

# Weight loss interventions for overweight and obese adolescents: a systematic review

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## Abstract

**Purpose** To determine what factors contribute to the efficacy of non-drug treatments designed to promote weight loss in overweight and obese adolescents.

**Methods** *Data sources* Medline/PubMed; Psychinfo; EMBASE; Web of Science (ISI); and Cochrane Central Register of Controlled Trials. *Study selection* Randomized clinical trials of treatments for obesity and overweight in adolescents aged 10–19 years with a minimum duration of 2 months. *Data extraction* 115 of the 12,948 publications retrieved met eligibility criteria and 26 were included in the final sample. *Period of extraction* January 2004 to November 2014.

**Results** The Delphi list was used to evaluate the methodological quality of the studies ( $M = 5.58$ ,  $SD = 1.027$ ). There was considerable variability between the interventions, but they were all multifactorial, with components such as nutritional education, physical activity, family support and psychological therapy. The number of contacts with subjects during the course of the intervention was a predictor of treatment efficacy when the groups were compared. **Limitations** This systematic review was limited to trials reported in English and by the lack of methodological rigor and shortcomings in reporting in the studies reviewed.

**Conclusions** Multidisciplinary interventions including family support and guided behavior modification appear to

be effective methods of reducing BMI in overweight and obese adolescents.

**Keywords** Adolescents · Controlled trial · Overweight · Obesity · Treatment · Systematic review

## Abbreviations

BMI Body mass index  
CBT Cognitive-behavioral therapy  
MI Motivational intervention

## Introduction

In the last 30 years, the prevalence of obesity in young children and teenagers has quadrupled. In 1980, 5 % of adolescents—defined as individuals aged between 12 and 19 years—were obese, but this figure has now risen to 21 % [1–4]. Obesity is associated with chronic diseases such as type 2 diabetes mellitus and hypertension and with abnormalities in lipid and glucose profiles. The joint presence of all these factors increases the risk of heart disease, the leading global cause of death, by a factor of four [5]. Cardiovascular risks are problems that can get aggravated or lead to premature death. There is a strong association between excessive weight in childhood and adolescence and health problems in early adulthood [6]. To prevent cardiovascular risk, interdisciplinary educational interventions designed to promote dietary changes and increase cardiorespiratory fitness are the first choice therapy for overweight and obesity [4, 7–12].

Several systematic meta-analytic reviews have evaluated the effectiveness of lifestyle change interventions in adolescents [13–16]; however, these reviews also included studies on younger children and did not discuss what

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components of interventions influence adolescents' adherence to treatment. Furthermore, all of them included clinical trials of both preventive and treatment interventions for obesity, although these two intervention types use different strategies and techniques to achieve their objectives. Nevertheless, the literature shows that to ensure adherence to educational programs among adolescents, it is necessary to use strategies designed specifically for this stage of development [7, 8, 17]. Moreover, the extremely negative stereotypes of people who are overweight and obese may contribute to a low quality of life in overweight and obese adolescents as well as increase the probability that they will experience depression, suicide, academic difficulties, vocational limitations and social challenges [18].

Kelly and Melnyk [19] looked at the efficacy of various interventions in a review of 17 randomized controlled trials (RCTs) carried out between 1980 and 2007; they discussed the implications of these trials for clinical practice and research. Another review evaluated the quality of clinical trials in which children and adolescents were assigned to immersion treatments that removed them from their obesogenic environment [20]. The authors pointed out that the main limitations of their studies [19–20] were: 1) They were not able to comprehend the participants' change mechanism and 2) the short description of the protocols. The authors of these earlier reviews recognized the need to expand them to include the latest research and research reported in other languages so as to be able to investigate how all levels of the ecological model can improve the intervention effect on behavior change in adolescents.

There has been only one systematic review focused on adolescent interventions and it showed that having the opportunity to use technology was an important component of the intervention to be successful, because young people are the main users of these resources [21]. One systematic review concluded that delivering material via the Internet and apps can be a good alternative to traditional methods for improving young people's knowledge of nutrition and another evaluated the use of video games as a tool for increasing the level of physical activity among adolescents [22, 23]. Neither of these reviews evaluated the effects of the interventions they considered on overweight and obesity and the samples did not consist exclusively of overweight or obese subjects [22, 23].

The objective of this systematic review is to determine what factors contribute to the efficacy of non-drug treatments designed to promote weight loss in overweight and obese adolescents. The effectiveness of interventions was evaluated via analysis of the effects on weight and cardiometabolic markers. This paper uses the World Health Organization's [24] definition of adolescence, namely the period from 10 until 19 years old and only studies that

investigated this population were considered for inclusion in our review.

## Methods

This systematic review followed the PRISMA checklist of items for systematic reviews and meta-analyses [25] and the Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0 [26].

### Eligibility criteria

This review covers studies in which the main target of the intervention was the adolescent; studies which focused on the treatment of the family were excluded. The RCTs included in this review cover interventions based on lifestyle change, adherence to diet and regular physical activity aiming at the behavioral change.

#### *Inclusion criteria*

- RCTs of overweight or obese adolescents.
- Trials with adolescents aged 10–19 years.
- Outcomes included body mass index (BMI) or percentile z-score for weight loss according to the World Health Organization criteria (1995).
- Treatment lasted at least 2 months.
- Published between 2004 and 2014.
- Published in English.
- Studies that tested lifestyle change interventions designed to promote weight loss in adolescents.

#### *Exclusion criteria*

- Studies that used medication in any of the groups.
- Studies where the sample included participants with normal BMI.
- Studies that focused only on the family or the school rather than directly on adolescents.
- Studies without a comparison group.
- Studies of preventive interventions.
- Studies which did not report treatment effectiveness.
- Studies exclusively to treat eating disorders.
- Studies that tested specific exercise protocols.
- Studies that tested specific diets or restrained diets.

#### *Information sources*

Detailed individual search strategies were developed for each of the following bibliographic databases: Embase, Medline (via PubMed), Web of Science and PsychInfo.

The Cochrane Central Register of Controlled Clinical Trials (Accessed by Cochrane Library) was also consulted to search registered trials and related publications. The end date for the search was November 23, 2014.

## Search

The selection of truncations and word combinations was adapted for each database search. All references were managed by Thomson Reuters Endnote reference manager (Web version) and duplicate hits were removed.

## Study selection

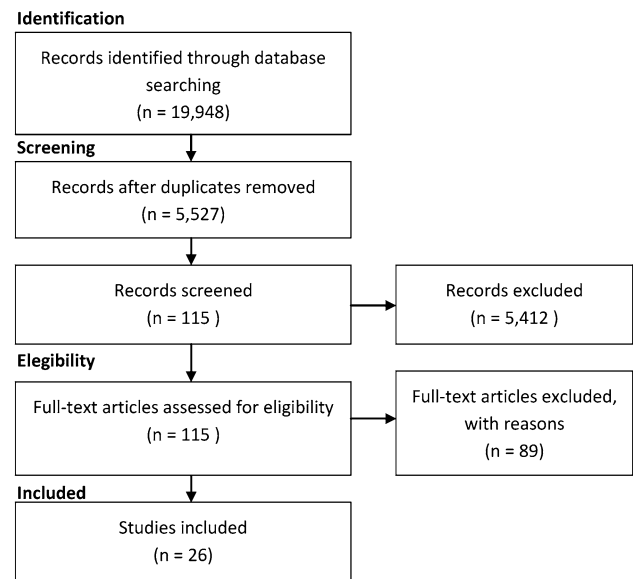
Two independent reviewers read the titles and abstracts of all studies to determine whether they met the eligibility criteria. The same two reviewers read all the articles independently and blindly to evaluate their methodology. A checklist based on the eligibility criteria was developed and used to classify studies as: positive (included), negative (not included) and neutral (doubtful). Studies were classified as positive if they met all the inclusion criteria, negative if they did not meet one or more of the criteria and neutral if the reviewer was uncertain about inclusion. One hundred and fifteen articles were assessed; overall inter-rater agreement was 86.9 % ( $n = 115$ ). In the disagreement cases, a third reviewer, expert on the subject, evaluated the articles to decide whether to include them or not. The concordance index, evaluated by kappa test, was estimated to be 0.650 and considered substantial, resulting in 26 articles being included.

## Data collection process

One author collected the required information from the selected articles. A second author cross-checked all the collected information and confirmed its accuracy. Disagreements were resolved by a third author who read the article concerned and made a final decision.

## Items of data

The following information was recorded: author(s), program name (where applicable), year of publication, country, sample size, age range, gender, eligibility criteria, time of first assessment and any follow-up assessments, description of each treatment group, support therapy used and comparison between the treatment groups. Effect size (ES) was calculated as Cohen's  $d$  for effects on weight (in kg) or BMI ( $\text{kg}/\text{m}^2$ ) in studies that reported means and standard deviations. Only the outcomes, which showed  $p$  values  $\geq 0.05$  for the difference between groups, were presented in the study.



**Fig. 1** Flowchart of the included studies

## Results

### Study selection

The search strategies retrieved 12,948 citations of which 7421 were duplicates. The remaining 5527 articles were evaluated on the basis of the title and abstract. The full texts of 115 publications were examined by two reviewers and on this basis 89 studies were excluded: 29 focused only on food intake or exercise prescriptions and did not include an intervention with a health education component; 18 had samples which did not meet the age criteria; 16 had samples which were not limited to overweight or obese adolescents; 10 did not include a control group; 5 were not randomized clinical trials; 5 were not published in English; 4 were descriptions of study protocols; and 2 were studies of preventive interventions. Figure 1 displays the flowchart for the inclusion of the 26 remaining trials and Table 1 presents their characteristics [27–52].

### Study quality assessment

The 26 clinical trials included in the review were assessed using the Delphi list [53] that consists of 12 items which allows the comparison among studies in methodological aspects, such as design, participants, intervention and clinical outcomes. This procedure was used to assess the methodological quality of studies and was not used to determine eligibility. One point was awarded for meeting each Delphi quality criterion and thus the maximum score was 12 points. The mean score of the included studies was 5.58 (SD = 1.027). Twenty-four of the clinical trials

**Table 1** Study characteristics

Author, program name (where applicable), year, country	Participants		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria			
Berkowitz et al. Lifestyle modification program (LMP) 2013, USA	169 12–16 M and F	Obese African-American and Caucasian adolescents BMI $\geq 28$ kg/m <sup>2</sup> (WHO)	(1) Self-guided LMP: participants had six scheduled clinic visits (45 min each) at which the parent and adolescent dyad met with a health coach for an individual family meeting. Group LMP followed the procedure, but only parents and teens in the Self-Guided LMP condition were instructed to read and complete the lessons in the treatment manual and review them at home together on a weekly basis (2) Group LMP: parents and teens in Group LMP were provided with 17 additional in-clinic group visits at which they reviewed their progress in completing the lessons from the treatment manual, discussed eating and physical activity topics and received peer support. Parents met in separate group sessions, which ran concurrently with the children's group	(1) Self-Guided LMP: required only six clinic visits, compared with 23 for Group LMP	Group difference Effect size (ES) for changes in weight or BMI 6 and 12 months: no group differences 1 = 2 a
Brennan et al. CHOOSE HEALTH, 2013, Australia	63 11–18 M and F	Overweight and obese adolescents BMI $> 85$ th percentile (IOTF)	(1) Cognitive behavioral principles were used to assist the adolescent and his or family to overcome barriers to changing lifestyle. Treatment was conducted on an individual basis and all sessions followed a specific structure. The treatment phase consisted of 12 60-min face-to-face sessions and 1 telephone session. Both parents and adolescents were required to attend the first six treatment sessions. Adolescents were then given the choice of attending the remaining sessions alone or with the support of a parent. The maintenance phase consisted of two 60-min maintenance clinic sessions and seven 15-min maintenance telephone sessions. Sessions were initially conducted weekly and gradually extended to monthly. Treatment was provided by a single clinician, the developer of the program	(2) Waiting list	6 Months: $\downarrow$ body fat mass ( $p < 0.01$ ); $\downarrow$ total body percent fat; ( $p < 0.001$ ); $\downarrow$ truncal fat mass ( $p < 0.001$ ); $\downarrow$ truncal lean mass ( $p = 0.006$ ); $\downarrow$ weight ( $p < 0.001$ ), $\downarrow$ BMI ( $p < 0.001$ ) and $\downarrow$ BMI z-score ( $p = 0.001$ ) 1 $> 2$ 1: weight ES: 0.07 BMI ES: 0.15 2: weight ES: $-0.04$ BMI ES: 0.08
Davis et al., 2012, USA	53 Mean 15.4 SD = 1.1 M and F	Adolescents with BMI $\geq 85$ th percentile (CDC), African-American or Latino ethnicity and grades 9th through 12th	(1) Maintenance group class: participants in the group class met monthly (classes lasted 90 min) at the Veronica Atkins Lifestyle Intervention Laboratory (VALIL). The format of classes was similar to the format of classes during the 4-month intervention: they included a cooking component, a snack, a nutrition lesson (focused on reducing sugar and increasing fiber intake) and a 45-min strength training session, led by a certified personal trainer	(2) Maintenance newsletter group: participants in the newsletter group received a monthly newsletter in the mail. The newsletter covered basic tips on how to continue to eat and drink foods and beverages low in sugar and high in fiber and included one or two new low-sugar or high-fiber recipes	4 months: $\downarrow$ bench press ( $p = 0.004$ ) $\uparrow$ protein (% kcal) higher in control 1 = 2 a

**Table 1** continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria	Intervention length	Follow-Up at baseline			
DeBar et al.,2012, USA	208 12–17 F	Eligibility was limited to female health plan members and BMI ≥90th percentile (IOTF)	5 months 12 months		(1) Multicomponent developmentally tailored behavioral intervention: the teen intervention comprised 16 90-min group meetings conducted over 5 months. Groups met weekly for 3 months and then biweekly during months 4 and 5. At each session, teens were weighed and reviewed dietary and physical activity self-monitoring records. If unable to attend a particular session, teens were offered telephone sessions. The intervention included the following: (1) changing dietary intake and eating patterns; (2) increasing physical activity by using developmentally tailored forms of exercise (e.g., exergaming); (3) addressing issues associated with obesity in adolescent girls (e.g., depression, disordered eating patterns, poor body image); (4) training participants' primary care providers to support behavioral weight management goals collaboratively	(2) Usual care: they received a packet of materials, including outline descriptions of evidence-based approaches to weight management for youth and adults, a parents' guide to helping adolescents make healthy lifestyle changes, information about local resources for weight management and healthy activity and a list of recommended books and online materials	Group difference Effect size (ES) for changes in weight or BMI 12 Months: ↑weight, lb ( $p < 0.015$ ) ↓BMI z-score ( $p < 0.012$ ) ↑Body satisfaction ( $p < 0.026$ ) ↓Appearance attitudes ( $p < 0.019$ ) ↓Family meals, times/week ( $p < 0.028$ ) ↓Fast food, times/week ( $p < 0.021$ ) 1 > 2 1: weight ES: -0.12 2: weight ES: -0.20
Doyle et al., Student Bodies 2 (SB2), 2008, USA	80 12–17 M and F	Overweight or risk to becoming overweight, BMI ≥85th percentile (IOTF) and Internet access	16 weeks 4 months		(1) Student bodies 2 (SB2): a 16-week, Internet-delivered program using a cognitive-behavioral approach to help adolescents to lose weight and increase positive body image. SB2 weekly content includes basic education, guided behavior modification aimed at improving weight control and cognitive exercises for improving body image. The first 8 weeks of the program were primarily oriented toward behavioral weight loss, whereas the second 8 weeks shifted to focusing on body image improvement. Participants were expected to spend 1–2 h per week and no more than 30 min per day using the program	(2) Usual care: adolescents and their parents received colored handouts containing basic information on nutrition and physical activity, but were not given specific instructions on behavior modification. They were told to continue visiting their physician as needed	4 months: ↓BMI z-score ( $p < 0.027$ ); ↑dietary restraint ( $p = 0.016$ ); ↓shape concerns ( $p = 0.044$ ); ↑healthy eating-related and physical activity-related skills ( $p = 0.001$ ); 1 > 2 1: weight ES: 0 BMI ES: 0.08 2: weight ES: -0.08 BMI ES: -0.03
Farah et al., 2013, Brazil	43 13–18 M and F	Obese adolescents BMI >95th percentile body weight <120 kg (IOTF)	6 months 6 months		(1) High-intensity aerobic exercise training (HIT): all participants received multidisciplinary nutritional, psychological and clinical counseling. Clinical counseling: medical follow-up was performed once a month by an endocrinologist. Psychological counseling: participants met with a psychologist weekly for one 1-h session in small groups. Nutritional counseling included hour-long, weekly small group sessions led by a trained nutritionist. Participants underwent personalized aerobic training on a treadmill, three times a week, under the supervision of an exercise physiologist. Participants in the HIT group exercised at an intensity corresponding to the ventilatory threshold I	(2) Low-intensity aerobic exercise training (LIT): same condition offered to intervention group; however participants in the LIT group exercised at a speed 20 % below the ventilatory threshold I	6 months: ↓HR ( $p = 0.036$ ); ↓WC ( $p = 0.022$ ); ↑VO <sub>2peak</sub> ( $p = 0.046$ ); ↑HRV ( $p = 0.038$ ); ↑HF ( $p = 0.004$ ) 1 > 2 1: weight ES: 0.71 BMI ES: 0.93 2: weight ES: -0.06 BMI ES: 0.4

Table 1 continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria	Intervention length	Follow-Up at baseline			
Gourlan et al., SWLP, 2013, France	54 11–18 M and F	Obese adolescents; BMI $\geq 90$ th percentile (IOTF)	6 months 3 and 6 months		(1) Standard weight loss program and motivational interviewing (SWLP + MI): participants received an intervention consisting of two individual face-to-face sessions of 30 min with a health-care provider at the hospital over a 3-month period. In this condition, participants received also six MI phone sessions with a trained physical activity counselor of 20 min over a 6-month period (three MI sessions between the two SWLP sessions and three after the last SWLP session)	(2) Standard weight loss program (SWLP): same program as the intervention group but without the MI	Group difference Effect size (ES) for changes in weight or BMI 3 months: there were no significant differences between groups 1 = 2 1: BMI ES: 0.24 2: BMI ES: -0.05 6 months: $\downarrow$ BMI ( $p = 0.001$ ); $\uparrow$ PA length ( $p < 0.05$ ); $\uparrow$ PA energy expenditure ( $p < 0.05$ ); $\uparrow$ integrated and identified regulations ( $p < 0.01$ ); $\downarrow$ amotivation ( $p < 0.01$ ) 1 > 2 1: BMI ES: 0.34 2: BMI ES: -0.52 <sup>a</sup>
Hofsteenge et al., Go4it, 2014, The Netherlands	122 11–18 M and F	Overweight and obese adolescents BMI $\geq 85$ th percentile (IOTF)	3 months 6 and 18 months		(1) Go4it: multidisciplinary group treatment for obese adolescents. Over the course of seven 90-min sessions delivered at 2- to 3-week intervals, participants received education on healthy diet, sedentary lifestyle and physical activity. The group size was 8–12 adolescents. Adolescents received cognitive behavioral therapy in which they learned how to improve their lifestyle and how to maintain energy balance. Go4it was delivered in an outpatient clinic by a team consisting of a dietician, pediatrician/endocrinologist and psychologist. Two parallel sessions for parents were organized alongside the first and fourth sessions for the adolescents	(2) Control group: received standard care in the Netherlands, consisting of referral to a dietician in the home care setting	6 months: $\downarrow$ BMI ( $p < 0.05$ ); $\downarrow$ weight ( $p < 0.05$ ); intervention > control 1: weight ES: -0.06 BMI ES: 0.10 2: weight ES: -0.15 BMI ES: -0.11 18 months: $\downarrow$ BMI SDS ( $p = 0.028$ ) 1 > 2 1: weight ES: -0.41 BMI ES: -0.16 2: weight ES: -0.38 BMI ES: -0.24

**Table 1** continued

Author, program name (where applicable), year, country	Participants		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria			
	Age		Intervention length		
	Gender		Follow-up at baseline		
Johnston et al. Instructor-led intervention (ILI) and Self-help program (SH), 2013, USA	71	Overweight and obese Mexican-Americans	(1) Instructor-led intervention (ILI): adolescents attended a nutrition class once a week and a physical activity training class 4 days a week. Classes were held during the final period of the school day and lasted 35–40 min. Parents were also involved; they attended monthly meetings during which study staff advised parents on how to support their children to change their habits. All aspects of the intervention were culturally tailored	(2) Self-help (SH): study staff provided adolescents and their parents with a book, <i>Trim Kids</i> , which categorizes children and adolescents into groups based on their weight, from normal weight to obese. This manual provides a 12-week weight management plan and instructions for long-term maintenance of changes	Group difference Effect size (ES) for changes in weight or BMI 1 year: ↓zBMI ( $p < 0.001$ ); ↓BMI kg/m <sup>2</sup> ( $p < 0.05$ ); ↓BMI percentile ( $p < 0.05$ ); 1 > 2 2 year: ↓zBMI ( $p < 0.01$ ); ↓BMI kg/m <sup>2</sup> ( $p < 0.05$ ); ↓BMI percentile ( $p < 0.05$ ); 1 > 2 <sup>a</sup>
	10–14 M and F	adolescents BMI ≥85th percentile (IOTF)	Follow-up: 12 and 24 months		
Johnston et al. Instructor-led intervention (ILI) and Self-help program (SH), 2010, USA	60	Overweight and obese Mexican-American children	(1) Instructor-led intervention (ILI): participants participated in an instructor/trainer-led intervention which consisted of daily (Monday through Friday) sessions for a period of 24 weeks	(2) Self-help (SH): participants received a 12-week parental guidance manual intended to promote child weight loss and long-term maintenance of changes	1 year: ↓weight ( $p < 0.001$ ) ↓BMI ( $p < 0.001$ ) ↓zBMI ( $p < 0.001$ ) ↓Total cholesterol ( $p < 0.05$ ) ↓Triglycerides ( $p < 0.05$ ) 1 > 2 2 years: ↓BMI z-score ( $p < 0.05$ ) 1 > 2 <sup>a</sup>
	10–14 M and F	Overweight and obese Mexican-American children BMI ≥85th percentile (IOTF)	Follow-up: 12 and 24 months		
Kitzman-Ulrich et al., 2009, USA	42	Overweight adolescents	This study compared two intervention groups with a control group: (1) Multifamily therapy plus psychoeducation: received a psychoeducational curriculum that included behavioral skill building and psychosocial components facilitated by master-level family therapists and trained graduate students. In addition to the psychoeducational curriculum, this group attended a weekly multifamily therapy group that lasted approximately 45 min (2) Psychoeducation only: received the psychoeducational curriculum over the course of 16 weeks. Participants in this group did not participate in a multifamily therapy group. To match the amount of contact time received by the two intervention groups, participants in the psychoeducation-only group played interactive games related to health behaviors instead of attending multifamily group therapy	(3) Waiting list	16 weeks: ↓energy intake ( $p < 0.01$ ) 2 > 1 and 3 <sup>a</sup>
	12–15 F	BMI ≥95th percentile (IOTF)	16 weeks		

Table 1 continued

Author, program name (where applicable), year, country	Participants		Intervention	Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria				
Kong et al, ACTION, 2013, USA	51	Overweight and obese adolescents; 9 to 11th grades; BMI $\geq$ 85th percentile (IOTF)	1 year	(1) ACTION: based on transtheoretical model, included three primary components: clinical encounters with the school-based health center clinician every 2–3 weeks for a total of eight visits over one academic year; use of motivational interviewing and obesity risk reduction strategies from a toolkit that was co-created with a community advisory group made of overweight and obese adolescents and their parents. Participants randomized to the ACTION condition received the DVD, a DVD player and a summary of medical results (BMI, blood pressure, fasting glucose and lipids) along with the American Academy of Pediatrics (AAP) obesity prevention/treatment recommendations	(2) Standard care group (SCG): participants received one clinic visit at the beginning of the trial that was similar in content to the first visit of the intervention group except that they were not given the DVD or DVD player. The AAP "Balance for a Healthy Life" booklet and medical results summary with AAP recommendations were also provided to participants	Group difference Effect size (ES) for changes in weight or BMI
	15 (mean) M and F	1 year				
Lloyd-Richardson et al., Behavioral Weight Control (BWC), 2012, USA	118	Obese adolescents, were between 30 and 90 % over BMI (with reference to median BMI for age and gender)	16 weeks	(1) BWC: met twice a week for 16 weeks, once a week for BWC intervention content and once a week for on-site physical activity. The weekly BWC intervention consisted of nutrition intervention, physical activity prescription and work on behavior modification. The nutrition intervention consisted of a prescribed balanced-deficit diet of 1400–1600 calories, with a focus on obtaining a balance of nutrients and calories across the day. The physical activity prescription included gradually increasing activity to a minimum of 30 min of aerobic activity a day for 5 days per week. Behavioral topics included self-monitoring of diet and physical activity, portion control, problem-solving, goal setting, use of stimulus control strategies, motivation for weight loss, social influences on diet and exercise and relapse prevention. Parental group sessions focused on similar content, as well as guidance on family-level support and implementation of behavioral changes	(2) BWC + EXER = this group received BWC (already described) and EXER: participated in weekly supervised aerobic exercise sessions. Activity sessions were supervised by an exercise physiologist or physical therapist	24 months: all variables changed over time, but there were no group differences 1 = 2 16 weeks: 1: weight ES: 0.25 BMI ES: 0.43 2: weight ES: 0.24 BMI ES: 0.50 24 months: 1: weight ES: -0.00 BMI ES: 0.02 2: weight ES: -0.27 BMI ES: -0.01
	13–16 M and F	12 months 24 months				
				(2) Plus PEAT: participated in weekly peer-based physical activity based on the principles of Outward Bound and designed to increase teamwork, social skills and self-efficacy		



**Table 1** continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings Group difference Effect size (ES) for changes in weight or BMI
	Sample size Age Gender	Eligibility criteria	Intervention length Follow-Up at baseline				
Naar-King et al., 2009, USA	48 12–17 M and F	African-American adolescents, primary obesity based on BMI $\geq$ 95th (CDC)	6 months 7 months	(1) Multisystemic therapy (MST): participants received 6 months of MST (2–3 sessions per week). Therapists drew upon a menu of evidence-based intervention techniques targeting barriers at the individual level, at the family level and at the extra-familial level	(2) Shapedown: a traditional 10-week family group weight management program with three follow-up monthly sessions added to match MST treatment length	7 months: ↓ % overweight ( $p < 0.05$ ), ↓ % body fat ( $p < 0.05$ ) and ↓BMI ( $p < 0.10$ ) 1 > 2 1: BMI ES: 0.11 2: BMI ES: 0.00 <sup>a</sup>	
Nguyen et al., Loozit, 2012, Australia	151 13–16 M and F	Overweight to moderately obese BMI z-score Range 1.0–2.5 (CDC)	24 months 12 months	(1) Loozit and ATC group: the Loozit group program adheres to Australian clinical practice guidelines for the management of child and adolescent overweight and obesity, in its healthy lifestyle recommendations and is based on a cognitive behavioral approach. The 24-month intervention consists of an intensive treatment phase followed by a longer maintenance phase. In phase 1 (baseline to 2 months), participants receive the Loozit group program, which consists of seven 75-min weekly group sessions; adolescents and their parents or caregivers attend separate sessions. In phase 2 (2–24 months) adolescents continue to attend booster group sessions approximately once every 3 months during school terms. In addition, adolescents in one study arm (Loozit and ATC) receive ATC during approximately once every 2 weeks; phase 2 in the form of telephone coaching, e-mails and/or short message service text messages	(2) Loozit only: this group did not receive ATC during phase 2	12 months: ↓BMI z-score worth ( $p < 0.001$ ), ↑global self-worth ( $p < 0.001$ ) 1 > 2 1: weight ES: -0.22 BMI ES: -0.13 2: weight ES: -0.27 BMI ES: 0	
Nguyen et al., Loozit, 2013, Australia	151 13–16 M and F	Overweight and obese BMI z-score Range 1.0–2.5 (CDC)	24 month 24 month	(1) Described earlier in this table in Nguyen et al. [42]	(2) Described earlier in this table in Nguyen et al. [42]	24 months: there were no group differences 1 = 2 1: weight ES: -0.22 BMI ES: -0.13 2: weight ES: -0.27 BMI ES: 0	

Table 1 continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria	Intervention length	Follow-Up at baseline			
Nowicka et al., 2008, Sweden	72	Obese adolescents	12 months		(1) Intervention group: received 4 visits. Family therapy was defined as a model of treatment aimed at involving the whole family or part thereof using a systemic interactional method. The basic idea underlying family therapy is that intervention within the family context has a greater impact on the obese child than single-family counseling. During the intervention, therapists aimed to reinforce family resources and create an emotional climate that would help the obese child. The therapy emphasized the need for parental cooperation, communication skills, mutual support, consistency and establishment of appropriate limits. Solution-focused therapy was used in addition to systemic family therapy in the Family Weight School	(2) Control group: waiting list for the program	Group difference Effect size (ES) for changes in weight or BMI 12 months: ↓BMI z-scores ( $p = 0.039$ ) $1 > 2$ 1: weight ES: $-0.17$ BMI ES: 0.0 2: weight ES: $-0.41$ BMI ES: $-0.26$
	12–19 M and F	BMI of 25 and 30 kg/m <sup>2</sup> (IOTF)	12 months				
Park et al., LIFE + EX, 2007, Republic of Korea	44	Obese adolescent girls who met a 95th percentile BMI (IOTF)	12 weeks		(1) LIFE + EX: the intervention consisted of walking and a healthy lifestyle education program. Participants performed 10 min of walking in the morning and 30–40 min in the afternoon (3 times a week) for 12 weeks. All the participants wore Polar heart rate monitors and pedometers. The lifestyle education curriculum used in this study was based on a structured behavioral modification program and delivered by a trained counselor over the course of 12 weekly sessions. In brief, the behavioral modification program covered the principles of self-monitoring, social skills, cognitive re-programming, control of stimuli, relapse prevention, changes in eating habits, positive reinforcement, dietetics, physiology and physical activities	(2) CON group: maintained their lifestyle as usual	12 weeks: ↓body weight ( $p > 0.001$ ); ↓BMI ( $p > 0.001$ ); ↓percent body fat ( $p > 0.001$ ); ↓WC ( $p > 0.001$ ); ↓WHR ( $p > 0.001$ ); ↓SBP ( $p = 0.005$ ), ↓TC ( $p = 0.014$ ), ↓LDL ( $p = 0.007$ ), ↓TC/HDL ( $p = 0.005$ ), ↓TAG ( $p = 0.002$ ), ↓glucose ( $p = 0.002$ ), ↓HOMA-IR ( $p = 0.017$ ), ↓CRP ( $p = 0.041$ ) and ↓leptin ( $p = 0.032$ ); $1 > 2$ 1: weight ES: 0.46 BMI ES: 0.61 2: weight ES: $-0.05$ BMI ES: 0.05
	13–15 F		12 weeks				

**Table 1** continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria	Intervention length	Follow-Up at baseline			
Reinehr et al., Obeldicks, 2009, Germany	288 10–16 M and F	Obese children BMI >97th percentile (IOTF)	12 months 12 months		(1) Obeldicks: the 1-year training program was divided into three phases: in the intensive phase (3 months), the adolescents followed a nutritional course and an eating behavior course that were delivered in six 90-min group sessions. Their parents were invited to attend six parents' evenings in parallel with the adolescents' group sessions. Individual psychological family therapy (30 min/month) was provided in the establishing phase (6 months). In the last phase of the program (accompanying the families back to their everyday lives) (3 months), further individual care was offered as and when necessary	(2) Control group: all obese children and their parents who were not participating in the lifestyle intervention were offered a 15 min consultation focusing on a suitable diet, the necessary physical exercise and behavior patterns. They were also given written information on nutrition and suggested recipes	Group difference Effect size (ES) for changes in weight or BMI 12 months: ↓SDS-BMI ( $p < 0.001$ ) ↓Waist circumference ( $p < 0.001$ ) ↓2 h glucose values in the oGTT ( $p < 0.001$ ) ↓Systolic blood pressure ( $p < 0.001$ ) ↓Diastolic blood pressure ( $p < 0.001$ ) ↓ Metabolic syndrome (IDF) 1 > 2 1: BMI ES: 0.46 2: BMI ES: -0.35 <sup>a</sup>
Sarvestani et al., 2009, Iran	60 11–15 F	Obese adolescents BMI ≥95th percentile (IOTF)	16 weeks 6 months		(1) Experimental: the experimental group received weekly 4-h structured small group sessions for 16 weeks. All sessions consisted of 2 h of behavior modification or dietary instruction and 2 h of yoga therapy. The program covered standard behavioral strategies such as self-assessment and monitoring of food intake; additional techniques covered were: stimulus control, cognitive restructuring, problem-solving skills, stress management (yoga), teaching healthy eating and physical behavior and parent consultation and social support	(2) Control: adolescents in the control group attended three sessions of the same program of the experimental intervention	6 months: ↓Body weight ( $p < 0.05$ ) ↓Body mass index ( $p < 0.05$ ) ↓Arm circumference ( $p < 0.05$ ) ↓Emotional eating ( $p < 0.05$ ) ↓External eating ( $p < 0.05$ ) ↑Restrained eating ( $p < 0.05$ ) 1 > 2 <sup>a</sup>
Tsiros et al., CHOOSE HEALTH, 2008, Australia	47 12–18 M and F	Overweight and obese adolescents BMI ≥85th percentile (IOTF)	10 weeks 20 weeks		(1) Cognitive behavioral therapy (CBT): the first 5 sessions focused on improving diet and activity habits through the use of behavioral strategies such as self-monitoring of diet and activity, external control strategies and goal setting. Sessions 6–10 focused on teaching strategies to maintain new health behaviors and introduced CBT strategies such as reframing of unhelpful thoughts and problem-solving	(2) Control (CON): no treatment	20 weeks: ↓weight, BMI, fat mass, abdominal fat and hip circumference (all $ps < 0.05$ ) 1 > 2 1: weight ES: 0.99 BMI ES: 1.69 2: weight ES: -0.71 BMI ES: -0.2

Table 1 continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria	Intervention length	Follow-Up at baseline			
Visser et al., 2008, Belgium	76	Overweight and obese adolescents	6 months		(1) Experimental group: the intervention was based on concepts from health behavior change models such as social cognitive theory, the theory of planned behavior, the transtheoretical model and stages of change. Participants in the intervention group were offered nutritional counseling from a dietician and a monthly counseling session with a physiotherapist to help them to increase their daily physical activity. They also participated in standard gym classes (2) Control group: There was no sham or alternative intervention in the control group. The group participated in standard gym classes	Group difference Effect size (ES) for changes in weight or BMI	
	Mean 17.3 SD = 1.3 M and F	Mean BMI: 29.1 kg/m <sup>2</sup>	6 months				6 months: ↓Weight and BMI ( $p < 0.001$ ) ↓Body fat ( $p < 0.011$ ) ↓WC ( $p = 0.025$ ) 1 > 2 <sup>a</sup>
Walpole et al., 2013, Canada	40	Overweight and obese youth, with BMI ≥85th percentile (IOTF)	6 months		(1) MI: participants in the MI treatment group met once a month for 30 min with a clinical psychology doctoral student trained in MI. The interventionist attempted to help clients to become more aware of unhealthy behaviors, to consider whether their current behavior was consistent with their personal values and to envision how change might be helpful to them. To address clients' ambivalence or resistance to change, the MI therapist used, when appropriate, agenda setting, decisional balances and scale questions while continuing to demonstrate empathy and support the client's autonomy (2) Control: social skills training group for 30 min once a month. The social skills interventionist, unlike the MI therapist, was expected to offer advice rather than attempt to elicit ideas from the client, and clients were prescribed goals to work on without specific regard to the client's readiness to change. Training was based on a standardized treatment manual, developed and validated for use with children and adolescents. Sessions were based around finding appropriate ways to navigate typical social situations	6 months: no group differences in self-efficacy or anthropometric variables 1 = 2 1: BMI ES: 0.07 2: BMI ES: 0.03 <sup>a</sup>	
	10–18 M and F		6 months				
Wengle et al., Golden Keys, 2011, Canada	38	Overweight and obese adolescents	6 months		(1) Mentored: subjects in the mentored group agreed to meet with their mentor once a week in person, for 1–2 h to help them achieve activity goals, participate in physical activity and discuss and set nutritional goals. They also agreed to communicate (either by telephone or e-mail) twice a week for support. Mentors had regular contact with study personnel, and monthly group meetings were held to provide support, troubleshoot challenges, provide insight and feedback and contribute to program refinement (2) Non-mentored: subjects and their family members attended a 1-day group educational workshop at the beginning of the study. At their baseline visit, all subjects learned about the study recommendations for nutrition and physical activity and were given specific instructions and written materials covering self-assessment of behavior and environment, and how to implement small changes by successfully setting measurable and attainable goals	6 months: ↓high fat/sugar ( $p = 0.002$ ) 2 > 1 ↓Systolic blood pressure ( $p = 0.02$ ), ↓CRP ( $p = 0.03$ ), ↓Fasting insulin ( $p = 0.03$ ), ↓HOMA-IR ( $p = 0.04$ ) 1 > 2 1: weight ES: -0.08 BMI ES: 0.09 2: weight ES: -0.03 BMI ES: -0.01	
	12–16 M and F	above 85th percentile (IOTF)	6 months				

**Table 1** continued

Author, program name (where applicable), year, country	Participants		Intervention		Intervention description (ID)	Control group (CG)	Findings
	Sample size	Eligibility criteria	Intervention length	Follow-Up at baseline			
Williamson, et al., 2006, HIPTeens, USA	57 11–15 F	Overweight or obese African-American adolescent girls BMI >85th percentile (IOTF)	24 months 24 months		(1) Behavioral: this intervention was based on family treatment methods. The web site provided nutrition education and behavior modification for adults and adolescents using a family-oriented format, i.e., a program that invited the parents, the child and other members of the family to be involved using mutual problem-solving and behavioral contracting. Counseling for behavior modification was accomplished primarily by asynchronous e-mail communication. Participants were encouraged to send weekly e-mails to their counselor reporting their progress in the program. All participants were given e-mail account that could be accessed through the web site, but the participants could also send e-mails from their own personal accounts. The e-mail communication also allowed counselors to provide feedback on the intervention program	(2) Control: participants in the control condition were provided with health education via a coordinated program consisting of face-to-face sessions and links to a variety of web sites promoting healthy lifestyle. The control web site did not provide explicit prescriptions for behavior change, behavioral contracts or opportunities for self-monitoring. Instead, the control web site was designed to be a passive (non-interactive) program that provided useful health education to parents and adolescents via electronic links to other health-related web sites	Group difference Effect size (ES) for changes in weight or BMI 6 and 12 months: ↓parents' BMI ( $p < 0.005$ ); ↓consumption of fattening foods ( $p < 0.05$ ); ↓parents' mean body weight ( $p < 0.05$ ); ↑parents exercise ( $p < 0.05$ ) 1 > 2 <sup>a</sup>
MacDonnell et al., 2012, USA	44 13–17 M and F	Overweight or obese African-American adolescents, with BMI ≥85th percentile (IOTF)	3 months 3 months		(1) Motivational Interviewing (MI): healthy choices was adapted by asking adolescents to choose changes in nutrition or activity in week 1, with the second week behavior discussed in week 2 using standard MI techniques to elicit and reinforce change talk. The dietitian met first with the adolescent and then with the caregiver and subsequently devised a change plan with the dyad using a menu of change options specific to weight loss	(2) Control (CO): adolescents and their caregivers received four joint sessions of nutritional counseling based on recommendations of the expert committee that were collected in a manual	3 months: ↓weekly consumption of fast food ( $p = 0.03$ ) 1 > 2 1: BMI ES: 0.07 2: BMI ES: 0.09 <sup>a</sup>

<sup>a</sup> Study did not present means or standard deviations for pre- or post-intervention data on weight or BMI, so it was not possible to calculate Cohen's *d* as a measure of effect size

reported eligibility criteria. All studies used random group allocation; in 6 the allocation was blinded and 22 studies matched groups with respect to baseline characteristics. Only 3 studies blinded the assessors to group allocation; 18 studies retained at least 85 % of the original sample at the end of the intervention and reported outcome variability statistics; 24 presented between-group comparisons.

### Characteristics of the studies

Table 1 shows the descriptive information of the studies. There was variability in the BMI classification criteria used: 19 studies used those of the International Obesity Task Force (IOTF), while 4 studies used those of the Centers for Disease Control and Prevention (CDC). Most of the studies included both male and female participants, but six included only female subjects [29, 30, 37, 44, 46, 52]. Ethnicity was an important component in four studies, where the aim was to develop an intervention targeted specifically at Koreans, African-Americans, Hispanic Americans or Mexican-Americans [27, 29, 35, 44]. One study had a sample including normal weight adolescents [35], but we only used outcome data from overweight and obese adolescents in our analyses. All studies involved the adolescents' family and eight also involved the school in some way [35–37, 41–43, 48, 49]. Half the studies were carried out in the USA and the majority had been published in the last 5 years.

### Intervention components

The studies covered many types of interventions of varying lengths and meeting frequencies (see Table 1). Data were collected from clinics, homes and schools or through the Internet. Changing the lifestyle of overweight and obese adolescents was an objective of all the interventions and they included elements designed to equip participants with the behavioral skills that would help them to follow a healthy diet and practice physical activity. Interventions were provided by various types of health professional: psychologists, nurses, nutritionists, physicians, fitness instructors and physiotherapists; the important point is that in all cases the intervention was multidisciplinary, taking into account all the various environments adolescents encountered, as required to treat obesity effectively. All studies lasted at least 10 weeks and the longest lasted 24 months.

In ten interventions, the parents were given advice on healthy lifestyle and how to motivate their children, but did not participate directly in the intervention [32, 35, 36, 38, 44, 46–48, 50, 51]. In six interventions, parents and adolescents both participated in intervention meetings

[27, 31, 37, 40, 43, 45, 47], and in one further study obese and overweight parents, but not normal weight parents, were invited to join the intervention with their children [52]. In six of the studies where both parents and adolescents participated, they had separate meetings [29, 34, 39, 41, 42, 49] and only in the Loozit study did the parents attend the same number of meetings as their children [41, 42].

None of the programs used low-calorie diets as their nutritional component; all used nutrition education based on international and national obesity treatment guidelines. The main recommendations and components were: healthy food choices, maintain an appropriate energy balance, reduce portion sizes, reduce energy and fat intake, increase fruit and vegetable consumption, make healthy beverage and snack choices, increase water consumption, learn how to categorize foods according to their health benefits and learn how to read labels on processed food. One of the studies gave to the adolescents a DVD with healthy cooking recipes aiming to modify the family eating [38]. Another study provided lessons in cooking healthy food for the adolescents.

All the programs promoted physical activities such as walking, running, team sports, strength exercises and guidance to play video games with motion sensor [29, 30, 32, 35, 36, 39, 44, 49]. In two studies, adolescents practiced yoga [30, 46]. In another study, participants were given free access to a gym [49]. All interventions recommended exercising for at least 90 min per week and in two interventions the teenagers were given pedometers to enable them to monitor their activity [30, 44].

The majority of studies used cognitive behavioral therapy (CBT) as a method of promoting behavioral change [27, 28, 30, 31, 34–36, 39, 41, 42, 44, 46–48]. The main techniques used to modify eating habits and increase rates of physical exercise were setting goals to increase healthy behaviors, self-monitoring, cognitive re-programming, control of stimuli, problem-solving, self-efficacy enhancement, social skills, assertive communication, stress management, contingency management, environmental support, token economy, positive reinforcement and relapse prevention. Motivational Interviewing (MI) is another therapy widely used to promote behavioral change in adolescents and this was the basis of treatment in seven studies; these studies also mentioned the importance of training health professionals in the use of MI [29, 33, 38, 49–52]. Family therapy was used in some interventions [37, 40, 43, 45]. Only one study did not report the form of therapy used; however, it was reported that therapy sessions focused on self-esteem, the relationship between food and feelings and anxiety and depression [32].

## Main outcomes

The mean sample size at baseline was 87.76 (SD = 60.91, range 38–288). All studies assessed BMI through Z-scores and BMI was one of the main outcome variables. Many studies also measured at least one of the variables used to assess the metabolic syndrome, namely waist circumference (WC), diastolic and systolic blood pressure (SBP and DBP, respectively), total cholesterol (TC), triglyceride (TGC), low-density lipoprotein cholesterol (LDLC), high-density lipoprotein cholesterol (HDL) and insulin resistance (HOMA-IR). Other biological variables related to exogenous obesity that were reported are as follows: glycated hemoglobin (HbA1c) levels, C-reactive protein (CRP) levels, leptin concentration, adiponectin, 30-min insulin secretion and 0- to 120-min insulinemia. One study used increase in cardiorespiratory capacity as the primary outcome and assessed this in terms of peak oxygen uptake ( $\text{VO}_2$  max), heart rate (HR), heart rate variability (HRV) and heart frequency (HF). The quality of nutrition was measured with self-report instruments in the majority of the studies; these instruments were designed to assess the intake of fat, vegetables, sugar, fruits and the eating habits that constitute a healthy diet for this population. In most studies, the primary outcomes were related to nutrition or biological fitness; however, nine studies also reported psychological and behavioral variables such as quality of life, body satisfaction, self-esteem, family support, self-concept, self-efficacy, attitude to appearance, frequency of family meals, emotional eating, restrained eating, use of cognitive skills, concerns about body shape, motivation to change behavior and processes of change [30, 31, 33, 38, 39, 41, 42, 46, 50].

All clinical trials that presented variability statistics reported changes in BMI over time ( $p < 0.005$ ). Six studies found that the intervention had no effect on any of the variables assessed based on group comparisons at various time points [21, 27, 33–35, 44]; one reported group differences in BMI z-score ( $p = 0.001$ ), length of PA ( $p < 0.05$ ), energy expenditure in PA ( $p < 0.05$ ), motivation regulation ( $p < 0.01$ ) and motivation over time ( $p < 0.01$ ), but only on the second follow-up assessment [27]. All the studies reported BMI z-score, BMI ( $\text{kg}/\text{m}^2$ ), BMI percentile, weight and waist circumference (WC). More than half of the studies ( $n = 14$ ) reported improvements in BMI; nine reported reductions in weight and six reported reductions in waist circumference variables in the intervention groups when compared with the control groups; these results are presented in detail in Table 1.

Five studies reported group differences in a variable related to metabolic syndrome at follow-up assessments

[33, 36, 42, 45, 51]. Six studies reported improvements in psychological outcomes and other variables, such as the learning of new behavioral skills, motivation, hours spent watching TV, academic achievement, body satisfaction, attitude to appearance, emotional eating, restrained eating and concerns about body shape (see Table 1). In all cases except one [31] where there were group differences between the intervention group and a control group, the intervention group had improved relative to the control group.

The reported effectiveness of interventions was greatest in studies that used a waiting list control or standard health care as a control group [28, 37, 43, 44, 48], whereas clinical trials that found group differences with respect to only a few variables also found low significance in the comparison [27, 39–41, 50]. Clinical trials that included regular exercise (at least 40 min of exercise 3 times per week) as a component of the intervention also found a bigger effect on their outcomes [32, 35, 36, 44, 46, 48].

One program based on motivational techniques was not effective when the comparison was between baseline data and data collected at the end of the intervention; however, 3 months later there were differences relative to baseline in the intervention group with respect to BMI ( $p = 0.001$ ), length of PA ( $p < 0.05$ ), energy expenditure in PA ( $p < 0.05$ ), motivation regulations ( $p < 0.01$ ) and motivation over the time ( $p < 0.01$ ) [33].

All the studies we analyzed were RCTs and this is the best design for establishing a cause and effect relationship between treatment and outcome variables. However, ten studies did not present means or standard deviations for pre- or post-intervention data, which made it impossible for us to evaluate ESs based on Cohen's  $d$  [27, 29, 33, 35–37, 46, 49, 50, 52]. Only one intervention produced a large reduction in adolescents' weight (ES:0.99) [48]; one other resulted in weight loss with a medium ES (ES:0.71) [32]. In seven interventions, the ES for weight was negative; in other words the adolescents weighed more after the intervention [30, 34, 38, 41–43, 51].

The ES for BMI was large in Tsiros et al.'s study (ES:1.69) [48] and in Farah et al.'s study (ES:0.93) [32]. In three studies, the intervention resulted in a medium ES with respect to BMI: Park et al. (ES:0.61) [44], Reinehr et al. (ES:0.46) [45] and Lloyd-Richardson et al. (ES:0.43) [39]. Small ESs were obtained in studies by Brennan et al. (ES:0.15) [28], Naar-King et al. (ES:0.11) [40], and Hofsteenge et al. (ES:0.10) [34]. In four studies, the intervention had an adverse effect on BMI, i.e., produced an increase in BMI [33, 38, 41, 42]. None of the clinical trials which reported means and standard deviations found a beneficial change (positive ES) in weight or BMI in the control group.

## Discussion

There was a low mean Delphi score (5.58; SD = 1.027) for elements of design intended to minimize bias in clinical trials. Some elements of good design, such as blinding the people delivering the treatment to group assignment, are impossible to apply in this type of study, but only three studies blinded the assessors pre- and post-intervention and the allocation of the subjects was blinded in just six of them. It was noticed that the interventions that had a larger number of variables associated with obesity were statistically significant when comparing groups. These interventions were the ones that compared the treatment with an unequal care group. This makes it difficult to assess whether good results are associated with the number of meetings or with multicomponent interventions.

Studies which offered a similar type of treatment in the experimental intervention and the control group found no differences between groups [27, 39–41, 50], thus confirming the importance of controlling confounding variables to evaluate the main variables of interest accurately [13]. Even so, in all clinical trials it was possible to find differences regarding BMI during the intervention. The differences regarding BMI have been discussed in one meta-analysis that concluded that treatment interventions were more effective than preventive on this variable [16].

The number of meetings with the participants influenced the success of interventions. Interventions involving more meetings produced better results in terms of effects on BMI and biological markers associated with overweight and obesity. Previous meta-analytic reviews have noted that interventions lasting at least 6 months tend to result in greater differences between groups of children and attribute this to the difference in ‘dose’ [13, 17, 39]. However, the treatment dose effect can be weakened by the time and due to this some clinical trials found differences over time in intervention effectiveness [35, 36, 39]. Other treatments can have its effect enhanced, for example one of the clinical trials that compared conventional therapy with therapy plus motivational interviewing found that at the first follow-up assessment (third month after the intervention end) there was no difference between groups, but in the second assessment follow-up assessment (sixth month after the intervention end) there were improvements, in the intervention group, in BMI ( $p = 0.001$ ), length of PA ( $p < 0.05$ ), energy expenditure ( $p < 0.05$ ), motivation regulation ( $p < 0.01$ ) and motivation over the time ( $p < 0.01$ ), which complies with the proposed approach [33].

Only one of the 16 studies for which it was possible to calculate ESs presented an intervention which had a large effect on weight; in this study, the experimental intervention focused on cognitive behavioral therapy (CBT), so this

finding highlights the importance of CBT-based approaches to promoting weight loss through behavioral change [48]. Earlier meta-analyses have also shown that the interventions failed in weight reductions [16, 54]. In research on overweight and obesity in adolescents, it is problematic to rely solely on weight as an outcome variable, because there are many variables that affect weight and these can be particularly important in longitudinal studies since in this population changes in body composition or growth can mask the effects of weight loss programs on weight. In the studies we analyzed, the interventions appeared more effective when assessed in terms of the ES for change in BMI: there was an intervention effect in eight studies [28, 32, 34, 39, 40, 45, 48]. Therefore, BMI is an outcome that is less influenced by other variables that cannot be controlled in the trial. Moreover, as well as considering effects on variables that are directly associated with overweight and obesity, it is important to consider the effects on eating behavior, physical exercise habits and metabolic indicators.

The treatment components can configure an important element for success of the treatment. Multidisciplinary weight loss interventions that focus on changing eating habits and encourage exercise practice to achieve emotional and behavioral change are most effective [15]. In addition, all interventions were unanimous in considering the family support as an important component in the weight loss of the adolescents. The results of the seven clinical trials that provided programs in schools and social interactions reinforce the importance of covering the different levels of the ecological model of obesity treatment, as a similar review carried out in 2008 already noted [19]. Although another study has referred the importance of dietary restriction for weight loss, in this review no restrictive diet was found in the interventions. All studies agreed that the nutritional education to healthy eating is more effective for eating maintenance than restrictive diets in the long term [4, 7]. Providing physical activity as one of the treatment elements directly influences the outcomes, but participants in such programs revert to a sedentary lifestyle after treatment [54].

Support therapies are important components in adolescent weight loss interventions, but they need to be tailored to the needs of this particular age group; the emotional causes and consequences of overweight and obesity are specific to each stage of development. The use of technology in educational work can have highly beneficial effects on nutrition and physical exercise behavior in adolescents [22, 23]. Studies which used computer programs, the Internet, short message service, CDs and video games in the delivery of the intervention reported good adherence. The success of these delivery methods is



presumably due to the fact that the adolescent participants were born in the digital era [29–31, 38, 41, 42, 52].

Twenty-five studies used CBT, motivational interviewing or family therapy to help participants change their lifestyle [20, 55]. The setting where the clinical trials were conducted reinforces the importance of joining interdisciplinary forces in health care, considering the complexity in the treatment of obesity, especially in adolescence. All studies were interdisciplinary or involved multidisciplinary teams.

Obesity treatment techniques in adolescence are far from being conclusive. However, this review has identified some potentially effective strategies and indicates that some non-drug interventions have promise as methods of promoting weight loss and improving psychological and biological markers that are consequences of overweight. Therefore, one of the main limitations of this review was to find a complete description of the clinical trials' methodology. In addition, the best evidence in this area depends on the outcome of homogeneous variables, which are no longer possible, considering that there is no consensus on the markers' overweight and obesity in adolescence.

The methodological weakness of the RCTs, in the data analysis description of the studies, made us describe in the results only the outcomes, which presented  $p$  value  $\leq 0.05$  in the difference between groups. It was not considered type II errors; in other words, the null hypothesis was rejected. Thus, factors such as underpower test or sample size's power of the RCTs were not considered. We reiterate that the clinical relevance of a finding does not depend exclusively on a  $p$  value [56], whereas a study may have had a significant difference between groups based on  $p$  value, but not present a significant effect for the participant, or both groups were effective (or ineffective) not presenting significant difference. In our study, we emphasized the discussion of the components that are common to all the interventions tested by the RCTs that help adolescents to lose weight. Therefore, we focus on the main aspects that can compose a specific treatment for this group age.

The effect of non-drug treatments on weight loss in adolescents depends on a multiplicity of variables; nonetheless, this review indicates the importance of taking an interdisciplinary approach that encompasses all the various levels of the ecological model. Weight loss interventions must be appropriate to the developmental stage of users, and it is important to take into account that today's adolescents were born in the digital era. We found that there were benefits to using technology involving the family and the school and using motivational and behavioral techniques to enhance adherence to programs based on healthy, but not restrained eating and regular physical exercise.

## Limitations

There are some limitations to this review: the lack of methodological rigor and the heterogeneity of the clinical trials that were analyzed. The lack of methodological rigor can be considered a bias to the effectiveness. Language limitation: we only considered English language publications.

Another important limitation in this study is that type II errors were not considered. The null hypothesis was rejected, when we considered only statistical significance between groups based on  $p$  value to describe some results. Therefore, we suggest that future studies consider type II errors and discuss the interventions' components that can have a robust effect on the weight loss and the cardiometabolic markers in obese adolescents.

## Conclusion

This study is not conclusive about the most effective treatment for obesity in adolescents. However, changes in eating habits and inclusion of exercise in the routine are important elements of effective weight loss interventions targeted at adolescents. To achieve changes in eating and exercise habits, it is normally necessary to provide psychological therapy. The most commonly used types of therapy are CBT and motivational approaches. The family support in the treatment and using technology also seem to enhance adherence to a healthy lifestyle designed to ensure weight reduction in overweight and obese adolescents.

## Compliance with ethical standards

**Research involving human participants and/or animals** This article does not refer to any studies with human participants performed by any of the authors.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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