Review

Impact of Strategies for Preventing Obesity and Risk Factors for Eating Disorders Among Adolescents: A Systematic Review

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Abstract: An effective behavior changes program is the first-line of prevention for youth obesity. However, effectiveness in prevention of adolescent obesity requires several approaches, with special attention paid to disordered eating behaviors and psychological support among other environmental factors. The aim of this systematic review was to compare the impact of two types of obesity prevention programs, inclusive of behavior change components on weight outcomes. Energy-balance studies were aimed at reducing calories from high-energy sources and increasing PA levels, while "shared risk factors for obesity and eating disorders" focused on reducing disordered eating behaviors to promote a positive relationship with food and eating. A systematic search of ProQuest, PubMed, PsycInfo, SciELO, and Web of Science identified 8825 articles. Twenty were considered "energy-balance" and fifteen "shared-risk factors for obesity and eating disorders". Overall, energy-balance studies were unable to support a maintenance weight status, diet, and PA over time. Shared risk factors programs also did not result in significant differences in weight status over time. However, the majority of shared risk factors studies demonstrated reduced body dissatisfaction, dieting, and weight-control behaviors. More research is needed to examine how a shared risk factor approach can address both obesity and eating disorder.

Keywords: Obesity, Eating Disorders, Adolescents, Prevention programs, Systematic Review

1. Introduction

Pediatric obesity is a well-accepted major public health concern [1]. The World Health Organization (WHO) defines pediatric obesity as a body mass index (BMI) at or above the 95th percentile among children and adolescents the same age and sex, often measured on BMI growth charts [2]. The global age-standardized prevalence of obesity increased more than 5% for girls and almost 8% for boys over the last 40 years [2]. Causes and effects of obesity are complex and multifaceted, and obesity is associated with increased risk of these chronic conditions such as cardiovascular diseases, type II diabetes, and certain

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types of cancer. However, children with obesity experience weight stigmatization, defined as the societal devaluing of an individual because of their body size [3], which often manifests in childhood as weight-based teasing and bullying [3].

Due to this stigmatization, obesity in youth has been shown to be a risk factor for psychopathology, that may manifest itself through body dissatisfaction, shape and weight concerns, and dieting and disorder eating behaviors such as binge eating and purging [4,5]. Research has also shown that obesity in youth is associated with sneaking and hoarding food, eating when not hungry and feelings of self-consciousness or embarrassment when eating in front of others [6,7]. Although disordered eating behaviors and eating disorders both encompass a broad array of dimensional maladaptive cognitions and behaviors relating to eating and weight, they differ in their diagnosis. The term *eating disorder* refers to a psychiatric disorder and include the following four categories: anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), and other specified feeding and eating disorders (OSFED) [8]. Those individuals who do not meet the specific diagnostic criteria of eating disorder may fall into the category of weight-related disorder, which includes disordered eating behaviors[9]. Thus, research exists to support the assessment of obesity-related problems should include disordered eating as disordered eating behaviors and obesity have similar risk factors, such as body dissatisfaction and weight control behaviors [4,10]. In addition, research also suggests that individuals may crossover from one condition to another [4]. Indeed, overweight adolescents have odds up to 5 times higher of developing eating disorders than normal weight youth [11,12].

Prevention programs that include diet, physical activity, and/or sedentary behaviors components are currently the first-line of prevention for obesity in adolescent youth [6]. The WHO Commission on Ending Childhood Obesity report [13] suggest a multi-component approach that includes comprehensive lifestyle weight-management support for youth who have an unhealthy weight status as part of a universal youth healthcare plan. Multi-disciplinary prevention programs do not have a specific definition. However, the WHO report [13] noted that a comprehensive prevention plan should include psychosocial and family support in addition to common components such as nutrition and physical activity or sedentary behavior change. Indeed, obesity prevention programs that predominantly focus on energy-balance approaches, including diet (e.g., avoiding or choosing certain food sources) and physical activity (e.g., to "burn" calories), have proven not be effective over a long period of time and may lead to an increase in the risk for disordered eating behaviors [14].

Thus, it is important to examine the implications of the aforementioned strategies and their impact on disordered eating risk factors and obesity prevention among adolescent youth in order to build a more sustainable approach through the integration of diet and physical activity components with psychosocial support. Previous systematic reviews and meta-analyses [6,15] have assessed the impact of obesity treatment on eating disorders in overweight or obese children and adolescents. However, there is a gap in the literature examining the impact of obesity prevention programs among youth on risk factors for disordered eating. Thus, the aim of this systematic review was to compare the impact of two types of obesity prevention programs, inclusive of behavior change components on weight outcomes. Energy-balance studies were aimed at reducing calories from high-energy sources and increasing PA levels, while "shared risk factors for obesity and eating disorders" focused on reducing disordered eating behaviors to promote a positive relationship with food and eating

2. Methods

The protocol for this systematic review was registered with PROSPERO (CRD 42017076547) [16], accessible at https://www.crd.york.ac.uk/prospero/ and has been reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [17].

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2.1. Data Sources and Search Strategy

A systematic search of published literature up to February 2020 was undertaken using five electronic databases PsycINFO, ProQuest, PubMed, SciElo (Scientific Electronic Library Online), and Web of Science. The following structured search strings were used: Adolescents OR Children OR Girls OR Boys OR Prevention OR Intervention AND Obesity OR Overweight OR Weight-Related Disorders OR Disordered Eating. Relevant truncations and adjacencies were used to enhance results by allowing variations of search terms. The search was limited to studies in adolescents. Hand searching of reference list was conducted to identify studies that may have been missed. Records were downloaded to EndNote X9.2 and duplicates removed. Records were first assessed by title and abstract and then full text. All records were assessed for inclusion based on the defined criteria. Any uncertainties regarding the inclusion of a study were resolved through discussion among A.L and K.D or. R.F.

2.2. Eligibility Criteria

All studies were assessed according to the following inclusion and exclusion criteria summarized according to PICO framework (Participants, Intervention Comparison, and Outcome):

Participants: Studies were eligible if they included adolescents age 10-19 years as defined by the WHO [18], and inclusive of all weight statuses. Adolescents must have participated in either of the two obesity prevention programs focused on: (i) energy-balancing approaches (targeting diet and physical activity); or (ii) shared risk factors for obesity and eating disorders. All participants were eligible if they participated at the beginning of each intervention type. Participants with a pre-existing disease, an organic cause for obesity and eating disorders, or on medication that could affect weight were excluded.

Intervention: Energy-balance interventions were defined as an approach to improve diet (e.g., energy, fat, sugar, sodium, and fruit and vegetables intake), increase (moderate-to-vigorous) physical activity, and reduce screen-time with the intent to increase energy expenditure [19]. Shared-risk factors for obesity and eating disorders programs were described as an approach to promote a positive relationship with weight and diet, through a reduction in the following factors that may have relevance for weigh-related concerns: dieting, media use, body image, weight control behaviors (e.g., use of food substitutes, diet pills, and diuretics), and weight-based teasing. These factors were selected on the basis that they are both amenable to change and suitable for addressing within prevention programs for youth [4]. Assessment of weight-related programs were obtained through adolescents' weight status; dietary, physical activity, and sedentary behaviors questionnaires. The Eating Disorder (ED) risk factors were obtained through a variety of different psychometric questionnaires.

Comparison: Different study designs (i.e., randomized controlled trials, non-randomized controlled trials, quasi-experimental control trials, and pre-post uncontrolled studies with no comparison group) were included in this review.

Outcome: The key outcome of interest was the impact of obesity prevention programs on disordered eating behaviors in adolescents. A secondary outcome was the impact of the programs on adolescent weight outcomes expressed as Body Mass Index (BMI), BMI zscore (BMIz).

Excluded studies focused on the treatment of individuals with overweight or obesity. Interventions relating to the treatment of EDs or psychological morbidity were also excluded, as were studies treating secondary or syndromic causes of obesity. No exclusion criteria were placed on intervention duration, length of follow-up, or date, but this review was limited to studies published in the English, Portuguese, and Spanish languages.

2.5. Data extraction

Data were independently extracted from eligible studies by one reviewer and cross-checked for accuracy by a second reviewer. Extracted data included sample characteristics, intervention setting, intensity and design, type of studies, tools used to assess outcome measurement, and pre-, post-intervention and/or follow-up data for both types of approaches.

2.6. Data Synthesis

Due to the heterogeneity of study population characteristics and programs features (i.e., length of treatment, outcomes measured and timing of assessment), it was not possible to perform a meta-analysis. A narrative summary of the findings was conducted.

2.7. Quality Assessment and Risk of Bias

Study quality was assessed using a designed appraisal tool developed by Cochrane: Version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2) [20] and Risk-Of-Bias In Non-Randomized Studies (ROBINS-I tool) [21]. Individual component quality rankings, including the risk of bias measures are included in **figure 1**. Component and overall quality ratings were scored as "low risk", "moderate" or "high" for the RoB 2; and as "low risk", "moderate", and "serious" [20,21].

3. Results

3.1. Overview of Studies

A flowchart summarizing the study selection procedure is presented in **Figure 1**. Electronic searches returned 8825 records. To begin, duplicates (n=2171) were removed. Second, a total of 4629 studies were screened by titles and abstracts. Finally, 211 studies were further excluded after reading through the full text. Of the excluded studies, 83 targeted children (≤10yo) or adults (≥20yo), 101 included non-healthy individuals (e.g., obese, eating disorders, or other health conditions), and in 28 studies an intervention was not considered. The remaining 35 studies met the inclusion criteria and were therefore eligible and included in this review. A total of 20 studies were energy-balance intervention studies, and 15 studies were a shared risk obesity and eating disorders program.

Data abstraction revealed 15 programs that had multiple publications. These included protocols, additional cohorts, further follow-up time-points, different outcome measures, or other secondary analysis. Thus, for reporting and analysis, studies were grouped by program cohort. Any uncertainties regarding appropriate program cohort for categorization were resolved through discussion.

3.2. Study Characteristics

Characteristics of selected studies are reported in **table 1**. All studies were published between 2005 and 2019. Fifteen studies examined shared risk factors for obesity and eating disorders programs [22-36] and 20 studies examined lifestyle energy-balance programs [37-53]. Overall, thirteen studies (37.1%) were conducted in the US, which included eight studies that included eating disorders risk factors to the program [22,26,28,31,33-35] and five studies that included energy-balance programs [37,38,46,50,53]. Five studies (14.3%) were conducted in Australia, and included four studies that examined energy-balance [43,45,54,55] and one study that examined shared risk factors [36]. Three studies (8.6%) were conducted in either Brazil [23,25,39] and Spain [27,30,48]. Other studies included countries within Europe [44,51,52,56,57] and Asia [41,42,49], and also Canada [32], Mexico [24], and Israel [40].

Programs were evaluated as controlled trials (n=32, 91.4%), randomized controlled trials (n=23, 65.7%), quasi-experimental (n=7, 20.0%), non-randomized (n=2, 5.7%), and as interrupted time series without

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comparison group (n=3, 8.6%). When considering only energy-balance programs, 13 studies were randomized controlled trials (RCT) [31,37-39,42,45,46,50-55,57], four were quasi-experimental trial [41,43,44,49], and one non-randomized controlled trial [40]. Two studies were one-group pre- and post-test assessment [48,53]. Programs that examined shared risk obesity and eating disorders included ten RCT [23,25,26,28,29,31,33-35], three quasi-experimental trials[24,27,30], one non-RCT [32], and one-group pre- and post-test assessment [22].

The sample size ranged from 27 [22] to 1451 [33] adolescents participating in the shared risk factors obesity and eating disorders program with 15.1±2.6 years old as the mean age of participants. The sample size for energy-balance programs ranged from 51 [38] to 3638 [56] and mean age was 12.7±1.8 years old. For both types of intervention programs, the majority of studies targeted both male and female adolescents. However, seven shared-risk factors for obesity and ED programs targeted only females [22-25,27,31,34], two energy-balance programs target only females [38,54] and one only males [45].

From the 35 studies, sixteen studies had no mention regarding whether they were theory-based. For those studies that reported on theory used in the program intervention, six studies that focused on "energy-balance" programs used Social Cognitive Theory [37,45,46,50,54,55], and two used Self-Determination Theory [37,45] as the theoretical basis for their program. For the studies that had programs which focused on combined shared risk factors for obesity and Eds, five used Social Cognitive Theory [23,25,29-31]. This was followed by focusing on approaches to reduce the risk for eating disorders, such as Media Literacy [27,30,36], Dissonance Behavioral Intervention [22,27] and Interpersonal Therapy [26,35]. Overall, 19 studies combined educational techniques with changes in the environment: 10 from energy-balance programs [40,43,45,46,49,52,54-57] and 9 from the shared risk factors for obesity and eating disorders programs [23,25-27,31-35]. Other studies focused only in educational techniques. In all studies, lifestyle prevention of youth obesity was provided. Two types of prevention programs were heterogenous in nature, including length, number, frequency and type of sessions, family involvement, and use of technologies.

3.3. Studies techniques

The majority (n=13, 65%) of the energy-balance programs used schools as the main settings for integrating diet and physical activity for promoting behavioral changes [37,40,41,43-45,48,49,51-55], 3 (15%) use the home setting [39,46,53], and two (10%) developed a web-based platform to deliver the intervention [38,42]. Some programs which used schools as the main setting combined multiple components to deliver the intervention, such as combining weekly text-messages and other mobile device technology (e.g., developing an app) [45,54], or integrating the family context (e.g., parents newsletters, homework and booklets) [44,53,54].

From the fifteen studies that have shared risk factors for obesity and eating disorders as the program approach, fourteen (93.3%) were conducted at school or university [22-28,30-34,36], and one was delivered through an internet-based platform [29]. Some of the school programs focused only on psychotherapy sessions to promote a healthy relationship with body and food [22,24,26,28,30,32,35,36], while others (n=6, 40%) [23,25,27,31,33,34] focused on both the psychotherapy sessions and other components to help achieve a sustainable diet and PA behaviors through the life course. Other components included weekly test messages, cooking classes, enhanced physical education classes, and healthy lunches and morning snacks at school time. Two studies [25,31] used individual counseling techniques to promote intrinsic motivational for behavior change via the motivational interview technique.

3.4. Studies assessment tools

Weight status was assessed in all the energy balance studies. Some of these studies (n=13, 65.0%) [39-41,45,49-55,57] combined other measurements to assess anthropometric outcomes, such as body fat

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percentage, waist circumference, and/or waist-to-hip ratio. Dietary intake was assessed with either food frequency questionnaires [39,40,45,54,55] or 24h recalls [37,38,44,50]. Those studies that utilized 24h recalls used at least two records to estimate participants' usual intake. For those studies that measured PA, some used questionnaires [37,39,41,43,44], while others objective measurements such as accelerometers [45,50,54,55] or pedometers [44]. Some studies (n=6, 30.0%) evaluated the youth physical fitness (e.g., cardiovascular, flexibility, muscular, strength and agility) [37,41,45,53,55,57]. Five studies (25.0%) evaluated sedentary behaviors, with a particular focus on screen-time questionnaires [38,43,45,52,54]. Four studies (20.0%) [40,41,43,44] assessed nutrition and PA knowledge gained through the program, four studies assessed other mental health outcomes (e.g., health-related quality of life, depressive symptomatology, or disordered eating components) [43,44,46,56]. Studies that assessed mental health outcomes were not identified as a shared risk obesity and eating disorders program as they did not target these components on the intervention but rather used this an indicator of inclusionary/exclusionary criteria of participants, and as a secondary outcome of the intervention. Three studies (15.0%) [41,52,53] used biomarkers such as plasma glucose and lipids as an outcome of diet and physical activity behavior change. Finally, two studies (10.0%) [46,51] targeted the pre-adolescent age group (10-12years old).

For the shared risk factors obesity and eating disorders program, all of these studies evaluated participant weight status through the use of BMI. Six studies (40%) [23,26,28,31,34,35] combined this measure with other anthropometric measures including waist circumference and %body fat (measured using DEXA, bioimpedance, or skinfolds). Seven studies (46.7%) evaluated diet intake through validated and reproduced food frequency questionnaires [22,23,28] and others through 24h recalls [31,33,34,36]. Those studies that used a 24h recall only collected data from one-day of diet intake. Physical activity was assessed by seven studies: five studies [22,23,31,33,34] used at least a 3-day recall to assess the PA of the participants; while the remaining studies [24,28,36] used a validated and reproduced questionnaire (e.g., International Physical Activity Questionnaire (IPAQ) [58] and the Paffenbarg Activity Questionnaire [59]).

Measures used to evaluate the shared risk factors for obesity and eating disorders are shown in **table 1** along with study characteristics. Eleven studies (73.3%) [22,26-30,32,35,36,60] used validated and reliable measurements that are used to assess eating disorders, including the "Eating Disorder Diagnostic Screening (EDDS)" [61], "Eating Disorder Questionnaire with Instruction (EDQ-I)" [62,63], "Dutch Restrained Eating Scale (DERS)" [64], "Difficulties in Emotion Regulation Scale (DERS)" [65], "Positive and Negative Scale-Revised (PANAS-X)" [66], "Sociocultural Attitudes Towards Appearance Scale (SATAQ)" [67] and " Perceptions Of Teasing Scale (POTS)" [68]. The purpose of these scales is to evaluate the occurrence of eating disorder symptoms, disordered eating behaviors, body, shape and weight satisfaction, and weight-teasing by family and friends/peers. The other five studies (33.3%) [23,31-34] assessed these measures through questionnaires used in previous surveillance studies, specifically the "Youth Risk Behavioral Surveillance System Survey (YRBSSS)" and "Project EAT". These questionnaires assessed the risk for disordered eating behaviors including dieting, weight control behaviors, binge eating, weight-teasing, and body/weight/shape concern.

3.5. Outcomes

The focus of this review was to assess the impact of obesity prevention programs on improving disordered eating behaviors and maintaining a healthy weight status among adolescents by comparing to types of interventions: energy-balance and shared-risk factors obesity programs and eating disorders programs (**table 2**).

3.5.1. Shared risk factors for obesity and eating disorders programs

All 15 studies showed no significant effects on weight status at post-intervention. Two programs [22,32] showed an increase in BMI and weight from post-intervention to follow-up. This increase in BMI

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ranged from 0.2 to 0.4kg/m^2, reflecting on average increase of 2.9kg. Leme et al. [23], although did not find significant results in BMI, found that results favored the intervention group (△=-0.26kg/m^2) with a lower increased in waist circumference for both groups. Female participants with high levels of anxiety demonstrated stabilization in adiposity (%body fat). However, those participants with low-levels of adiposity and those who participated in the control group showed no differences [26]. Moderation analyses also indicated a stronger BMI effect for youth with initially elevated symptoms of eating disorders and higher initial BMI scores [28,29], and weaker eating disorder symptoms and body image dissatisfaction [28].

Six studies [22,30,31,33,34,36] also found a reduction in several risk factors that were sustained at follow-up, specifically, eating pathology, appearance satisfaction, thin-ideal, negative affect, and emotion dysregulation. Two studies [24,29] that targeted both sexes found an interaction effect for time and group in thin-idealization, disordered eating attitudes/behaviors for females only. Leme et al. [23] and Sanchez-Carracedo et al. [27] found that results for eating disorder risk factors were in the opposite hypothesis direction, including results for appearance attitudes, eating disorders symptoms, and unhealthy weight control behaviors (e.g., skip meals, eating very little, and fasting).

Leme et al., [23], Simpson et al. [22] and Neumark-Sztainer et al., [31] were the only studies that assessed diet intake, PA, and sedentary behaviors of the participants. These two studies showed an improvement in healthy eating and physical activity. Both showed that social support, particularly for the family, was improved after intervention along with other socio-cognitive aspects. For example, behavioral strategies for healthy eating such as preparing meals or snacks with little fat or sugar.

3.5.2. Energy-Balance programs

Ten studies [40,41,43,48,51-56,69] showed small improvements on youth weight status as measured by BMI, BMI zscores, or percent prevalence for being overweight/obese. A reduction was observed by a difference between groups (intervention vs. control) of at least 0.1kg/m^2, or by 1.7% decrease on the prevalence of being overweight/obese from baseline to post-intervention/follow-up assessments. Five studies [42,44,45,54] did not find any significant effects on weight status change, while three studies [39,49,57] experience an increase on weight status change. For example, one study showed a large increase in overweight and obesity prevalence (10.1% and 12.6%) [49], and another study [39] showed a small increase in BMI of 0.2kg/m^2 for the intervention group and a decrease of % of body fat. Interestingly, a study conducted by Fulkerson et al. [46] found that although they found no significant treatment group differences in BMI zscores at post-intervention, a post-hoc stratification by pubertal onset indicated pre-pubescent youth had significantly lower BMI zscores than their control group counterparts (ß=0.08, 95%CI 0.01, 0.34).

Four studies (20.0%) [37,39,49,54] did not find significant differences in diet outcomes after the intervention, which included the reduction on total energy intake and improvement on the intake for certain food groups (e.g., fruit and vegetables). However, five studies (25.0%) [38,44,45,50,55] showed an improvement in intake of sugar sweetened beverages, and fruit and vegetables. Sgambato et al. [39] did not find any significant differences when evaluating diet intake using a food frequency questionnaire, however, analyses of 30% of the sample that used a 24h Recall showed a significant decrease the intake of fruit juice (△=-0.42±0.18 serving/day) compared to control group.

Physical activity level was improved in four studies (20.0%) [39,44,50,52] with an average of +12.5min/week. Two studies conducted by Lubans et al., one targeting only boys [45] and other both sexes [55], found an improvement in physical fitness (i.e., muscular fitness and resistance training) despite finding no significant effect on PA level. The remaining four studies [37,38,48,54] found no significant effect on PA level. Shawn-Peri et al. [53] found that large classes and short Physical Education periods are major challenges when implementing programs. Sedentary behaviors or screen-time were improved in

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three studies [45,52,54]. Dewar et al. [54] showed improvement in screen-time behaviors at immediate post-intervention (after 12month from baseline), but at follow-up (after 24months) found no significant differences. An average of significant difference was -30.7 minutes/day.

Three studies [40,44,50] evaluated participants' knowledge of nutrition and PA, and found significant improvements in their knowledge. Three studies [41,50,53] assessed biological markers to verify improvements in lifestyle behaviors, including blood pressure and fasting capillary plasma. Significant results were found among male participants with higher BMI and older adolescents.

4. Discussion

This systematic review filled a major gap in the literature by assessing the impact of obesity prevention programs, with behavior change components on weight outcomes in adolescents. Diet intervention, as either a primary goal or combined with PA, has emerged as promising component in youth obesity prevention programs. In order to assess the impact of these programs, two approaches were compared: energy-balance and shared-risk factors for obesity and eating disorders. This systematic review highlights the specific differences in the program components and outcomes that goes above and beyond simply using BMI or other anthropometric measurement as primary outcome. This review demonstrates better anthropometric outcome measures in the "energy-balance" programs that include physical activity components such as enhance physical education classes and encouragement of behavior change activities at immediate post-intervention. Upon examination of interventional studies, PA seems to be moderately to highly effective in improving body composition, especially with improving resistance exercise [45,53,55] and increasing lean mass [70]. However, a posteriori effect on BMI and body weight may not be affected by PA. In line with previous work [70], several intervention studies were unable to prove success at long-term follow up with PA outcomes. This may be explained by the approach used in these interventions, specifically educational and behavioral, which did not produce sustainable results. As shown in the risk of bias, a meta-analysis of reviews [70] have found low methodological quality studies included in the meta-analyses, high level of heterogeneity, limited number of studies available, mixed populations of overweight and non-overweight adolescents, as well as inadequate description of the interventions.

Numerous programs have been evaluated in the literature; however, the most effective strategy remains to be developed. Studies that have diet as a primary component have not been shown to be sustainable over time. The combination of diet and PA was shown to be a more effective tool against preventing youth obesity, than diet alone. Schools were the most common setting where these interventions were implemented. Alternatively, results derived from combining physical activity or diet with secondary component like education and/or changes in the environment such as policies focused on food canteens, and school curriculum, were associated with a smaller effect sizes or even non-significant results [70]. This suggests a high degree of heterogeneity, and lack of methodological rigor [71]. Thus, an adequate combination that would further improve the success remains an important issue under investigation.

Population-based interventions designed to maintain a healthy weight status that focused on shared risk factors for obesity and eating disorders have been a focus of attention in the general adolescent literature over the past few years [4,10,72,73]. However, few studies have been designed to reduce the burden of these shared risk factors. Indeed, results of at least some of the prevention programs suggest that weight status should not be the main outcome when considering obesity management strategies. This is because some of the disordered eating factors, mainly dieting, can lead to unsustainable dietary practices which can lead to unhealthy weight gain or eating disorders [4]. Tanofsky-Kraff et al. [26] suggested via exploratory post-hoc analyses evaluating baseline social-adjustment problems (as an index for mental health problems) [74] and anxiety as moderators of group effect on weight gain. This study revealed that adolescents with more psychosocial difficulties initially had the most benefit with intervention programs using interpersonal techniques compared to health education techniques. Moreover, both social

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functioning and anxiety moderate intervention outcomes for depressed adolescents [75], as youth with worse baseline psychosocial functioning experience the greatest improvements in depressive symptoms if they received interpersonal interventions targeting the shared risk factors as opposed to conventional approaches. Therefore, social-adjustment and anxiety are important components for weight-related prevention trials and should directly focus on improving interpersonal functioning and negative mood states.

Another issue raised among interventions targeting obesity and eating disorders risk factors is weight-teasing or stigmatization. Research suggests that attitudes towards individuals with obesity may be reduced through the provision of non-modifiable risk factors for these specific concerns [76]. Considering this, studies that focused on causes and risk factors for obesity and eating disorders identified in this review, as well as other corroborating reviews [72,77,78], showed that biological and genetic factors played a minor role in the etiology of these shared risk factors when compared with social-cultural factors. This was confirmed in studies that include both public and health professionals [72]. Thus, the published literature seems to indicate an opportunity for change in this respect. Even if successful, prevention programs of this kind presented conflicting ethical questions [79].

Despite an overall improvement in the disordered eating risk factors; such as body satisfaction, unhealthy weight control behaviors, and teasing; two studies [23,27] identified an increased risk for these factors at follow-up, and female adolescents tend to have less favorable impact on these risk factors than male participants. One study reported an increased risk for skipping meals, eating too little, and fasting at 6-month follow-up [23]. Similarly, a Spanish quasi-experimental trial [27] found that at post-intervention, drive for thinness, negative affect, and self-esteem were in the hypothesized direction but socio-attitudes towards appearance and eating disorders symptoms were in the opposite direction to what was hypothesized. All outcomes were non-significant. It is uncertain if these findings differ from the typical rate of development of eating disorders or obesity that are seen within obesity prevention trials targeting adolescents, and especially adolescent girls. Nevertheless, the early signs and symptoms of these shared risk factors in adolescents attempting to lose weight may be missed, particularly when the focus is on weight loss or the adolescent remains within or above a healthy weight status [15]. These findings support previous recommendations [80] that interventionists, public health policy makers, and other behavior-change researchers should monitor for the development of or exacerbation of these combined risk factors during weight-related prevention programs.

Strengths and Limitations

The strength of this systematic review includes the development of a comprehensive search strategy applied in order to fill the literature gap on the impact of weight-related prevention trials, maintenance of a healthy weight status, and decreasing the burden of the shared risk factors for obesity and eating disorders among adolescents. However, there are some limitations of the current review that should be noted. Despite the authors' extensive efforts, including systematic searching of databases and manual searching of literature reference lists, it is possible that studies meeting the inclusion criteria may have been missed. Further only one author performed title, abstract, and full-text screenings. However, any uncertainties regarding study inclusion were resolved through discussion among three authors. Moreover, although a strict inclusion and exclusion criterion was established, the aim of some studies included in this review was not explicitly to measure the influence of weight-related concerns on weight status and other behaviors. Thus, some outcome data was not provided in detail, limiting the conclusions able to be drawn in these instances. This review was also limited by the heterogeneity of the included studies, whereby reporting measures and outcomes were often not consistent.

5. Conclusion

Evidence showed that both energy-balance and shared-risk obesity and eating disorders prevention programs for adolescents were not able to support sustainable changes in weight outcomes, diet, and physical activity behaviors. However, improved disordered risk factors were seen in the shared-risk factors, e.g., weight control behaviors, and shape and weight concerns, especially among overweight adolescents. However, some studies found non-significant effects or even increased risk of these shared risk factors at post-intervention among adolescent girls, suggesting that a more intensive or targeted approach may be needed for this at-risk group. More research is needed to examine how a shared risk factor approach can address both obesity and eating disorder, and identify whether additional supports are needed for adolescent girls.

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Figure 1. – Flowchart showing the process of article selection.

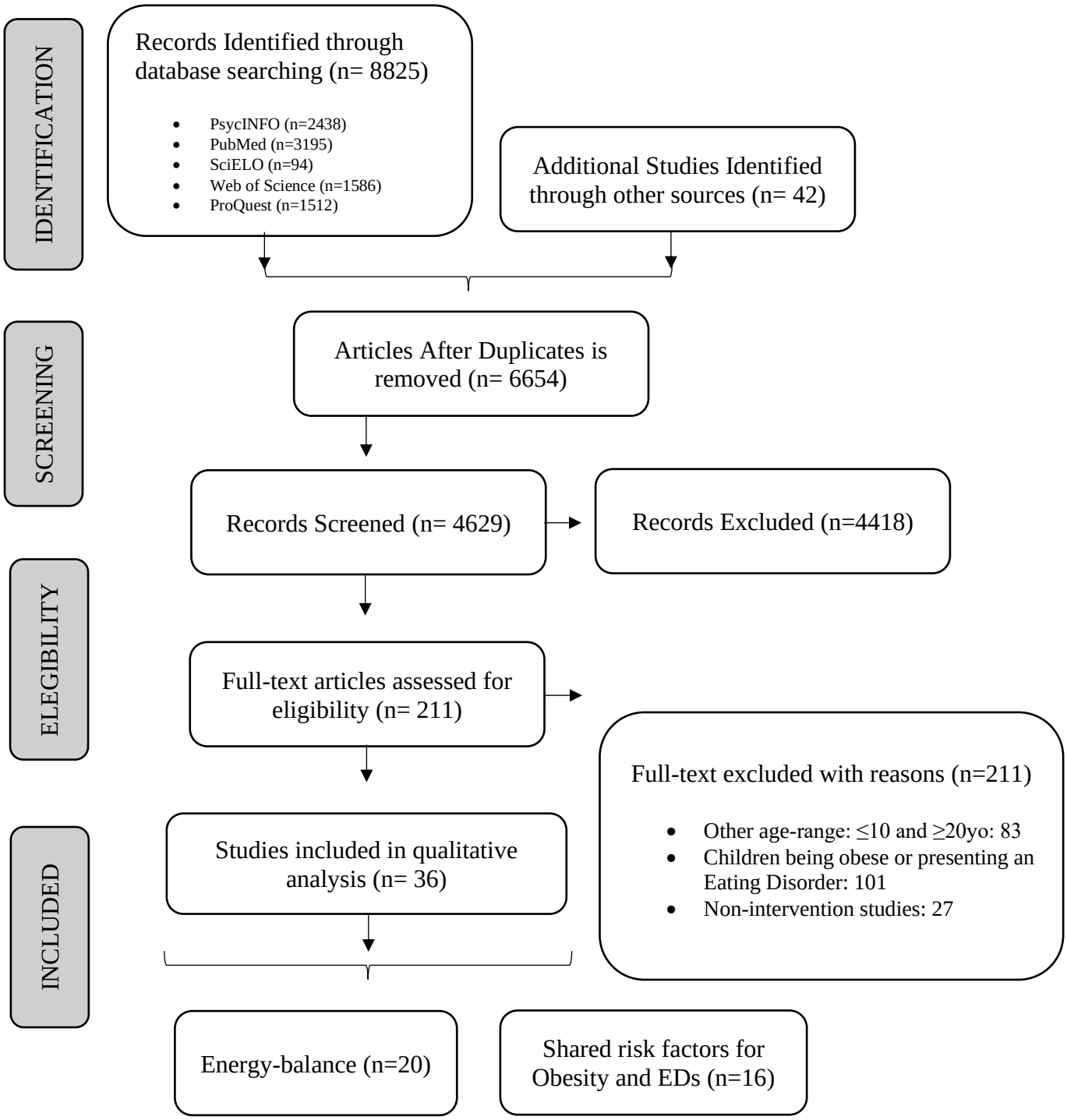

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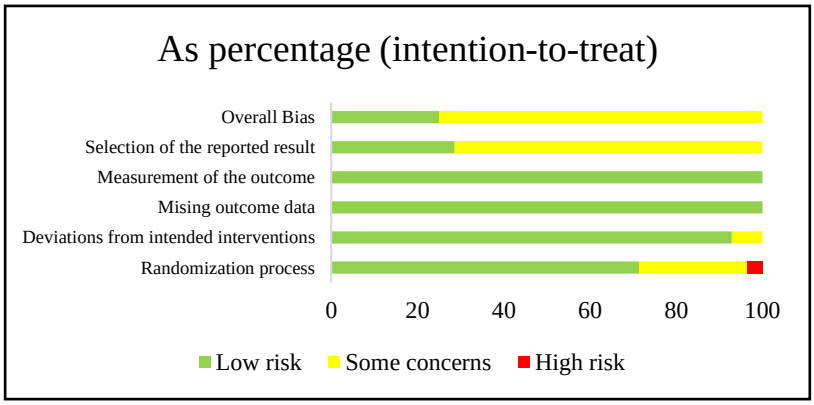
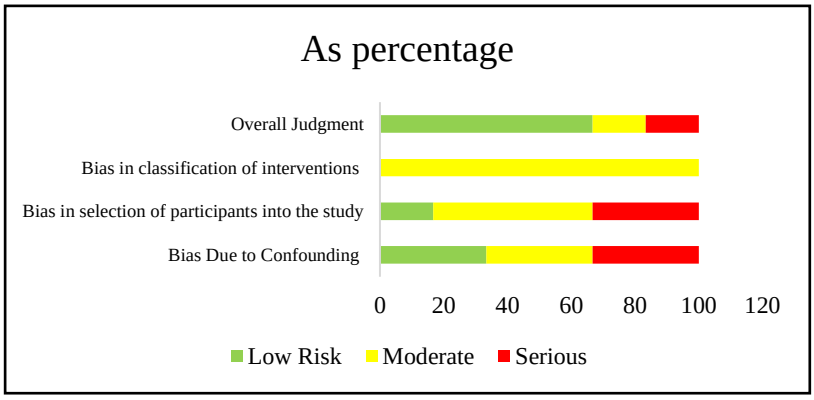
Figure 2. – Risk of bias for Randomized Controlled Trials (a) and Non-Randomized Controlled trials (b).

(a)



(b)



*Based on Revised Cochrane Risk-of-Bias tools for Randomized Controlled trials (ROB-2) and Non-Randomized Controlled Trials (ROBINS-1)

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Table 1 – Characteristics of the included studies, assessments and outcomes of intervention strategies.

Studies	Study characteristics	Type of strategy and techniques	Assessment at follow-up
Shared risk factors for obesity and eating disorders programs			
• Simpson et al., 2019[22] • Country: USA Intervention name: INSPIRE	• One group • Pretest-post-test design. • 27 young female adults with 18.59±1.01years old, 71% were 1st year undergraduate	• Integrated Dissonance-Based Intervention; Healthy Weight Intervention; and Dialectical Behavioral Therapy.	• Eating Disorder Diagnostic screening (EDDS) • Demographic questionnaire • Height and weight • Eating Disorder Questionnaire with Instruction (EDQ-I) • Body Image Ideals Questionnaire (BIIQ) • Ideal-Body Stereotype Scale Revised (IBSS-R) • Dutch Restrained Eating Scale (DRES) • Difficulties in Emotion Regulation Scale (DERS) • Positive and Negative Scale-Revised (PANAS-X) • Block Food Screener • 7-day PA recall • Participant satisfaction • Therapist feasibility questionnaire
• Leme et al. 2016, 2018[23,81] • Country: Brazil • Intervention Name: "Healthy Habits, Healthy Girls – Brazil"	• Randomized controlled trial. • Post-intervention and 6-month follow-up • 253 adolescent girls with 16.05±SE 0.05 years old, 142 enrolled in intervention group at baseline.	• Social Cognitive Theory. • Based in the Social Cognitive theory with strong peer and parent involvement to help girls to achieve sustainable diet and PA behaviors, as well as decrease disordered eating behaviors, body dissatisfaction, and weight stigmatization.	• Demographic Questionnaire • Food Frequency Questionnaire • 7-day PA recall • Height, weight, and waist circumference • Body Image Satisfaction • Weight Control Behaviors • Weight Stigma (teasing) • Social Cognitive aspects of eating and PA
• Castilo et al. 2018[24] • Country: Mexico	• Three-arm quasi-experimental study • Post-intervention and 3-month follow-up • Female young adults with 19.78±2.06 years old, with 133 participating in experimental group; 105 in control skills group; 123 non-intervention group	• Developed based on Cognitive Dissonance raising awareness to beauty standards and ideals perpetuated by the mass media for male/female adolescents. • Activities to increase physical activity and healthy eating. • Improve self-esteem, build positive self-concept, reducing extreme perfectionism, and resolving conflicts with an assertive approach. • Improve university academic performance based on a constructivist approach.	• Demographic Questionnaire. • Sociocultural Attitudes Towards Appearance Scale (SATAQ) • Eating Attitude Test (EAT) • Symptom Check-list-90 Revised (SCL-90R) • Male Body Attitude Scale • Body Shape Questionnaire (BSQ) • Multidimension Perfectionism Scale • Rosenberg Self-Esteem Scale • International PA Questionnaire (IPAQ short version) • Body Mass Index

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• Lenz & Claudino et al. 2018[25] • Country: Brazil • Adaption of the US trial NewMoves for the Brazilian reality.	• Randomized Controlled trial • Post-intervention and 6-month follow-up • 270 adolescent girls with 13.4±0.64 years old, with 139 enrolled in intervention group at baseline.	• Social Cognitive Theory • An adaption of the US New Moves trial. • Address issues related to female adolescents (e.g., self-image perception).	• Demographic Questionnaire • Body Shape Questionnaire (BSQ) • Rosenberg Self-Esteem Scale (RSS) • Body Mass Index
• Shomaker et al., 2017[35] • Country: USA	• Randomized Controlled trial • Post-intervention, 6-month, and 1-year follow-up. • 29 pre-adolescents with 11.7±1.6 years old, with 15 enrolled in intervention group at baseline.	• Family-based interpersonal therapy • Psycho-education about the Interpersonal model of Loss of Control-eating and general skill-building applied to improve communication, increase support, and resolve conflict within the parent-child relationship. • 12-weekly sessions of 45min delivered to parent-dyads.	• Weight status and body fat (DEXA) • Eating Disorder Examination adapted for Children (ChEDC) • Schedule for Affective Disorders and Schizophrenia for school-age children (K-SADS) • Social Adjustment Scale Self-Report (SAS-SR) • Children's Depressive Inventory (CDI) • State-Trait Anxiety Inventory for Children (STAIC)
• Tanofsky-Kraff et al. 2017[26] • Country: USA.	• Randomized controlled trial. • 3-year follow-up • 113 adolescent girls with 14.5±1.5 years with 55 enrolled in intervention group at baseline.	• Program included individual 1.5-hour meeting followed by 12-week consecutively 90-min group sessions. • The technique used was Interpersonal Psychotherapy (IPT) in order to identify connections among their relationships, mood and eating. • The goal of IPT was to reduce negative-affect induced loss-of-control eating episodes that promote excess weight gain. • There was a Health Education (HE) group that was based on previous program and manual add for high-school students.	• Height, weight, and body fat (%) (dual-energy X-ray absorptiometry). • Eating Disorder Examination Version 14 (eating disorders and loss of control). • Social Adjustment Scale Self-Reported. • Beck Depression Inventory.
• Sánchez-Carracedo et al., 2016[27] • Country: Spain • Intervention name: The MABIC Project	• Non-randomized controlled trial. • Post-intervention and 1-year follow-up • 565 adolescent girls with 13.8±0.5 years old, 152 enrolled in intervention group at baseline.	• Two components: increase knowledge and discussions of practical and relevant aspects of food. • Social Cognitive Theory/Media Literacy Education Approach/ Cognitive Dissonance Theory. • Social Cognitive Model	• Biographic Data (demographics) • Body Mass Index • Sociocultural Attitudes Towards Appearance Questionnaire (SATAQ-3). • Children's Eating Attitudes Test (ChEAT) • Perceptions of Teasing Scale (POTS) • Eating Disorders Inventory-3 (EDI-3)

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		• Media Literacy Approach • Cognitive Dissonance Theory • Increase knowledge through sessions, practical and relevant aspects of food discussed through analysis of four menus, questioning the thinness ideal, how to create media message and develop critical thinking and active behaviors toward messages conveyed by the media.	• Spanish version of SCOFF-c (screening tool for possible cases of ED). • Negative Affect Scale (PANAS-N) • Rosenberg Self-Esteem Scale (RSES) • Process evaluation Questionnaire
• Wilkish et al., 2015[36] • Country: Australia	• Four-arm randomized controlled trial • Post-intervention, 6-month and 12-month follow-up. • 1316 adolescents, with 13.21±0.68 years old, 269 enrolled to intervention1 (media smart group), 347 in intervention2 (life smart) and 225 intervention3 (HELPP).	• Principles of media internalization (intervention1). • Principles that health is more than weight (intervention2). • Principles of eating disorder risk factors of internalization of social appearance ideals and comparisons. • Three programs developed based on evidence principles of being interactive; avoiding psychoeducation about eating disorders and obesity, and having multiple sessions. • Eight, 50-min sessions with learning activities (e.g., for the media smart group: talking about stereotypes; for the life smart group: talking about health more than weight; and for the HELPP group: appearance and pressure to be thin).	• Eating Disorder Examination – Questionnaire (EDE-Q): weight, shape and eating concern. • Dutch Eating Behavior Questionnaire – Restrained: dieting, • Eating Disorder Inventory (EDI): Body Dissatisfaction • Sociocultural Attitudes Towards Appearance Questionnaire-3 (SATAQ-3): media internalization • Perceived Sociocultural Pressure Scale • Child Depression Inventory – Short Form • McKnight Risk Factor Survey: weight-related peer teasing • Multidimension Perfectionism Scale • Regular Eating (Project EAT Questionnaire), Screen-time and Physical Activity (Project Growing Up Today Study)
• Stice et al., 2013[28] • Country: USA	• Randomized controlled trial • Post-intervention, 6-month, 1-year and 2-year follow-up. • 398 young adults, mean age 18.4 (range 17-20 years), with 192 enrolled in intervention group at baseline.	• Healthy Weight approach to reduce the double-burden of weight related problems. • Second refined version of previous study “Healthy Weight”. • Promote participant-driven lasting healthy improvements to dietary intake and physical activity in young women (M=18.4; 17-20yo) with body image	• Eating Disorder Diagnostic Interview • Threshold and subthreshold of eating disorder diagnoses. • Body Mass Index • DEXA to measure body fat • Block Food Frequency Questionnaire • Dutch Restrained Scale • Paffenbarg Activity Questionnaire • Body Dissatisfaction Scale

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		concerns, reduced eating disorders symptoms and BMI. • Added nutrition science principles for health behavior changes (e.g., replacing high-energy dense foods with low-energy dense foods).	• Schedule for Affective Disorders and Schizophrenia for School-Age Children Interview • Perceived Social Cultural Pressure Scale
• Franko et al., 2013[29] • Country: USA • Intervention name: BodyMojo	• Randomized controlled trial • 4-6 weeks and 3-month follow-up • 65 boys (15.4±1.4years old) and 113 girls (15.2±0.3years old), participants randomized in classes.	• Internet-based program to promote health behavior change, through technology and social engagement, offering a personalized experience by providing relevant information and feedback, goal setting, specialized body image and related content (e.g., nutrition), interactive games and quizzes, and videos for the age group. • Socio-Cognitive Theory, Health Belief Model, Theory of Planned Behavior, Transtheoretical Model. • Internet-based program that promotes health behavior change through technology and social engagement, offering a personalized experience by providing relevant information and feedback, goal-setting, specialized body image and related content (e.g., nutrition), interactive games and quizzes, and videos that are specific to this age group.	• Demographic Questionnaire • Body Esteem Scale for Adolescents and Adults (BES) • Eating Disorder Inventory (EDI) – Body Satisfaction Scale. • Physical Appearance Comparison Scale (PACS) • Satisfact[60]ion Survey.
• González et al., 2011[30] • Country: Spain	• Three arms quasi-experimental design • Post-intervention, 6 and 30-month follow-up. • 443 adolescents, 13.5±0.4 years old, 143 media literacy and 99 media literacy and nutrition.	• Focused on media literacy and nutrition awareness • Social Cognitive Theory • Media literacy and media literacy + nutrition awareness. • Interactive format, sessions and incorporated new activism and media literacy components. • Encouraged critical thinking and promoted health and well-being of	• Socio-biographical data • Eating Attitude Test (EAT-40) • Questionnaire on Influence of Aesthetic Body Ideal-26 • Body Mass Index

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		students, developing resilience to sociocultural messages.	
• Neumark-Sztainer et al., 2010[31] • Country: USA • Intervention name: New Moves	• Randomized controlled trial • Post-intervention and 9month follow up • 356 adolescent girls, 15.8±1.2 years old, 182 participated in intervention group at baseline	• Socio-environmental factors, personal factors, and behavioral factors to bring about changes in diet/PA/weight control behaviors • Targeted girls in pre-contemplation, contemplation, and preparation stages for PA and aimed to move forward. • Social Cognitive Theory and Transtheoretical model. • Guided by extensive formative research and pilot testing. • Four components: (i) PE class, with incorporated nutrition and social support/self-empowerment sessions; (ii) individual counseling sessions using motivation interviewing techniques; (iii) lunch get-togethers (lunch bunches) once a week during maintenance period; (iv) minimal parent outreach activities.	• Percentage of body fat (DEXA) • Body Mass Index • 3-day Physical Activity Recall • One 24h dietary recall • New Moves Survey (targeting constructs of the Social Cognitive Theory and Transtheoretical Model)
• Stock et al., 2007[32] • Country: Canada • Intervention name: Healthy Bodies	• Prospective pilot study • Post-intervention • 199 adolescents from 4th to 7th grade, 128 participated in intervention group at baseline	• Prescribed learning outcomes from the British Columbia Minister of Health • Regular physical activity, healthy eating, and healthy body image, self-esteem and social responsibility. • Program content is based on 3 main components of healthy living: being physically active, eating healthy foods and having a healthy body image. • 21 healthy-living lessons designed and taught over the course of the study school year.	• Height and weight • Blood pressure and heart rate • Fitness (9minutes run) • Healthy Living Questionnaire (knowledge about and behaviors towards various aspects of healthy living – body image, food preoccupation, self-competence, knowledge about physical activity and nutrition, and frequency of healthy eating, exercise and healthy eating behaviors. Also, included general health attitudes and emotional health) • Harter Self-competence scale (3 domains: social, cognitive and physical; and fourth subscale measure general self-worth). • Perceive Competence and Social Appearance for Young Children • Schematic figures to assess body image perception and satisfaction • Children's Eating Attitude Test (ChEAT) (screening symptoms of eating disorders)

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• Austin et al., 2007[33] • Country: USA • Intervention name: The 5-2-1 go! Intervention	• Randomized controlled trial • Post-intervention • 1451 adolescents from grade 6th and 7th, 614 participated in intervention group at baseline.	• Learning outcomes from previous trial (Planet Girls)[34] • Promote healthful nutrition and physical activity and reduce overweight. • Included two tools: Previous trial curriculum and School Health Index Physical Activity and Healthy Eating. • Health messages focused on PA, TV viewing, and consumption of FV and fats that are provided in the major subject area in PE classes. • A tool developed by the Centers for Disease Control and Prevention assisted the schools in assessing the PA and nutrition policies and programs. • Consisted of multiple modules to help schools address nutrition and PA in various domains of the school such as nutrition services, PE, and school policies and environment.	• Demographic characteristics • Youth Risk Behavioral Surveillance System Survey (self-reported diet, physical activity, sedentary behaviors, and disordered eating behaviors) • Social environmental behaviors (prevalence of disordered eating behaviors risk factors at schools at baseline)
• Austin et al., 2005[34] • Country: USA • Intervention name: Planet Health	• Randomized controlled trial • Post-intervention and 21-month follow-up. • 480 adolescent girls, mean age 11.5±0.7 years old, 254 participated in intervention group at baseline.	• Promote healthful nutrition and physical activity and reduce sedentary behavior. • Focused on 4 behavioral changes: reducing TV viewing to <2hours/day; increasing MVPA; decreasing consumption of high fat foods, and increasing FV to 5 a day or more. • Behavioral-choice and social cognitive theories. • Interdisciplinary curriculum approach, with intervention material infused into major subject areas and PE, using grade- and subject appropriate skills and competencies	• Demographic characteristics • Youth Risk Behavioral Surveillance System Survey (dieting, vomiting, laxative use, and taking pills to control weight; and self-report diet, physical activity and television viewing) • Height and weight; and triceps skinfold thickness

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Energy-Balance programs			
• Sgambato et al., 2019[39] • Country: Brazil • Intervention name: PAAPPAS (Portuguese acronym for Parents, Students, Community Health Agents and teachers for Healthy Eating)	• Randomized controlled trial. • Post-intervention • 2447 adolescents with 11.5±1.4 years old, being that 1290 were enrolled in intervention group at baseline.	• Family Health System. • Families are visited by community health agencies, whose activities are performed through household visits. • Reduced weight gain combining primary prevention at schools with the primary care system.	• Short version of Food Frequency Questionnaire combined with one 24h Recall in random subsample of participants. • 7-day PA recall. • Height, weight, and %body fat. • Demographic questionnaire.
• Aperman-Itzhak et al. 2018[40] • Country: Israel	• Controlled, non-randomized and non-blinded trial. • Post-intervention • 373 adolescents (10-12 years old) with 187 enrolled in intervention group at baseline	• Promotion of Healthy Eating and Physical Activity. • Developed by a Dietitian and Cardiologist. • Collaboration between the authors and the head of local council stakeholders and to work with 5th and 6th grades teachers in the school. • Teachers encouraged to integrate PA and healthy eating during class time in different subjects. • Based on the European Healthy Eating and Physical Activity in Schools program adapted to the Israeli cultural and religious background. • Safe and attractive playgrounds was developed. • Teachers encourage to eat healthy during school breaks to encourage students.	• Demographic Questionnaire • FFQ • Health knowledge, attitudes, and behavioral knowledge. • Height, weight, and fat percentiles
• Yang et al. 2017[41] • Country: South Korea.	• Quasi-experimental trial • 1-year follow-up • 768 adolescents with 11.0±1.5 years old, with 418 enrolled in intervention group at baseline.	• Based on pre-intervention results. • Improve PA and dietary habits, and on daily caloric intake. • Environmental intervention + usual school curriculum	• Demographic Questionnaire • Height, weight, waist circumference, and body fat • Blood Pressure • Physical fitness (cardiovascular, flexibility, muscular, strength, and agility).

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		• Based on pre-intervention results, personalized suggestions for improving physical strength and dietary habits, and information on daily caloric requirement. • Intervention centered in the school, but continued in the community.	• Survey to asses health behaviors (PA, sleeping, dietary habits, nutritional knowledge, physical self-image, self-respect, life quality, and depression. • Parental Questionnaire (birth weight, delivery method, breastfeeding status and past history) + child's family such as parental height and weight, family morbidity, diet, PA level and SES.
• Rerksuppaphol & Rerksuppaphol 2017[42] • Country: Thailand.	• Randomized controlled trial. • Post-intervention. • 217 adolescents with 10.7±3.1, with 111 enrolled in intervention group at baseline.	• Internet based obesity program. • Information related to healthy nutrition and PA. • Individual weight status informed the content of the program for the participants. • Consist of personal data collection, anthropometric variables and the interpretation of weight status, information related to health nutrition, food habits and physical activity. • Information over the internet included text and graphics.	• Weight status, waist and hip circumference.
• Malakellis et al. 2017[43] • Country: Australia • Intervention name: Australian Capital Territory "It's Your Move" (ACT IYM).	• Quasi-experimental trial. • 2-year follow-up • 880 adolescents between the age of 12-16 years, 628 enrolled in intervention group at baseline.	• Multiple component targeting key-elements of obesity and obesogenic environments. • Based on the Analysis Grid for Element Linked to Obesity (ANGELO). • Identify and prioritize key determinants while considering gaps in knowledge, community capacity, culturally specific needs, and current health promotion. • Changes on the school and community-based systems changes to facilitate healthier lifestyles. • Based on the changing the school environment by implementing a "Food at School Policy"	• Weight and height • Adolescent Behavior Attitude and Knowledge Questionnaire (nutrition/diet, PA, sedentary behaviors, perceptions of school environment, home environment, and neighborhood environment. • Mental wellbeing (health-related quality of life and depressive symptomatology). • Demographics
• Ardic & Erdogan 2017[44] • Country: Turkey	• Quasi-experimental trial • Post-intervention and 12-month follow-up.	• Educational information on leading a healthy lifestyle. • Cognitive behavioral skill building.	• Demographic questionnaire • Weight and height • Pedometers: subjects' steps

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• Intervention name: COPE healthy lifestyles teen program	• 100 adolescents with 12.8±0.8 years old, 50 enrolled in intervention group at baseline.	• Education information on leading a healthy lifestyle and cognitive-behavioral skill building. • Adaption of an US study to Turkish reality (COPE).	• Water consumption • 24hRecall: daily food • Adolescent lifestyle profile scale: nutrition behaviors, PA behaviors, stress management behaviors. • Frequency of health promoting behaviors. • Nutrition Knowledge Scale for adolescents • PA Knowledge Scale for adolescents • Healthy Lifestyle beliefs scale • Beck Depression Inventory
• Lubans et al., 2016[45] • Country: Australia • Intervention name: ATLAS Boys	• Randomized controlled trial • Post-intervention, 8 and 18-month follow-up • 361 adolescent boys with 12.7±0.5 years old, 181 enrolled in intervention group at baseline.	• Self-Determination and Social Cognitive Theory. • Increase autonomy, competence, and relatedness to improve their autonomous motivation for school sport and leisure time PA. • Support students' psychological needs for autonomy, competence and relatedness to improve their autonomous motivation for school sports and leisure time PA. Teachers were trained to deliver enhanced sport sessions to enhance students' autonomous motivation for PA.	• Body Mass Index and waist circumference • Physical Activity (ActiGraph® accelerometer) • Adolescent Sedentary Activity Questionnaire (ASAQ) • Sugar Sweetened Beverages – through two items from NSW Schools PA and Nutrition Survey (SPANS). • Muscular Fitness (90º Push Up test, handgrip dynamometer to determine hand and forearm strength). • Resistance Training Skills Battery (perfume lung, push-up, overhead press, front support with chest touches, squat and suspend row). • Motivation regulation for school sports.
• Fulkerson et al., 2015[46] • Country: USA • Intervention name: Home Plus	• Randomized controlled trial • 12 and 21-month follow-up • 149 families (children mean age=10.3±1.4 years old; parents mean age=41.6±7.6 years old), 74 families enrolled in intervention group at baseline.	• Social Cognitive Theory and Social Ecological Model • Personal, behavioral, and environmental factors was found to be associated with healthful home food environments; sedentary behavior, including screen time; meal and snack times, including preparation; and food and beverage consumption within family homes. • Address personal, behavioral and environmental factors was associated with healthful home environment, sedentary behaviors, meal and snack	• Psychosocial Survey • Height and weight • Family Dinner Frequency • Pubertal Development Scale

		times, and food and beverage consumption within families. • Targeted family change in the planning, frequency, and healthfulness of family meals and snacks, and limiting meal-related screen time. • Attended 10 monthly group sessions and five brief goal-settings telephone calls. • Family received a guidebook with sessions topics, strategies to promote behavior change and study goals, recipes and community resources.	
• Lazorick et al., 2015[37] • Country: USA • Intervention name: MATCH	• Randomized controlled trial • Post-intervention • 362 adolescents with mean age 13.1±0.5, 189 enrolled in intervention group at baseline.	• Social Cognitive Theory and Self-Determination Theory • Education and Behavioral Curriculum. • Lessons are delivered by classroom teachers and embedded within standard educational curricula in 7th grade. • Lessons were delivered in sequence planned manner, key concepts were repeated and applied to enhance skills development in making healthy choices. • MATCH group teachers provided lessons over 14 weeks, compared to the control who received usual curriculum. • Student maintained a notebook to track lessons and progress. • Pedometers and small incentives* were provided for achieving goals. * pens, lanyards, drawstring, bags, calculators, and water bottles	• Socio-demographics: sex, age, race • Weight Status (BMI) • Fitnessgram (fitness test) • 37-item lifestyle questionnaire (based on the Youth Risk Behavior Survey and National Health and Nutrition Examination Survey): sleep, eating, physical activity, and technology use.
• González-Jiménez et al., 2014[48] • Country: Spain	• One group, pre post-test design • Post-intervention • 91 adolescents, between 15-17years old.	• School-based knowledge education program to reduce unhealthy weight gain.	• Body Mass Index

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		• Nutrition and Physical Activity Intervention • Three workshops on healthy eating and food guides; Agreement with the PE teachers from the schools to establish a series of games and activities during PE classes.	
• Grydeland et al., 2014[51] • Country: Norway • Intervention name: HEIA Study	• Randomized controlled trial • 2-0month follow-up • 1485 adolescents, 11.2±0.3 years old, 465 participated in intervention group at baseline	• Social Ecological Framework. • Multiple intervention efforts to promote healthy diet and increase awareness of healthy choices, increase PA during school hours and leisure time, and to reduce screen-time. • School teachers were key persons in implementing intervention components. • Healthy Weight promotion program. • Did not contribute to increase rates of unwarranted diet behaviors and eating disorders (but did not added focus on eating disorders)	• Waist circumference, Body Mass Index, and Waist-to-Hip ratio • Pubertal Category Scores (self-reported pubertal status) • Demographic characteristics
• Nollen et al., 2014[38] • Country: USA	• Randomized controlled trial • Post-intervention (4week), 8-week and 12-week follow-up. • 51 adolescent girls, 11.3±1.6 years old, 26 participated in intervention group at baseline.	• Promote health behavioral change • Mobile technology with three 4-week modules: fruit and vegetables, sugar-sweetened beverages, and screen-time. • Goal setting and planning for girls to set 2-daily goals. This was accompanied with a plan for improving the behavior addressed in each module including cues to action and self-monitoring. Intervention was delivered on handheld computer.	• Socio-demographic characteristics: DOB and race/ethnicity • Availability of FV, SSB and screen-time devices at home. • 2-day 24h Recall to assess FV and SSB intake. • Brief Questionnaire of Television viewing
• Dewar et al., 2013[54] • Country: Australia	• Randomized controlled trial • 12 and 24-month follow up	• Social Cognitive Theory • Guided by previous pilot RCT • Combine range of strategies to promote lifestyle (e.g., walking to school)	• Body Mass Index and Body Fat (Bioelectric impedance) • Physical Activity (via ActiGraph) • Diet Intake (Australian Child and Adolescent Eating Survey) • Sedentary Behaviors (Adolescent Sedentary Activity Questionnaire)

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• Intervention Name: NEAT Girls	• 357 adolescent girls, 13.2±0.5 years old, 178 enrolled in intervention group at baseline.	and lifetime PA (e.g., resistance training), improve dietary intake, and reduce sedentary time.	
• Bonsergent et al., 2013[56] • Country: France • Intervention name: PRALIMAP Trial	• Randomized Controlled trial • Mid-study and post-intervention • 3538 adolescents, 15.6±0.7 years old, 1949 participated in education strategy (1029 environmental and 920 non-environmental strategy) and 1589 in non-education strategy (699 environmental and 890 non-environmental strategy).	• Three strategies for prevention was used: educational strategy (personal skills), screening strategy (detection of weight-related problems and proposing a care model), and environmental strategy (favorable and supportive environment). 1. Education: development of nutritional knowledge and skills; 2. Environment: creation of a favorable environment by improving availability of "healthy" dietary items and physical activity; 3. Screening and care: detection of overweight/obesity and, if needed adapted care management.	• Demographic characteristics • Mental health (anxiety, depression and eating disorders). • Eating Attitudes Test 40 (EAT-40) • Hospital Anxiety and Depression Questionnaire (HAD) • Body Mass Index
• Lubans et al., 2011[55] • Country: Australia • Intervention name: Physical Activity Leaders (PAL)	• Randomized controlled trial • 3 and 6-month follow up • 100 adolescents, 14.3±0.6 years old, 50 enrolled in intervention group at baseline.	• Promotion of lifestyle and lifetime activities. • Social Cognitive Theory. • Intervention components, behavior change strategies, and targeted constructs (SCT). • Focuses on the promotion of lifestyle (i.e., activities that are performed as part of everyday life, walking to school and using the stairs) and lifetime activities (i.e., activities that may be easily carried out into adulthood because they generally need one or two people, e.g., resistance training).	• Height, weight, waist circumference, and % body fat • Leg dynamometer, 90º push-up test, 7-stage abdominal strength test • Physical Activity (via pedometers) • Diet behaviors (daily consumption of fruit of vegetables, sugar contained beverages, and water) • Process evaluation
• Jansen et al., 2011[57] • Country: The Netherlands	• Randomized controlled trial • Post-intervention • 1236 adolescents, 10.8±1.0 years old, 583 enrolled in intervention group at baseline.	• Theory of Planned Behavior. • ANGELO framework (identify and prioritize environmental determinants)	• Height, weight, and waist circumference • Fitness (20m shuttle run) • Demographic characteristics

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• Intervention name: Lekker Fit (Enjoy being fit)		• Focuses on the promotion of healthy eating and active living rather than achievement of an ideal body weight. • Intervention targets individual behaviors, as well as school policies and curriculum.	
• Fotu et al., 2011[49] • Country: Tonga • Intervention name: Ma'alahi Youth Project	• Quasi-experimental design • 3-year follow-up • 1712 adolescents, 14.8±1.9 years old, 897 participated in intervention group at baseline	• Build capacity of communities to create their own for promotion of healthy lifestyle. • Social marketing approaches, community capacity building, and grass roots activities to promote healthy behaviors.	• Body Mass Index and Body Fat (Bioelectric impedance)
• Chen et al., 2011[50] • Country: USA • Intervention name: WEB ABC study	• Randomized controlled trial • 2, 6 and 8-month follow up • 63 adolescents, 12.5±3.2 years old, 27 participated in intervention group at baseline.	• Activities to enhance self-efficacy and facilitate understanding and problem-solving skills • Transtheoretical Model and Socio-Cognitive Theory. • Web-based program consisted of activities to enhance self-efficacy and facilitate understanding and use of problem-solving skills related to nutrition, PA, and coping. • PA has the goal of increasing energy expenditure. Participants engage in different types of non-competitive activities, learn types of activities to perform during recess, and at home, and learn alternatives to watching TV. • Internet sessions for parents (three) to coach parents in the skills needed to help their kids improve progress toward healthy lifestyle and healthy weights.	• Family information (socio-demographics) • Suinn-Lew Asian Self-reported Acculturation Scale • Body Mass Index • Waist-to-hip ratio • Blood pressure • Physical Activity (via ActiGraph) • 3-day food diary • PA and diet knowledge • Child Dietary Self-Efficacy • PA self-efficacy
• Simon et al., 2008[52] • Country: France	• Randomized controlled trial	• Theory-based multilevel	• Fasting blood samples (glucose, total and high-density lipoproteins, triacyclglycerols and insulina)

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	• Mid-intervention and 4-year post-intervention • 954 adolescents, mean age 11.6±0.6 years old, 475 participated in intervention group at baseline.	• Change attitudes towards PA, social support by parents and educators, and provide environmental and institutional conditions to use knowledge and PA skills acquired • Program included an educational component focusing on PA and SB • Change attitudes towards PA. • Promote social support by parents and educators. • Provide environmental institutional conditions encouraging the adolescents to use knowledge and PA skills acquired.	• Height, weight, %body fat (bioelectric impedance) • Modifiable Activity Questionnaire (Physical Activity and Screen time)
• Shaw-Peri et al., 2007[53] • Country: USA • Intervention name: NEEMA	• Pre-post without control design • 269 adolescents, mean age 10.5±0.7 years old.	• Developed based on learning outcomes from a study reporting increased risk for Diabetes type 2. • Social structure to change health behaviors (increase PA, increase fiber intake, and decrease saturated fat, sugar intake and sedentary time) • Reinforce lessons learned in health class and promote leisure time PA. • Improve nutrition knowledge of food service staff • Promote healthy food choices to entire family • Modeled based on health program that was developed in response to two local studies showing increase rates of diabetes risk factors. • Organized health program sessions transmitted to children through pre-existing social structures (home, health class, school cafeterias, and after school) to change health behaviors (increase PA, dietary fiber, and decrease saturated fat, refined sugar intake, and sedentary time).	• Height, weight and %body fat (bioelectric impedance) • Fasting Capillary Glucose • Physical fitness (20m shuttle run test)

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Table 2 – Findings from the intervention studies

Author, publication year	Summary of main results	Key statistical methods and co-variates variables
Shared risk factors for obesity and eating disorders risk factors		
Simpson et al., 2019[22]	• Intervention was both acceptable and feasible. • Reduction in several risk factors that were sustained at follow-up: eating pathology, appearance satisfaction, thin-ideal internalization, restrained eating, negative affect, emotion dysregulation and fat intake. • BMI was not changed from baseline to post-intervention, but increased from post-intervention to follow-up (+0.34kg)	• Descriptive statistics to evaluate acceptability and feasibility of the intervention. • Qualitative content analyses explored open-ended responses to the exit questionnaire. • Hierarchical linear models (HLM) to assess within-subjects change on the outcome across three-points. • Paired-sample t-tests were used to examine if mean scores differ across time.
Leme et al., 2016[81] e 2018[23]	• Although no significant differences on BMI, this favored intervention group (-0.26kg/m^2) at post-intervention. • A lower increase in waist circumference was found in the intervention group at post-intervention and 6-month follow-up. • Improvement in screen time on the weekends and vegetable intake was found at post-intervention. • Significant results favored control group regarding time spent on screens during weekdays and weekend at 6-month follow-up. • PA social support and healthy eating strategies were improved at post-intervention. • Healthy eating, social support, and strategies were improved at 6 month follow-up. • Intervention groups were more likely to report unhealthy weight control behaviors at follow-up	• Descriptive statistics were used to characterize the sample • Chi-square and t-tests were used to examine baseline differences between intervention and control groups. • One-way analyzes of covariates (ANCOVA) were used to evaluate the effect of the intervention. • Adjustment for clustering at school level using a random intercept. • For categorical variables (dichotomic), logistic generalized estimating equations (GEE) were used to determine the impact of the intervention. • Intention-to-treat was employed.

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Castillo et al. 2019[24]	• Program did not have any effect on male students. • Interaction effect for time and group in thin-ideal internalization and in disordered eating attitudes/behaviors, with improvements over time only for females. • Effect size was insignificant, meaning that the effectiveness of this integrated prevention program was limited.	• Descriptive statistics were used to characterize the sample. • BMI changes over time by group was calculated using a Kruskal-Wallis test. • Comparisons were performed separately for sexes using two-way analyses of covariance with type of group and time as independent variables. • Age was treated as confounder variable. • Mixed Model Repeated measures analyses of covariance models tested whether intervention effect varied for each type of group. • Post-hoc Bonferroni test. • Effect size was measured using eta squared (η^2).
Dunker & Claudino 2018[25]	• Did not result any statistically significant differences between intervention and control groups, including: • Body Shape Questionnaire (intervention: OR 64.33, 95%CI 59.2-69.33 vs. control: OR 62.02, 95%CI 56.63-67.40). • Adherence was low during the intervention (32.9%) and maintenance phase (19.1%) of the program.	• Descriptive statistics were used to characterize the sample. • Chi-square and t-tests were used to examine baseline differences between intervention and control groups. • Generalized Estimating Equations to evaluate the intervention impact (taking into account groups and time). • Intention-to-treat protocol
Shomaker et al., 2017[35]	• Family-base, Interpersonal-Therapy was feasible and acceptable indicating good attendance (83%). • Perceived benefits to social interactions and eating. • Post-treatment, children in the Family-base, Interpersonal-Therapy reported greater decreases in depression (95%CI -7.23, -2.01, d=1.23) and anxiety (95%CI -6.08, -0.70, d=0.79) and less odds of loss of control (95%CI -6.08, -0.70, d=0.38) than the family-base, Health Education. • 6 month follow-up: children in FB-IPT had greater reductions in disordered-eating attitudes (95%CI -0.72, -0.05, d=0.66).	• Chi-square and t-tests were used to examine baseline differences between intervention and control groups. • ANOVA/ANCOVA was used to assess intervention diferences. • Logistic regression was used to assess intervention differences based on categorical variables. • Adjusted for baseline characteristics: children's sex, baseline age, and BMI zscore. • Intention-to-treat protocol.

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	• 1 year follow-up: greater decreases in depressive symptoms (95%CI -8.82, 0.44, d=0.69) than control group (health education). • No significance in BMI gain between groups.	
Tanofsky-Kraff et al., 2017[26]	• No significant effect of group on change in BMI zscore and adiposity. • Baseline social adjustment problems and trait-anxiety moderated outcome. • Girls with high self-reported baseline self-adjustment problems or anxiety, IPT compared to HE was associated with the steepest declines in BMI zscores. • For adiposity, girls with high- or low- anxiety in HE, and girls with low-anxiety in IPT experienced gains, while girls with high-anxiety stabilized.	• Descriptive statistics were used to characterize the sample. • Pearson correlations were used to verify associations key baseline variables. • Logistic regression was used to predict 3year attrition from baseline variables. • Linear mixed model used to evaluate primary hypotheses. • Age and height were computed as co-variates.
Sanchez-Carracedo et al., 2016[27]	• There is no significant difference in BMI from baseline (21.2±3.7kg/m^2) to post-intervention (21.5±3.4kg/m^2). • At post-intervention drive for thinness, negative affect, self-esteem was in the hypothesized direction, with exception for SATAQ-P and EDI-BD, but none reach significance. • Girls from the intervention group showed significantly greater reductions in beauty ideal internalization, disordered eating attitudes, and weight-related teasing from baseline to 1 year follow-up compared to girls in the control group.	• Generalized Estimating Equation (GEE) models were used to evaluate intervention impact. • Adjustments for co-variates BMI, age, SES, and origin of parent population. • Cohen's D effect size of the intervention.
Wilkish et al., 2015[36]	• Media Smart girls had half the rate of onset of clinically significant concerns about shape and weight than control girls at the 12m follow-up. • Media Smart and HELPP girls reported significantly lower weight and shape concern than Life Smart girls. At the 12m follow-up. • Media Smart and control girls scored significantly lower than HELPP girls on eating concerns and perceived pressure at 6m follow-up. • Media Smart and HELPP boys experienced significant benefit on media internalization compared to control	• Analyses of Covariance (ANCOVA) was used examine baseline differences between four groups. • Linear Mixed Models were used for the intervention efficacy. • Adjustments for baseline results. • Bonferroni post-hoc and Cohen's D effect sizes was used to examine significant comparisons. • Logistic regression was used to examine proportion differences.

	boys. These results were sustained at 12m follow-up in Media Smart boys. • Group-time effect found that Media Smart participants reported more PA than control and HELPP participants at 6m follow-up. • Main effect for group found Media Smart participants reported less screen time than control participants.	
Stice et al., 2013[28]	• Intervention participants showed significantly less body dissatisfaction and eating disorder symptoms, and lower eating disorder onset through 2-year follow-up versus control (but differences were small). • No main effects for BMI, depressive symptoms, dieting, caloric intake and physical activity, or obesity onset. • Moderator analyses revealed stronger eating disorder symptom effects for youth. Including initially elevated symptoms and lower pressure to be thin, stronger BMI effects for youth with initially elevated symptoms and BMI scores, and weaker eating disorder symptom effects for youth with initially elevated pressure to be thin.	• Fit unconditional mixed models with person nested in the group. • Wald test to test significance of random effects. • Effect sizes were calculated (Cohen's D). • Multiple imputations to account for missing data. • Proportional hazard model to test whether onset of eating disorder and obesity differ across conditions. • Analyses of reliable change scores to assess main clinical significance effects • Moderator models included all variables in the main effect models and all 2- and 3-way interactions between group, time, and the moderator.
Franko et al. 2013[29]	• Girls reported decreased body dissatisfaction, decreased physical appearance comparison, and increase appearance satisfaction relative to control group. • Effects were not maintained at 3 month follow-up. • No-significant differences were found between the intervention and control groups with boys. • Moderation analyses suggested positive effects for diverse adolescents, as well those where overweight or indicated baseline high body dissatisfaction.	• Analyses conducted separately among boys and girls. • Baseline differences between control and intervention groups using t-tests. • 2x2 mixed model ANOVA to assess intervention effect. • Intention-to-treat. • Partial eta square to estimate effect sizes.
González et al., 2011[30]	• Participants from both prevention programs scored lower than the participants in the control group at follow-up assessments on EAT-40 and CIMEC-26 scores.	• Sheffé's multiple comparison procedures for baseline differences. • Two linear mixed-model analyses to assess the effectiveness • Adjusted for baseline differences and type of school • Bonferroni-adjusted *post-hoc* were conducted to value the effect of group condition. • McNemar procedures for value changes.

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Neumark-Sztainer et al., 2010[31]	• Did not lead to significant changes in girls' %body fat or BMI • Improvements were seen for sedentary activity, eating patterns, unhealthy weight control behaviors, and body/self-image. • Sedentary behaviors were decreased by one 30-minute block/day. • Increased portion control behaviors. • Unhealthy weight control behaviors decreased by 13.7%. • Improvements were seen in body image and self-worth. • More support by friends, teachers, and families for healthy eating and PA.	• Descriptive statistics were used to characterize the sample. • Two-time point repeated measures analysis of post-class and follow-up. • Adjusted for baseline measure, age, and ethnicity/race and with schools
Stock et al., 2007[32]	• Increase in healthy-living knowledge behavior and attitude scores, and smaller increase in systolic blood pressure. • BMI and weight had a smaller increase.	• Descriptive statistics was used to characterize the sample. • 2-tailed paired test to evaluate significance of changes • Effect of intervention using mixed effects models (linear mixed models).
Austin et al., 2007	• Follow-up girls, 3.6% (15 of 422) in control schools compared with 1.2% (4 of 327) in intervention schools reported engaging in disordered weight control behaviors. • Odds of these behaviors in girls in intervention schools were reduced by 2/3 compared with girls in control groups (OR: 0.33, 95%CI 0.11-0.97). • No intervention effect was observed in boys.	• Multivariate logistic regression models with generalized estimation equation models. • Adjusted for intervention condition, school-level baseline prevalence of disordered weight-control behaviors, sex, and an intervention condition sex interaction term. • Additional models also controlled for grade, race/ethnicity, and overweight.
Austin et al., 2005[34]	• After the intervention, 14 (6.2%) of 226 girls in control schools and 7 (2.8%) of 254 girls in intervention schools reported purging or using diet pills to control their weight. • Girls in intervention schools were less than half as likely to report purging or using diet pills at follow-up compared with girls in control schools (OR 0.41, 95%CI 0.22-0.75).	• Multivariate logistic regression models with generalized estimation equation models. • Adjusted for intervention condition, school-level baseline dieting, age, obesity, and ethnicity.

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Energy-balance programs		
Sgambato et al., 2019[39]	• BMI was slighter higher in intervention group (0.2kg/m²) and small decrease in % body fat. • There were no significant differences in daily frequency intake of foods. • Physical activity significantly increased for intervention group (△=12.5min/week). • Analyses of 30% of the sample that used the 24h Recall significantly decreased the intake of fruit juice (△=-0.42±0.18) compared to the control group.	• Changes in the outcomes were analyzed using mixed models. • Intention-to-treat. • Considered the clustered effect of classes. • Random intercept and slopes were used for adequacy of the models. • Data for specific food groups measured by one 24h Recall were made using marginal generalized linear models.
Aperman-Itzhak et al., 2018[40]	• Overweight and obesity decreased significantly within intervention group (25% to 17.9%, p=0.04), without a significant change in the control group (20.5% to 17.6%, p=0.12). • Religious children had double the risk of being overweight/obese (OR 2.10, 95%CI 1.15-3.73, p=0.02). • Knowledge was improved in both study groups, with no differences in health behavior scores at the beginning or end of the year.	• Unpaired tests for comparison between groups. • Paired tests for changes from beginning to end of year, separately for each group. • Chi-square, McNemar's and Fisher's exact tests were used for categorical and dichotomous variables • T-tests were used to compare interval variables means. • Multiple logistic regression was used to identify risk factors for overweight/obesity. • Repeated measures general linear model test was used to evaluate interactions between study groups and time of measurements.
Yang et al., 2017[41]	• 1-year follow-up showed no significant difference in incidence rates of overweight/obesity and remission rates between groups. • However, intervention group showed a greater decrease in BMI zscore (-0.11, 95%CI -0.16 to -0.06), height (1.1cm, 95%CI 0.8 to 1.4), reduction on %body fat and increase in muscle mass compared with control. • Blood pressure was significantly reduced and results showed an improvement in physical fitness. • Subgroup analysis showed that normal weight males, and younger participants demonstrated the most beneficial results in weight-related outcomes. • Blood pressure reduction was more pronounced in the higher BMI group, boys, and older children.	• Descriptive statistics were used to characterize the sample. • Chi-square and t-tests were used to examine baseline differences between intervention and control groups. • Linear Mixed Models were used to evaluate changes in the outcomes (continuous). • Generalized Estimation Equations were used to compare results of categorical variables. • Adjusted for sex and age. • Sub-group analyzes according to weight status, age and sex.

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Rerksuppaphol & Rerksuppaphol 2017[42]	• Baseline anthropometric parameters and % of overweight/obesity were not significantly different between groups. • Control groups increased their % for overweight/obesity compared to intervention group. • Control group had significantly higher increase in BMI than those in the intervention group (1.2kg/m^2 vs 0.4kg/m^2. • Intervention group showed no change in BMI zscore, contrary to those in the control group which showed a significant increase in BMI zscore by the end of study.	• Descriptive statistics were used to characterize the sample. • Chi-squared, Fisher-exact test, t-students, Mann-Whitney U-test were used to verify differences across groups. • Paired t-test was used to verify differences in anthropometrics across times.
Malakellis et al., 2017[43]	• Proportion of overweight or obesity were similar over time within the intervention (24.5% baseline and 22.8% follow-up) and comparison groups (31.8% baseline and 30.6% follow-up). • Within schools, 2 of 3 intervention schools showed a significant decrease in the prevalence of overweight and obesity.	• Descriptive statistics were used to characterize the sample. • Chi-squared and t-students were used to verify differences across groups. • Mixed effect linear regressions or Generalize Estimating Equations to verify the intervention effects. • Adjusted for sex, age, parental education, and school.
Ardic & Erdocan 2017[44]	• Adolescents from the intervention group showed improvement in diet behavior, physical activity, and stress management. • Increase number of physical steps per week. • Improvement in daily fruit and vegetable consumption and daily water ingested. • Nutrition/Physical activity knowledge increased and weight and anxiety symptoms decreased. • Effect on BMI, depression, and health beliefs were not significant compared with the control group.	• Descriptive statistics were used to characterize the sample. • Chi-squared and t-students were used to verify differences across groups. • Repeated Measures Multivariate Analysis of Covariance (MANCOVA) and Cohen's D effect size differences between groups over time.
Lubans et al., 2016[45] and 2014[47]	• At post-intervention and 18-month follow-up, there were no intervention effects for BMI, waist circumference, or %body fat. • No significant effect for PA at post-intervention. • Significant intervention effects were found for screen time, sugar sweetened beverage consumption, muscular fitness and resistance training at post-intervention.	• Descriptive statistics were used to characterize the sample. • Linear Mixed Models were used to evaluate the intervention impact at baseline and follow-up. • Adjust for clustering at school level using a random intercept and participants SES. • Proportion differences between study arms among those improving weight status were done. • Intention-to-Treat Analysis

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	• Sustained (18-month follow-up) effects for screen-time, resistance training, skill competency, and motivational regulations for school sport.	
Lazorick et al., 2015[37]	• Post-intervention, MATCH had significant decrease in BMI measures compared to control. • Significant differences for combined overweight and obese participants from MATCH (-0.05, 95%CI -0.07, -0.02) and control group (-0.01, 95%CI -0.04, 0.02) for BMI zscore. • After 1-year, improvements were sustained for the overweight subgroup, the mean BMI zscore decrease from 1.34 to 1.26 post-MATCH, then to 1.26 after 1-year, for the obese subgroup, mean BMI Zscore=2.16 to 2.13 post-MATCH to 2.08 after 1y. • Self-reported lifestyle behaviors showed no differences.	• Chi-squared, Fisher-exact test, t-students were used to verify baseline differences across groups. • Multi-regression models to compare changes. • Adjusted for effects of sex, race, school, and baseline BMI measures.
Fulkerson et al., 2015[46]	• No significant treatment group differences were found in BMI zscores at post-intervention or follow-up. • However, promising reduction in excess weight gain. • Post-hoc stratification by pubertal onset indicated prepubescent children in the intervention group had significantly lower BMI zscores than their control group counterparts.	• Baseline comparisons were done between intervention and control groups. • Generalized linear models to assess intervention effects. • Adjusted for baseline child BMI zscore, age, sex, race, and family receipt of economic assistance. • Intention-to-treat analysis.
Gonzalez-Jimenez et al., 2014[48]	• Students improved weight status at post-intervention, not taking into account their sex. • BMI before (M=23.2±4.1kg/m^2) and after (M=23.0±3.9kg/m^2). • Significant results for healthy eating behaviors. • No significant results for PA by the end of the study (1-year).	• Comparing means among variables of interests to evaluate improvement on weight status or healthy habits.
Nollen et al., 2014[38]	• Mobile technology girls used the program 63% of days • Trends toward increase in FV (+0.88) and decrease SSBs (-0.33). • Adjusted difference between groups of 1.0 servings of FVs (d=0.44) and 0.4 servings of SSBs (d=0.34) indicated small to moderate effects of the intervention.	• Generalized Linear Models to assess association between mobile-technology and behavior change. • Independent t-test and paired sample t-tests to assess between and within-group change across groups. • Cohen's D effect sizes estimates

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	• No differences were observed for screen-time or BMI.	
Dewar et al., 2013[54]	• After 12 months, changes in BMI (△= -0.19, 95%CI -0.70 to 0.33kg/m^2) BMI zscore (△= -0.19, 95%CI -0.70 to 0.33zscore) and %body fat (△= -1.09, 95%CI -2.88 to 0.70%) favored the intervention, but they were not statistically different from those in the control group. • Changes in screen time were statistically significant (△=-30.7, 95%CI -62.43 to -1.06min/day). • No significant group by time effects for PA, dietary behavior, or self-esteem. • After 24 months, there were no intervention effects on BMI (adjusted mean △= -0.33, 95%CI -0.97, 0.28kg/m^2) and BMI zscore (△=-0.12, 95%CI -0.27, 0.04 zscore). • Results showed a significant difference for %body fat (△= -1.96, 95%CI -3.02, -0.89%). • No significant effects for PA, screen time, and dietary intake.	• Linear Mixed Models • Intention-to-treat principles • Adjusted for clustering at school level.
Bonsergent et al., 2013[56]	• Adolescents who completed the PRALIMAP trial were younger, less often suspected of having eating disorders and depression, and came from higher SES than those who did not. • 2-year change of outcomes was more favorable in the 12 screening and care high schools compared to the no-screening ones: 0.11 lower increase in BMI, 0.04 greater decrease in BMI zscore, and a 1.71% greater decrease in overweight/obesity prevalence. • Education and environment strategies were not effective than no strategy intervention.	• Descriptive statistics to assess baseline participants characteristics. • Bivariate and then multivariate hierarchic mixed models were used to identify baseline characteristics associated with the completion of PRALIMAP and to highlight a potential selection bias. • Comparisons of outcome changes (T2-T0) between each strategy's schools and their controls were carried out using a three-level hierarchic mixed model (repeated measurements, within students, within high schools). • Potential confounders were the main variables known to be associated with BMI, namely, age, sex, SES, and eating disorders.
Lubans et al., 2011[55]	• Significant group-by-time interaction effects were found for BMI (△= -0.8kg/m^2, d=0.7), BMI zscore (△= -0.2%, d=0.7) and body fat (△= -1.8%, d=0.5), but not for waist circumference, muscular fitness, or physical activity. • Participants in the intervention group reduced their consumption of sugar-containing beverages.	• Independent sample t-tests were used to compare differences between intervention and control groups at baseline and for differences between participants who completed the study and those who had dropped out. • Linear Mixed Models were used to assessed primary outcomes for impact of group, time, and group-by-time interaction. • Adjusted for clustering at school level. • Cohen's D effect sizes.

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		• Proportion of overweight/obese participants in each group compared using chi-square tests. • Nutrition variables recoded as dichotomous variables (e.g., ≤2 servings of fruits/day or >2 servings/day) and treatment effects using logistic regression. • Baseline variables count as covariates.
Jansen et al., 2011[57]	• Prevalence of overweight increased by 4.3% in the control group and by 1.3% in the intervention group. • No significant effects were found for BMI.	• T-test and chi-square was used to compare intervention and control groups at baseline. • Evaluation of the effectiveness via multilevel analysis: multi-linear and logistic regression analyses. • Adjusted for baseline values, socio-demographics, weight status, and time-between measurements. • Missing value analyses for children lost to follow-up as compared to children with follow-up measurements using logistic regression. • Missing data were imputed using multiple imputation.
Fotu et al., 2011[49]	• Both intervention and comparison groups showed large increases in overweight and obesity prevalence (10.1% and 12.6%). • Small decrease in %body fat in intervention group (-1.5%). • No differences in outcomes for any other anthropometric variables between groups. • Behavioral changes (diet and PA) did not follow a clear positive pattern.	• Outliers (>3 SD from mean) values on anthropometrics at baseline or follow-up were removed from analyses. • Descriptive statistics were used to assess baseline participants characteristics. • T-test and chi-square was used to compare intervention and control groups at baseline. • Logistic regressions was used to assess differences between follow-up and baseline. • Adjusted for baseline variable, age at follow-up, height and weight at follow-up, sex, and duration between measurements.
Chen et al. 2011[50]	• Decrease in waist-to-hip ratio and diastolic blood pressure. • Increase in fruit and vegetables intake, PA, and knowledge about PA and nutrition.	• Descriptive statistics were used to assess baseline participants characteristics. • T-test used to compare intervention and control groups at baseline. • Linear Mixed Models to examine change across times between groups.
Grydeland et al., 2014[51]	• Beneficial effects found for BMI and BMI zscore in girls, but not in boys. • Beneficial effect for BMI in participants of parents reporting a high level of education. • Negative effect were found for waist-to-hip ratio in participants reporting a low level of education.	• Descriptive statistics were used to assess baseline participants characteristics. • T-test and chi-square were used to compare intervention and control groups at baseline. • One-Way-Analyses of Covariance (ANCOVA) was used to evaluate the effect of intervention.

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	• No intervention effects for waist circumference and weight status.	• Logistic regressions (for categorical variables) was used to evaluate differences. • Adjusted for interaction terms (sex, pubertal status and parental education level).
Simon et al., 2008[52]	• Intervention students had lower increase in BMI and age-sex adjusted BMI over time than controls. • Age-sex adjusted BMI changes (-0.29, 95%CI -0.51 to -0.07kg/m^2 at 3 years) and (-0.25, 95%CI -0.51, 0.01kg/m^2 at 4 years). • Intervention had a significant effect throughout the study initially in non-overweigh adolescents (-0.38, 95%CI -0.60, -0.11kg/m^2) for adjusted BMI at 4y, corresponding to lower increase in fat mass index. • Non-significant differences in overweight adolescents across groups at 2 years (-0.40, 95%CI -0.94, 0.13kg/m^2) • At 4 years, 4.2% of the initially non-overweight adolescent were overweight in the intervention schools, 9.8% in the controls (0.41, 95%CI 0.22-0.75). • Intervention adolescents had increase in supervised PA, decrease of TV/video viewing, and an increase in HDL-cholesterol concentrations.	• Descriptive statistics to assess baseline participants characteristics. • T-test and chi-square was used to compare intervention and control groups at baseline. • Mixed Linear and Logistic Models were used to analyze outcomes. • Adjusted for clustered randomization and individual data by time.
Shaw-Peri et al., 2007[60]	• Face-to-face interviews revealed diabetes, obesity, and food insufficiency as major health concerns among Physical Education (PE) teachers. • Large classes and short PE periods were major challenges for implementing the program. • Between baseline and follow-up, fitness laps increased from 16.40±9.98 to 23.72±14.79, fasting capillary glucose decreased 89.17±10.1mg/dl to 83.50±11.26mg/dl, and %body fat decrease from 27.26±12.89% to 26.68±11.67%.	• Descriptive statistics were used to assess baseline participants characteristics. • Paired t-test was used to compare intervention and control groups at baseline.