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

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Abstract

Background Literature has shown a tendency of inadequate eating habits 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 and it has been associated with positive results. **Purpose** This review aimed to describe how the TTM has been applied to nutritional interventions for adolescents. **Methods** 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 to nutritional interventions targeting adolescents were included, with no restrictions on publication date. **Results** The initial search yielded 3779 results, of which 13 were included. Two more articles were added after a search update, totaling 15 articles. The included adolescents were mostly recruited from schools, and the duration of the studies ranged from one month to three years. The TTM was used alone or combined with other behavior-change theories. Nine interventions had positive results. The participants in six studies progressed through stages of change or improved decisional balance. **Conclusion** There are some limitations related to the studies included in this review, such as the differences in design and intervention exposure time, as well as using the TTM in association with other behavior-change theories. Nevertheless, the TTM seems to be a successful strategy for nutritional intervention in adolescents. Further studies comparing the TTM with other behavior-change theories should be conducted 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, since it can lead to improvements in both dietary consumption and eating behaviors.

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. 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 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 [6].

Different processes are involved in progression through the stages of change [6]. 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. The four constructs of TTM are the stages of change, the processes of change, self-efficacy and decisional balance [6].

This model is widely used for health education interventions, such as physical activity [7], fruit and vegetable consumption [8] and weight control [9], and it has been associated with positive results. Some positive aspects of using the TTM include its low-cost, its adaptability to a number of problems [7], and the fact that the intervention can be tailored for participants according to their level of readiness for change [6]. It is well known that personalized interventions are more effective for changing health behaviors [10, 11].

There has not yet been a systematic review of adolescent eating behavior interventions involving the TTM. Moreover, this model consists of many constructs, so it is applied in different ways by different authors. Therefore, this review aimed to describe how the TTM is applied to nutritional interventions for adolescents and evaluate its effectiveness.

Methods

This study followed the PRISMA guidelines [12] 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: Adolec, 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”, “feeding behavior”, 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 according to TTM constructs were eligible. No other restrictions were applied. 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 for the intervention), or studies in which the intervention had not yet been implemented. Obese individuals were not classified as unhealthy. No restrictions were set regarding publication date.

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 Centre for Reviews and Dissemination for Undertaking Reviews in Healthcare instructions [13]. Data were extracted on the publication type, intervention characteristics and outcomes, population characteristics (such as age, gender, ethnicity), and measures, including 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 [14]. 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 [15]. 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 hand search of references from the included studies was also conducted. 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 [16, 17, 18, 19, 20, 21, 22,

23, 24, 25, 26]. Two of the articles were assessed jointly because they covered the same intervention [19, 20]. 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 [25, 27]. After the updated search, two more papers were included [29, 30], totaling 15 articles and 12 interventions. All but one of the studies received funding, although this was not considered a potential added bias.

Methodological quality of the studies

Four articles were classified as weak [16, 18, 24, 30], five as moderate [17, 21, 23, 26, 29] and three as strong [19, 24, 27]. Most of the studies were rated as weak due to having a non-representative sample [16, 18, 24, 30] and because blinding was not mentioned in the paper [16, 24]. 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 [19, 20], another recruited adolescents in search of nutritional treatment [29] and a third recruited adolescents through digital media, radio and television [30]. The remaining studies recruited adolescents from schools [16, 17, 18, 21, 22, 23, 24, 25, 26]. The participants' age ranged from 7 to 19 years old, with only one study including preteens, whose age ranged from 7 to 12 years old [21]. The other studies included adolescents between twelve and nineteen years old. The majority of the studies targeted low-income populations [17, 18, 19, 21, 22, 23, 24, 29], with three focusing on middle-income adolescents [16, 25, 26], one on African Americans [19] and two exclusively on girls [17, 26]. Four studies focused on obese adolescents [21, 26, 29, 30].

Study design characteristics

The sample sizes varied from 21 to 4158 participants. A total of seven randomized controlled trials [16, 17, 21, 22, 24, 25, 30] and five quasi-experimental studies [18, 19, 23, 26, 29] were included. All but four of the studies had two follow-up measurements, [16, 21, 25, 29]. The study duration (including pre-test and post-test measurements) ranged from one month to three years, with many lasting six months or more [16, 17, 21, 22, 24, 25, 26, 29].

Intervention strategies and measured variables

The majority of the interventions involved digital technology [16, 17, 18, 19, 22, 24, 25]. Their strategies included the use of websites [16, 25], videos [18], e-mail [22] and CD-ROMs [17, 19] as means of providing information and assessment. One intervention involved SMS messages [24]. One intervention mailed magazines and newsletters [22]. Some studies used nutritional counseling targeting the specific processes of change as ways to promote behavioral change [21, 29, 30]. Regarding the topics covered, four studies focused on strategies for obese adolescents [19, 24, 29, 30], three promoted a low-fat diet [17, 18, 23], one focused on reducing cancer risk behaviors [24], three aimed at preventing obesity or improving fruit and vegetable consumption [16, 19, 25]. Some of the interventions also focused on physical activity [16, 18, 21, 23, 24, 25, 29, 30]. Most of the interventions occurred during class [16, 17, 18, 23, 25, 26]. Some studies involved dietary assessment methods, such as food frequency questionnaires, 3-day food records, and self-reported consumption [18, 19, 20, 22, 23]. One study assessed previous nutritional guidance [22], and seven evaluated physical activity status [16, 18, 21, 23, 24, 25, 30].

Application of the TTM

All studies but one assessed stages of change [17]. Seven studies included measures of decisional balance [16, 17, 19, 22, 23, 26, 30], five measured self-efficacy [17, 19, 22, 26, 30] and only one measured processes of change [26]. The participants in Mauriello et al. received stage-matched, tailored feedback messages based on their TTM assessments, which included all TTM constructs [16]. Haerens et al. used the TTM to define the content of and feedback about a fat and fruit consumption intervention. Concepts of self-efficacy and the benefits and barriers to fat intake were also applied [17]. The intervention in Frenn et al. was designed for the whole class, focusing on processes of change appropriate for those in the precontemplation and contemplation stages. Individual stage-based computer-generated feedback on physical activity and 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 physical activity and emphasizing its benefits [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 [19, 20]. 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 [21]. Toral et al. developed and mailed printed educational materials promoting healthy dietary habits to participants according to their stage of change [22]. 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. Lana et al. developed a website based on attitude, social influence and self-efficacy theory and TTM, sending SMS messages to increase self-efficacy [24]. Brick et al. provided tailored TTM-based computer intervention sessions for three groups according to their grade [25]. Jalambadani et al. provided lessons on identifying and overcoming barriers and methods for staying motivated. The curriculum also included information on processes of change and self-efficacy [26]. Filgueiras et al. provided nutritional counseling that set specific stage-based behavioral change goals, as well as nutritional education workshops [29]. 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 [30].

Other theoretical bases

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 [18, 23], one measured psychosocial determinants from social cognitive theory and the theory of planned behavior [17], and one article used the Attitudes Social influence Self-efficacy model in association with the TTM [24].

Intervention duration and frequency of exposure

In one study the participants were exposed to the intervention only once [17], while five interventions had weekly sessions [19, 21, 26, 29, 30], and another sent magazines and newsletters once a month [22]. One study enabled access to a website for nine months, including teacher support [24].

Main outcomes

Nine interventions found improvement in dietary behaviors or TTM measurements [16, 17, 18, 19, 21, 24, 25, 26, 29], with significant differences in comparison with the control group. Jalambadani et al. found significantly greater weight loss in the experimental group than the control group at the final follow-up [26], whereas in Yusop et al. weight increased in both groups, although it was more expressive in the control group [21]. These authors also found statistically significant increases in physical activity in the intervention group compared to the control group, although there were no significant differences between groups for dietary intake [21]. There were positive results in intervention groups of Haerens et al. and Freen et al. regarding fat intake [17, 18]. Nevertheless, the percentage of fat increased in Freen et al.'s intervention group, although it was significantly less than the control group [23]. Freen et al. also found improvement in physical activity in the intervention group [23]. 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 [22]. There was an improvement in fruit and vegetable consumption in the intervention groups of three studies [16, 19, 24] and two also progressed through stages of change [16, 24]. Participants from one intervention had a higher probability of transitioning toward maintenance [25]. All the participants in Filgueiras et al. were in the action or maintenance stages by the end of the intervention [29].

Discussion

This is the first systematic review to collect data on how the TTM has been applied to nutritional interventions for adolescents. This review also showed the effectiveness of each intervention. According to Celis-Morales et al., personalized interventions that incorporate behavior change techniques are more effective than conventional interventions for dietary behavior change [11]. This is important since the TTM is a method of personalizing interventions and, thus, interventions involving the TTM that had positive outcomes provide evidence for the efficacy of personalized intervention.

Many studies recruited adolescents from schools, a normal setting for health programs [31]. Implementing healthy eating programs at schools is recommended by the World Health Organization [32]. In addition, school health programs tend to be more cost-effective [32]. The studies focusing on low income populations had positive 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 [33].

Two interventions focused only on girls, and both had positive results [17, 26]. 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 [34]. This indicates that gender preferences should be considered when developing nutritional interventions. When the topic is specifically tailored to the study population, the intervention becomes more effective.

At baseline, stages of change were the most commonly measured construct (eleven articles) [16, 18, 19, 21, 22, 23, 24, 25, 26, 29, 30], while the processes of change were measured only once [26]. Eight studies measured decisional balance [16, 17, 19, 22, 23, 26, 30] and five measured self-efficacy [17, 19, 22, 26, 30]. This was probably due to the higher availability of validated questionnaires on stages of change. Only three studies presented follow-up assessments for three constructs: stages, decisional balance and self-efficacy [19, 22, 26].

Since the most measured construct at follow-up was stage of change, it also had more positive results, with a significant increase compared to controls in six studies [16, 19, 23, 25, 26, 29]. One study found that self-efficacy meaningfully increased after intervention [26], and one study found an increase in decisional balance [19]. Two studies found no significant increase in any construct [17, 22]. The low frequency of exposure to the intervention or aspects of their designs are possible explanations for this result.

Guerra et al. found that interventions with longer durations have more positive results [36]. According to the TTM, at least six months are required to maintain a behavior. Seven studies continued six months or more, so the time period was a positive aspect of their design [36]. On the other hand, there were only two follow up assessments in most of the studies, which is a weakness [17, 18, 19, 22, 23, 24, 26, 30].

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 [37]. 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 [38]. 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 [39]. However, it is unclear whether this conclusion is also valid for nutritional interventions.

Seven studies used information and communication technologies in their interventions, including strategies involving websites, videos, email 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]. According to Rose et al., using digital media leads to short-term results [40], although long-term results are difficult to infer in the present review since many of the studies only had one follow up assessment [18, 19, 21, 22, 23, 24, 26, 29, 30].

Regarding nutritional intervention strategies, although one intervention, whose objective was to reduce dietary fat intake, found that it increased in both the intervention and the control group, it can be suggested that this result was influenced by other factors besides the intervention, given that the intervention group's consumption increased significantly less than the control group's [26].

Eight interventions focused on physical activity associated with a nutritional component. Browne et al. reported that a combination of physical activity and nutritional intervention is more effective than either one alone [41].

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 [42]. In addition, the TTM is a more sensitive measure of progress for eating behavior change. 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 [42]. Theories of behavioral change, including the TTM, tend to emphasize the individual's characteristics over social and environmental factors [43], so the design of the intervention should incorporate such variables to guarantee its effectiveness.

Although the effectiveness of the TTM was addressed in the included studies, they had significant methodological differences. Moreover, no studies compared the effectiveness of different theoretical models for changing eating habits, or even whether it is better not to use them [44]. Moreover, 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 [45]. 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 short length of follow-up assessment, and poor study designs were among the limitations of the selected studies. The non-inclusion of gray literature in the search is a further limitation of this review.

Conclusion

There are some limitations related to the studies included in this review, such as the differences in design and intervention exposure time, as well as using the TTM in association with other behavior-change theories. Nevertheless, the TTM seems to be a successful strategy for nutritional intervention in adolescents. 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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The study received no financial support.

Authors' contributions

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

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

NT: Conceptualization, Project administration, Supervision, Visualization, Writing – review & editing.

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Tables

Table 1: Main results of the included studies

<i>Study</i>	<i>Purpose</i>	<i>Participant characteristics</i>	<i>Intervention</i>	<i>Duration of exposure, follow-up and frequency</i>	<i>Main results</i>
Mauriello et al. [16]	To report on effectiveness of Health in Motion, a computer-tailored multiple behavior intervention for adolescents.	Sample: 1800 Mean age: 15.9 y Gender: Male and female Country: England	Self-directed 30-minute TTM-based assessments and stage-matched and tailored feedback messages based on participant responses.	Duration: 2 months. Follow-up: Baseline and after 6 and 12 months. Frequency: Three intervention sessions.	The treatment group reported eating significantly more servings of fruits and vegetables than the control group at 2 months, 6 months, and 12 months.
Haerens et al.[17]	To examine the mediating effects of changes in psychosocial determinants of dietary fat intake on changes in fat intake in adolescent girls.	Sample: 843 Age: 11 - 15 y (mean 12.9 y) Gender: Female Country: Belgium	Students completed a youth-based version of the computer-tailored fat intake intervention during one class hour.	Duration: 1 hour. Follow-up: Baseline and 1 year after intervention. Frequency: One class hour.	On average, fat intake in the intervention group was reduced by 9.0 g/day vs. the control group.
Freen et al. [18]	To examine the effectiveness of 8 sessions of a TTM/Health promotion intervention (Internet/video-based) to increase physical activity and reduce dietary fat	Sample: 134 Age: 12 - 14 y Gender: Male and Female Country: United States	Each student was provided with a computer to participate in an intervention that focused on strategies appropriate for all stages of change, particularly the precontemplation	Duration: One month. Follow-up: One week before and after intervention. Frequency: 8 sessions of 40 min (one class period).	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

	among 7 th graders.		and contemplation stages.		the sessions was not significantly different than the control group.
Di Noia et al. [19]	To examine the efficacy of a TTM-based computer-mediated intervention to increase fruit and vegetable consumption among economically disadvantaged African-American adolescents.	Sample: 549 Age: 11 - 14 y (mean 12.4 y) Gender: Male and Female Country: United States	In the introductory session, the program described the benefits of consuming five or more daily servings of fruits and vegetables. Three additional intervention sessions were completed according to the students' classification.	Duration: 4 weeks. Follow-up: Two weeks before and after the intervention. Frequency: Four onsite 30-minute weekly sessions.	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.
Yusop et al. [21]	To assess the effectiveness of a stage-based lifestyle modification intervention for obese children.	Sample: 50 Age: 7 - 11 y (mean 9.8 y) Gender: Male and Female Country: Malaysia	A stage-based intervention that included activities such as nutrition counseling, and a hands-on activity (healthy food preparation). Study conducted at the University Putra Malaysia.	Duration: 24 weeks. Follow-up: baseline, follow up every month and at the end of the intervention. Frequency: Three sessions of 2 hours of aerobic exercise on weekends (once every two months) 1 hour of	After the intervention, the participants were at higher stages of change (maintenance or action) and were consuming less fat than those at lower stages, specifically precontemplation. This difference showed that enrolment in nutrition

				Nutritional counseling every week.	counseling raised awareness about nutrition.
Toral et al. [22]	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: 860 Age: 11 - 19 y Gender: Male and Female Country: Brazil	Each month for six months, the intervention group received colorful printed magazines on healthy eating and information newsletters directed toward the participants' stage of change.	Duration: 6 months. Follow-up: Baseline, and follow-up assessment after the intervention. Frequency: A total of 6 monthly newsletters and magazines.	No significant changes were found in fruit and vegetable intake, benefits, barriers or perceived self-efficacy.
Freen et al. [23]	A stage-based intervention to reduce fat consumption in middle school students.	Sample: 182 Age: 12 - 17 y (mean 13.82 y) Gender: Male and Female Country: United States	A four-session stage-based classroom intervention on fat consumption during a middle school Family and Consumer Education class.	Duration: Four class periods. Follow-up: Pre-test, and post-test. Frequency: Four 45-min sessions.	The average percentage of fat in food ranged from 30.7 % to 32.8 %; the percentage of fat increased less in the intervention group than the control group.
Lana et al. [24]	To assess the impact of a web-based intervention supplemented with text messages to reduce cancer risk linked with smoking, unhealthy diet,	Sample: 2001 Age: 12- 16 y Gender: Male and Female Country: Spain and Mexico	Free access to a tailor-made interactive website was given to an experimental group, which was divided into two subgroups, one of which also	Duration: 9 months. Follow-up: Baseline and posttest. Frequency: 9 months of website access.	In the SMS subgroup, the number of students who did not consume enough fruit decreased by more than 70%, although the same thing

	alcohol consumption, obesity, sedentary lifestyle and sun exposure.		received SMS messages.		occurred in the other groups.
Brick et al. [25]	To evaluate change stage progression in a large computer-based, TTM-tailored intervention involving physical activity, fruit and vegetable consumption, TV viewing, and substance abuse prevention.	Sample: 4158 Age: 10 - 15 y (mean 11.4 y) Gender: Male and Female Country: United States	There were 5 group-specific 30-min computerized intervention sessions. The energy balance intervention aimed to increase or sustain physical activity and fruit and vegetable consumption, as well as reduce TV viewing. The alternate intervention was to prevent substance abuse.	Duration: Three years Follow-up: Baseline, follow up assessment every year for three years. Frequency: 5 sessions.	Regarding fruit and vegetable consumption, the energy balance group had greater percentages than the substance use prevention group, progressing to the action or maintenance at 12, 24, and 36 months.
Jalambadani et al. [26]	Investigated the effects of education (TTM) on reducing fast food consumption among female adolescents suffering from obesity and	Sample: 420 Age: 15 -18 y (mean 16.36 y) Gender: Female Country: Iran	The participants were assigned to an education or a control group. Each group met for 60 minutes twice a week for 12 weeks. The curriculum focused on identifying the	Duration: 12 weeks Follow-up: Pre-test, and post-test. Frequency: 60 min, twice a week.	Changes in average self-efficacy scores showed an increasing trend from elementary to advanced stages. The education group lost significantly more weight at

	overweight in Sabzevar, Iran.		changing behavior of subjective norms, perceived behavioral control, stage of change, decisional balance, processes of change and self-efficacy.		the final follow-up than the control group.
Filgueiras et al.[29]	A multidisciplinary TTM-based motivational intervention involving nutritional counseling for obese and low-income adolescents.	Sample: 21 Age: 11- 17 y Gender: Male and Female Country: Brazil	<p>The participants were classified in stages of change to study motivation and development of goals for nutritional behavior change - The participants ————received nutritional counseling once a month and nutritional education workshops once a week.</p>	Duration: 13 months Follow-up: Baseline, 6 and 13 months. Frequency: Once a week.	At the beginning, about 70% of the participants were in the precontemplation stage. After six months, 60% had changed to the action stage. At the end of the intervention, all participants had reached the action or maintenance stages. Body fat was reduced by about 4% and there was a 3% increase in lean mass.
Boff et al. [30]	To evaluate the effectiveness of a TTM-based intervention on	Sample: 135 Age: 15- 18 y Gender: Male and Female	TTM was used in the experimental group to increase motivation for	Duration: 3 months. Follow-up: Baseline and	No statistically significant difference was found between

anthropometric, metabolic and motivational outcomes in obese adolescents.	Country: Brazil	changing eating and physical activity habits, focusing on the stages and processes of change and on self-efficacy.	after 12 weeks. Frequency: 12 meetings, once a week.	groups for the outcome variables. There was more expressive effect magnitude in the intervention group for BMI percentile, waist circumference, waist-to-hip ratio, readiness to change diet, and readiness to start exercising.
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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

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