different components in order to address every stage. | Content: The intervention presented different components in order to address every stage. | Research team | 8 weeks | Dietary intake |

Haerens et al. Sample: Duration: Outcome analyzed:

Sample: 702

Who delivered: Research team

Duration: 8 weeks

Outcome analyzed: Process of change, Stages of change, Decisional balance, Self-efficacy

Main Results:
The difference in consumption of fruit and vegetable six months after the intervention was 3·7 portions/d for those who were in the precontemplation stage, 3·0 portions/d in those in the contemplation stage and 2·4 portions/d in those in the preparation stage. The difference for those in the action stage was 0·8 portions/d. In the maintenance stage, total F&V consumption had decreased by 1·2 portions/d. Students in the action and maintenance stages increased, while the percentage of students in the precontemplation, contemplation and preparation stages decreased.
To examine the mediating effects of changes in psychosocial determinants of dietary fat intake on changes in fat intake in adolescent girls.

### Sample: 788 School staff
- **Age:** 11 - 15 y (mean 12.9 y)
- **Gender:** Female: 100%
- **Country:** Belgium

### To whom: Female students
**Follow-up:** Baseline and 1 year after intervention
**Format:** Intervention and Control groups
**Frequency:** 1 hour

**Context:** The intervention occurred during class hours

**Content:** The students completed a youth-based version of the computer-tailored fat intake intervention. The TTM was used to define the content and approach of feedback.

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Jalambadani et al. [27] (2017)

To investigate the effects of education (TTM) on reducing fast food consumption among female adolescents suffering from obesity and overweight in Sabzevar, Iran.

### Sample: 420 Research staff
- **Age:** 15 – 18 y (mean 16.36 y)
- **Gender:** Female: 100%
- **Country:** Iran

### To whom: Female students with obesity
**Who delivered:**
**Follow-up:** Pre-test, and post-test
**Format:** Education and Control groups
**Frequency:** 12 weeks

**Context:** The intervention took place in the classroom

**Content:**
The education group participated in meetings that focused on nutrition concepts and identified methods to stay motivated. The meetings also included discussion with students on

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**Outcome analyzed:** Dietary intake and nutritional knowledge

**TTM constructs used:**
- Self-efficacy
- Decisional balance

**Main Results:** The average rates of stages of change, processes of change, and self-efficacy in the education group improved significantly. No statistical significance was obtained for decisional balance between the two groups after the intervention. The education group lost...
difficulty and ease in consumption reduction of fast food.

| Lana et al. [28] (2013) | Who delivered: | Duration: | Outcome analyzed: |
|-------------------------|----------------|-----------|-------------------|
| 737                     | Self-delivered | 9 months  | Dietary intake and weight change |

To assess the impact of a web-based intervention supplemented with text messages to reduce cancer risk linked with smoking, unhealthy diet, alcohol consumption, obesity, sedentary lifestyle and sun exposure.

| Sample: 737 | To whom: Students | Follow-up: Baseline and post-test |
|-------------|-------------------|----------------------------------|
| Age: 12-16 y |                    |                                  |
| Gender: Male: 45.2%  Female: 54.8% | Format: | Frequency: 9 months of website access |
| Country: Spain and Mexico | Context: Online |                               |

Content:
The EG1 and EG2 members had free access to a tailor-made and interactive website. During the academic year, this website was periodically updated with different school and leisure activities related to the avoidance of risk behaviors. The EG2 also received encouraging text messages. Cancer risk behaviors, such as not eating enough fruits and vegetables and being overweight were assessed before and after the study.

| Duration: 9 months | Follow-up: Baseline and post-test | Frequency: 9 months of website access |
|-------------------|----------------------------------|---------------------------------------|

Main Results:
Both groups decreased by more than 70% the number of students who did not consume enough fruit. Prevalence of being overweight in the EG2 decreased significantly (about 20%), while in the other groups it rose during the same period.

Mauriello et al. [29, 30] (2010)
To report on the effectiveness of Health in Motion, a computer

| Sample: 1800 | Who delivered: Research assistants | Duration: 2 months | Outcome analyzed: Dietary intake |
|-------------|-----------------------------------|--------------------|----------------------------------|
| Age: Mean 15.9 y | To whom: Students | Follow-up: Baseline and after 6 and 12 months |
| Gender: Male: 49.2% | Format: |                               |

TTM constructs used:
Stages of change

Main Results:
The multimedia intervention group
tailored multiple behavior intervention for adolescents. Female: 50.8%

Country: England

Multimedia intervention and Control groups

Context:

All sessions were administered via computers in school computer laboratories

Content:

Students self-directed through the 30-minute program in which they completed a series of TTM-based assessments and received stage-matched and tailored feedback messages related to fruit and vegetable consumption based on their responses.

Frequency: 3 sessions

reported eating significantly more servings of fruits and vegetables than the control group at 2 months, 6 months, and 12 months.

 Individuals within the intervention group were found 1.4–4.2 times more likely to progress to action or maintenance.

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Muzaffar et al. [31] (2019)

To evaluate the afterschool PAWS (Peer-education About Weight Steadiness) Club program delivered by peer or adult educators to improve food choices, physical activity, and psychosocial variables related to healthy eating.

Sample: 109

Age: 11-14y

Gender: Male: 30%

Female: 70%

Country: United States

Who delivered: Educators

To whom: Students

Format: Peer-led and adult-led groups

Context: The intervention occurred at school

Content: The curriculum was focused on building healthy eating patterns and addressing stages of change variables. Printed goal-setting worksheets were provided to the participants at each of the 12 sessions.

Duration: 12 weeks

Follow-up: Baseline, post-intervention, and 6 months after the intervention

Frequency: Weekly sessions of 1h30min

Outcome analyzed: Dietary intake and weight change.

TTM constructs used: Stages of change

Main Results:

There were no significant differences found between the adult-led and peer-led groups for change in Body Mass Index percentile. All participants significantly reduced kcals/day from baseline to 6-months post-intervention. For the peer-led group, self-reported intake of whole grains (servings/day) increased from baseline to 6-months post-intervention.
| Toral et al. [32] (2012) | To assess the impact of a six-month stage-based intervention on fruit and vegetable intake for perceived benefits, barriers and self-efficacy among adolescents. |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Sample:** 771          | **Who delivered:** Research staff                                                                                     | **Duration:** 6 months                           |
| **Age:** 11 - 19 y       | **To whom:** Students                                                                                                          | **Follow-up:** Baseline, and follow-up assessment after the intervention |
| **Gender:** Male: 40.5%  | **Format:** Intervention Group and Control Group                                                                           | **Frequency:** 6 monthly newsletters and magazines |
| Female: 59.5%            | **Context:** The materials were distributed in classrooms and by mail                                                  |
| **Country:** Brazil      | **Content:** The students received printed educational materials for promoting healthy dietary habits, both in classrooms and by mail. The materials were directed toward the participants’ stages of change. |
|                         | **Outcome analyzed:** Dietary intake                                                                                       | **TTM constructs used:** Processes of change      |
|                         | **TTM constructs used:** Stages of change                                                                                   | Stages of change                                 |
|                         | **Main Results:** No significant changes were found in fruit and vegetable intake, benefits, barriers or perceived self-efficacy. | Self-efficacy                                      |

| Yusop et al. [33] (2018) | To assess the effectiveness of a stage-based lifestyle modification intervention for children with obesity. |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Sample:** 40            | **Who delivered:** Researchers                                                                                                         | **Duration:** 24 weeks                           |
| **Age:** 7 - 11 y (mean 9.8 y) | **To whom:** Students with obesity and parents                                                                                   | **Follow-up:** Baseline, follow up every month and at the end of the intervention |
| **Gender:** Male: 52.5%   | **Format:** Intervention group and Control group                                                                               | **Frequency:** 3 sessions of 2h of aerobic exercise on weekends (once every 2 months); 1h of Nutritional counseling every week. |
| Female: 47.5%             | **Context:** The intervention study was conducted at a university Dietetic Clinic                                                   |
| **Country:** Malaysia     | **Content:** Intervention group received stage-based                                                                                   | **Outcome analyzed:** Dietary intake and anthropometric variables |
|                         | **TTM constructs used:** Stages of change                                                                                           | Stages of change                                 |
|                         | **Main Results:** The increases in weight and waist circumference were significantly higher in the control group than in the intervention group. Body Mass Index for age z-scores decreased significantly in the intervention group only. Dietary intake was not significantly different between the two groups. |
lifestyle modification intervention based on the Nutrition Practice Guideline for the Management of Childhood Obesity, while control group received standard treatment.

Figures

adolescent OR adolescents OR adolescence OR teen OR teens OR teenager OR teenagers OR youth OR youths

AND

"nutritional intervention" OR "nutritional interventions" OR "intervention study" OR "intervention studies" OR education OR "health education" OR "nutrition education"

AND

eating OR food OR "food intake" OR ingestion OR consumption OR "food consumption" OR "feeding behavior" OR "feeding behaviors" OR "eating behavior" OR "eating behaviors" OR "feeding pattern" OR "feeding patterns" OR "dietary habit" OR "dietary habits" OR "food habits" OR "food habit" OR "eating habit" OR "eating habits" OR "diet habit" OR "diet habits"

AND

"transtheoretical model" OR "stages of change" OR "stages of behavioral change"

Figure 1

PubMed search strategy
Figure 2

Selection process

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.
• QUALITYASSESSMENTQUESTIONNAIRE.xlsx
• DATAEXTRACTIONTABLE.xlsx