



# Appraisal of Clinical Care Practices for Child Obesity Treatment. Part I: Interventions

Asheley C. Skinner, PhD,<sup>a</sup> Amanda E. Staiano, PhD, MPP,<sup>b</sup> Sarah C. Armstrong, MD, FAAP,<sup>c</sup> Shari L. Barkin, MD, MSHS,<sup>d</sup> Sandra G. Hassink, MD, FAAP,<sup>e</sup> Jennifer E. Moore, PhD, RN, FAAN,<sup>f</sup> Jennifer S. Savage, PhD,<sup>g</sup> Helene Vilme, DrPH,<sup>h</sup> Ashley E. Weedn, MD, MPH, FAAP,<sup>i</sup> Janice Liebhart, MS,<sup>j</sup> Jeanne Lindros, MPH,<sup>k</sup> Eileen M. Reilly, MSW<sup>l</sup>

The objective of this technical report is to provide clinicians with evidence-based, actionable information upon which to make assessment and treatment decisions for children and adolescents with obesity. In addition, this report will provide an evidence base to inform clinical practice guidelines for the management and treatment of overweight and obesity in children and adolescents.

To this end, the goal of this report was to identify all relevant studies to answer 2 overarching key questions: (KQ1) “What are clinically based, effective treatments for obesity?” and (KQ2) “What is the risk of comorbidities among children with obesity?” See Appendix 1 for the conceptual framework and a priori key questions.

Obesity is a common concern in pediatric practice. In caring for patients with obesity or patients who may be at risk for developing obesity, clinicians have many unanswered questions. Examples of these questions include: What is the best way to identify excess adiposity, and does the identification of obesity provide opportunities for treatment? If so, what evidence-based interventions for obesity treatment, delivered at least in part by clinicians in office-based settings, are most effective? Among children and adolescents identified as having obesity, does screening for comorbidities result in improved health outcomes?

Many previous studies, most notably the systematic review conducted for the US Preventive Services Task Force (USPSTF), have synthesized research regarding the efficacy of treatment of obesity, particularly in the context of prevention of future comorbidities.<sup>1</sup> However, some important gaps remain. First, the USPSTF recommended that obesity treatment should include at least  $\geq 26$  hours of face-to-face contact over 2 to 12 months. However, subsequent studies have failed to

## abstract

<sup>a</sup>Department of Population Health Sciences, Duke University School of Medicine, Durham, North Carolina; <sup>b</sup>Louisiana State University Pennington Biomedical Research Center, Baton Rouge, Louisiana; <sup>c</sup>Departments of Pediatrics and Population Health Sciences, Duke Clinical Research Institute, Duke University, Durham, North Carolina; <sup>d</sup>Children's Hospital of Richmond at Virginia Commonwealth University, Richmond, Virginia; <sup>e</sup>Medical Director, American Academy of Pediatrics, Institute for Healthy Childhood Weight, Wilmington, Delaware; <sup>f</sup>Institute for Medicaid Innovation, University of Michigan Medical School, Ann Arbor, Michigan; <sup>g</sup>Center for Childhood Obesity Research, Pennsylvania State University, Department of Nutritional Sciences, Pennsylvania State University, University Park, Pennsylvania; <sup>h</sup>Department of Population Health Sciences, Duke University School of Medicine, Durham, North Carolina; <sup>i</sup>Department of Pediatrics, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma; <sup>j</sup>American Academy of Pediatrics, Itasca, Illinois; <sup>k</sup>American Academy of Pediatrics, Itasca, Illinois; and <sup>l</sup>American Academy of Pediatrics, Itasca, Illinois

This document is copyrighted and is property of the American Academy of Pediatrics and its Board of Directors. All authors have filed conflict of interest statements with the American Academy of Pediatrics. Any conflicts have been resolved through a process approved by the Board of Directors. The American Academy of Pediatrics has neither solicited nor accepted any commercial involvement in the development of the content of this publication.

Technical reports from the American Academy of Pediatrics benefit from expertise and resources of liaisons and internal (AAP) and external reviewers. However, technical reports from the American Academy of Pediatrics may not reflect the views of the liaisons or the organizations or government agencies that they represent.

The guidance in this report does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations,

**To cite:** Skinner AC, Staiano AE, Armstrong SC, et al. Appraisal of Clinical Care Practices for Child Obesity Treatment. Part I: Interventions. *Pediatrics*. 2023;151(2):e2022060642

demonstrate a consistent hours-based dose-response. In addition, feasibility studies have clearly shown how unrealistic it is for primary care or tertiary care providers to deliver this many hours of treatment in real-world, clinical settings.<sup>2</sup> Additional information is needed about resources or partnerships that help reach that contact hour goal, the essential components delivered during these contact hours, the period of time over which this is delivered, and information about lower-intensity strategies with some effectiveness.

Second, most treatment decisions are made in the context of choosing between alternative treatments, not effectiveness compared with no treatment, like many current randomized controlled trials (RCTs). The USPSTF had a primary goal of determining which interventions were efficacious, compared with no or minimal treatment. Our goal was to provide greater contextual evidence of the types of interventions that are effective, effectiveness compared with alternative interventions, and promising interventions that do not yet have randomized trials underlying them.

Finally, primary care pediatricians have a great need to understand how to approach recommendations for screening comorbidities in their patients with obesity. Although previous recommendations have supported screening for common comorbidities, such as dyslipidemia and diabetes, there has been conflicting evidence regarding timing and effectiveness of screening. We now have additional data that provide clinicians and researchers with information about comorbidity prevalence and severity by obesity class. The intent is to help the clinician screen for comorbidities when there is a high likelihood of detecting an

abnormality and when detection of that abnormality leads to treatment options that can improve child health. Obesity classifications, including a more granular categorization of obesity as classes I through III, might assist us in determining for whom screening would be most useful, rather than viewing screening as a homogeneous approach for anyone whose BMI is  $\geq 95$ th percentile.

## METHODS

### Scope of the Review

This technical report was designed to answer 2 overarching key questions: (KQ1) “What are effective clinic-based treatments for pediatric obesity?” and (KQ2) “What is the risk of comorbidities among children with obesity?” We developed this focus based on the needs of clinicians and the evidence required to inform the future development of clinical practice guidelines. This report will not attempt to quantify the magnitude of the effect of obesity on child or adult outcomes. It will also not attempt to address treatment strategies for comorbidities (eg, hypertension), as other guidelines and reviews are available to guide such treatment.<sup>3–6</sup>

In this paper, we report the results for KQ1, intervention studies. Results for KQ2, comorbidity studies, are reported separately.<sup>7</sup> The 2 components of the review were conducted concurrently, so we present methods for both below.

### *Rationale for KQ1 (Intervention Studies)*

Clinicians are a trusted source of health information for parents, including issues related to nutrition and physical activity, which are key components of obesity prevention and treatment. Clinicians need to know what strategies have high-quality evidence for effectiveness in

preventing and treating obesity. Additionally, clinicians need guidance on which treatments are effective for their patient population and how to leverage available resources for treatment efforts.

### *Rationale for KQ2 (Comorbidity Studies)*

Previous recommendations have included assessments of comorbidities, including hypertension, dyslipidemia, glucose, fatty liver disease, and others. It is not clear whether these assessments lead to improved treatment strategies or outcomes. Additionally, it is not clear whether conducting these assessments would result in an adverse patient outcome. We will examine specific conditions that were previously recommended or that would reasonably require screening: dyslipidemia, hypertension, diabetes, fatty liver disease, depression, sleep apnea, and asthma.

### Search Strategy

We searched Pubmed and CENTRAL (for trials), completing the final search on April 6, 2018. An additional search was conducted to update the review, covering the time period April 7, 2018, through February 15, 2020. We combined the searches for both key questions because of significant overlap and to more efficiently review studies. Because our focus was on interventions that are relevant to primary care, we did not search other discipline-specific databases, such as ERIC or PsycInfo.

The complete search strategies are included in Appendix 2. Briefly, we searched for studies of children or adolescents; with a focus on overweight, obesity, or weight status; involving clinicians, health care, or other treatment or screening (KQ1); and examining common comorbidities (KQ2). For both questions, we limited only

using key words, not filters, to ensure we included the newest studies that were not yet fully indexed. No date limits were placed on searches. In practice, this meant we reviewed studies from 1950 to 2020, although <2% were published before 1980.

## **Inclusion Criteria**

The complete inclusion criteria are included in Appendix 3.

### *Inclusion Criteria Common to All Studies*

All studies were required to include children ages 2 to 18 years, although studies could also include young adults up to age 25 years if stratified from older adult participants, as long as children younger than 18 years were also included. Children could have other conditions (eg, asthma), as long as they were not known to cause obesity, such as Prader-Willi syndrome, obesogenic medication (eg, antipsychotics), or known genetic mutations associated with obesity (eg, MC4R). All studies had to originate from Organization for Economic Cooperation and Development (OECD) member countries and had to be available in English.

### *Inclusion Criteria for KQ1 (Intervention Studies)*

The primary aim of the intervention studies had to be examination of an obesity prevention (targeting children of any weight status) or treatment intervention (targeting children with overweight or obesity). The primary intended outcome had to be obesity, broadly defined, and not an obesity comorbidity. Studies of obesity interventions that reported only other outcomes were not included. Interventions could be comprised of any approach, including screening, lifestyle counseling, medically managed weight loss, pharmaceutical treatment, or surgery. Regardless of the components, there had to be some

level of outpatient clinical involvement in the treatment (ie, not just referral to an outside program), such as screening or a clinic follow-up appointment. Interventions completely outside the scope of health care were excluded. We did not limit based on study design but did report experimental and nonexperimental studies separately. Although we included nonexperimental designs, all studies had to have a relevant comparison group.

See the other technical report on comorbidities<sup>7</sup> for a detailed description of KQ2 inclusion criteria.

## **Review Process**

We used Covidence to manage the review process. Covidence is a program for online collaboration and management of systematic reviews. All abstracts were reviewed by 2 independent reviewers for inclusion in full-text review. Articles were reviewed by 2 reviewers, with conflicts discussed and resolved. Articles excluded at this stage were assigned an exclusion reason, with a hierarchy as shown in Appendix 4.

## **Data Extraction and Quality Assessment**

All articles deemed relevant for full text inclusion were categorized into different data extraction strategies. Those given a quality assessment were reviewed using the Cochrane Risk of Bias tool. We chose not to limit studies based on quality, as many did not reach “high quality” using any tools. These studies did not meet “high quality” criteria largely because they were primarily behavioral interventions without the possibility of blinding. All studies, regardless of group, were fully extracted by 2 reviewers, and conflicts were reviewed.

### *Group 1 Extraction*

Group 1 articles included randomized trials of diet or lifestyle

interventions. “Diet” includes specific meal plans or substitutes, whereas “lifestyle” refers to nonpharmaceutical, nonsurgical intervention and may incorporate nutrition, activity, and other components. Extraction of these articles included sponsorship or funder, design, population information, provider type, detailed intervention strategies and intensity, and BMI-based outcomes. We also identified outcomes other than BMI, including lipids, glucose metabolism, blood pressure, other laboratory values, other obesity measures, psychosocial outcomes, mental health, behaviors, and other outcomes (primarily parent BMI and child cardiovascular fitness). We categorized the intensity of interventions in a manner consistent with the USPSTF, to allow for comparisons with its findings, into <5 hours, 5 to 25 hours, 26 to 51 hours, and 52 or more hours, all over ≤12 months. Quality assessment was conducted for group 1 articles.

### *Group 2 Extraction*

Group 2 articles included randomized controlled trials of pharmaceutical treatments. We extracted similar information as above, using a brief description of the intervention and no categorization of intensity. These articles also received a quality assessment.

### *Groups 3 to 5 Extraction*

Group 3 articles included nonrandomized comparative studies of diet and lifestyle interventions. Group 4 articles included nonrandomized comparative studies of pharmaceutical treatment, and Group 5 articles included any surgical studies. Because of small numbers, we combined randomized and nonrandomized surgical studies. Brief intervention descriptions and BMI-related outcome data were

extracted from these, but the Cochrane Risk of Bias tool was not used because these were observational designs.

See other report for detailed description of KQ2 extraction procedures.

**Data Synthesis and Analysis**

Our primary method of data synthesis is narrative. To allow broad inclusion, we did not limit to specific designs or measures that would facilitate meta-

analysis. We report on studies in each group, based on their type and design, and we report findings for outcomes other than BMI.

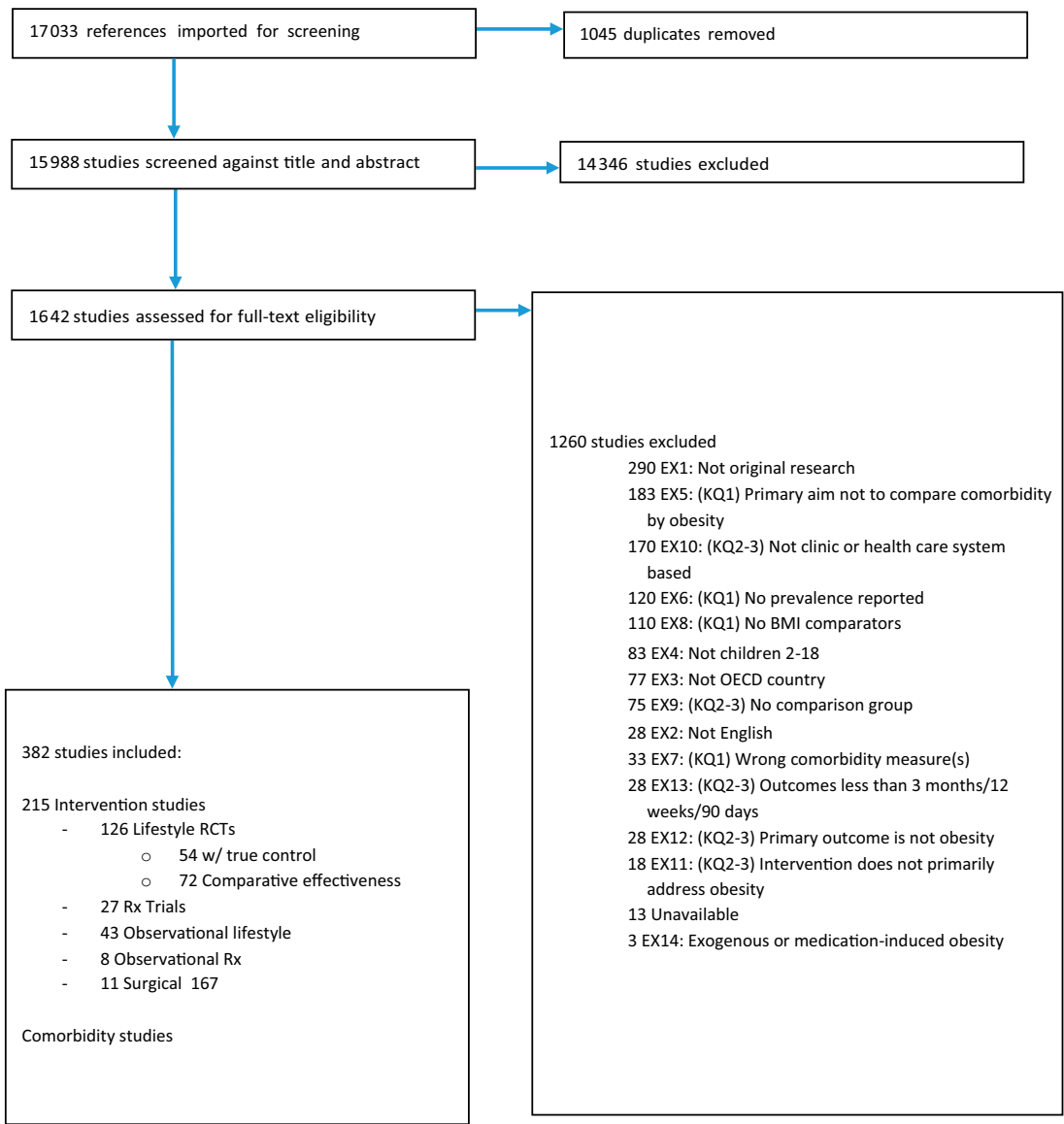
**RESULTS**

A total of 15 988 studies were screened in the title and abstract stage. Of these, 1642 were given a full-text review. Excluded studies (*n* = 1260) were most commonly not original research, did not compare comorbidities by obesity (KQ2), or were not health-care

system based (KQ1). See Fig 1 for the complete PRISMA diagram. Of the 382 studies included, 215 were intervention studies and 167 were comorbidity studies. This report focuses on the 215 intervention studies; the 167 comorbidity studies are reported separately.<sup>7</sup>

**Intervention Studies (KQ1)**

Of the 215 studies included for KQ1, the majority (*n* = 126) were randomized trials of lifestyle or diet interventions (group 1), 27 were



**FIGURE 1**  
PRISMA diagram.

randomized trials of pharmaceutical treatments (group 2), 43 were observational studies of lifestyle or diet interventions (group 3), 8 were observational studies of pharmaceutical treatment (group 4), and 11 were studies of surgical interventions (group 5). Complete data extraction for all KQ1 studies is available in Appendix 5.

**BMI Outcomes of Lifestyle RCTs (Group 1)**

Group 1 studies included 54 with minimal-intervention controls<sup>8-61</sup> and 72 comparative effectiveness studies<sup>62-133</sup> (Table 1). Overall, 35% of the studies demonstrated any difference in BMI SD score (SDS) or BMI attributable to the intervention. There was significant variation in the number of hours of contact among the studies, with an overall increase in the likelihood of any successful weight change as contact hours increased. Detailed summaries of each of these studies are available in Tables 2 and 3.

**Quality of Lifestyle RCTs**

A summary of the Cochrane Risk of Bias tool is provided in Fig 2, with further details in Table 4. The

majority of studies were of medium to poor quality based on this risk of bias tool. However, the major contributor to the quality assigned to these studies was their inability to blind participants or personnel. Additionally, the reporting of most studies did not allow for complete ascertainment of selective reporting or other sources of bias.

**Lifestyle RCTs With Minimal-Intervention Control**

For lifestyle and diet studies with minimal-intervention controls, Table 2 provides additional information on the type of intervention, sample size, age, BMI inclusion, and intervention components. These are categorized by the intensity, in hours, of the comparison group and listed with the intervention intensity. Published articles did not typically quantify dose of intervention in a consistent manner. Therefore, we extrapolated dose based on the number of sessions and average time each session lasted, to the extent this information was available from the published manuscript. We categorized findings using the USPSTF intensities of

intervention delivery as <5 hours ( $n = 20$ ),<sup>13,15,17,19,25,29,30,32,33,37,39-41,44,46,48-51,56</sup> 5 to 25 hours ( $n = 26$ ),<sup>8,11,14,16,18,20-24,26-28,31,36,38,42,43,45,47,52,53,57,59-61</sup> and 26 to 51 hours ( $n = 7$ ).<sup>9-11,34,35,54,55</sup> There was only 1 RCT with a minimal intervention control in which the intervention arm provided an intensity >51 hours.<sup>58</sup> Most studies relied on usual care or primary care provider (PCP)-only as a comparison group. The sample size ranged widely, from 17 to 645.

To understand how intensity of treatment and treatment components were associated with BMI outcomes, we examined patterns noted in Table 2. For studies that provided fewer than 5 hours of contact hours over 2 to 24 months, for children ages 2 to 17 years, 25% demonstrated improvement in BMI outcomes; none of the 5 that included a second measurement time point showed differences at this later time-point. These studies typically included nutrition and physical activity counseling to children who had overweight and/or obesity. Providing additional components,

**TABLE 1** Overall Summary of Lifestyle and Diet RCTs

	Number	Total With Any Success at Time 1	Percent With Any Success at Time 2	Total With Time 2 Measures	Total With Any Success at Time 2	Percent With Any Success at Time 2
Studies with minimal control						
Comparison is less than 5 h	20	5	25	5	0	0
Comparison is 5–25 h	26	9	35	11	3	27
Comparison is 26–51 h	7	5	71	5	3	60
Comparison is 52+ hours	1	1	100	1	1	100
Comparative effectiveness studies						
Most intense comparator is less than 5 h	9	2	22	2	1	50
Most intense comparator is 5–25 h versus lower intensity	10	3	30	5	1	20
Most intense comparator is 5–25 h versus same intensity	28	10	36	10	3	30
Most intense comparator is 26–51 h versus lower intensity	4	3	75	2	2	100
Most intense comparator is 26–51 h versus same intensity	5	0	0	5	2	40
Most intense comparator is 52+ hours versus lower intensity	11	5	45	8	3	38
Most intense comparator is 52+ hours versus same intensity	5	1	20	3	0	0
Total	126	44	35	57	19	33

TABLE 2 Description of Lifestyle and Diet Trials With Minimal-Intervention Controls

Authors	Country	Intensity	Difference		N	Ages	Weight	Length (months)	Outcome (months)	Provider Types						
			T1	T2						PCP	Subspecialist	Nutrition	Mental Health	Psychosocial	Exercise	Research
Comparison is less than 5 h Broccoli, S	Italy	<5	Y	N	372	4–7	OW	12	12/24	x						
Davis, A	USA	<5	N		17	10	OW+	2	12	x			x			
Davoli, A	Italy	<5	N		372	4–7	OW	12	12	x						
Grieken, A	The Netherlands	<5	N		637	5	OW	24	24	x						
Kong, A	USA	<5	Y		51	14–17	OW+	6	6	x						
Love-Osborne, K	USA	<5	N		165	Mean 16	OW+	6	6	x						x
McCallum, Z	Australia	<5	N	N	163	Mean 7	OW	3	9/15	x						
Novotny, R	USA	<5	N	N	85	5–8	HW/OW	9	6/15	x						x
Parra-Medina, D	USA	<5	N		118	5–14	OB+	4.5	4.5	x						x
Resnicow, K	USA	<5	Y		645	2–8	OW/OB	24	24	x						
Rifas-Shiman, S	USA	<5	N		445	2–5	OW+	12	24	x		x				
Sherwood, N	USA	<5	N		80	Mean 3	OW+	4	6	x		x				x
Small, L	USA	<5	N	N	60	4–8	OW+	4	3/6	x						x
Stovitz, S	USA	<5	N		71	4–9	OW+	3	3	x						x
Taveras, E	USA	<5	N		445	2–6	OW+	12	12	x						x
Taveras, E	USA	<5	Y		549	6–12	OW+	12	12	x						
Taylor, R	New Zealand	<5	Y		206	4–8	OW+	24	24	x			x			x
Wake, M	Australia	<5	N	N	258	5–10	OW	3	6/12	x		x			x	
Crespo N 2018	USA	5–25	N		291	5–10	OW+	12	12	x						x
Moschis G 2019	Greece	<5	N		65	6–12	OW+	1(?)	Varied 3	x	x	x				
Comparison is 5–25 h Arauz Boudreau, A	USA	<5	N		26	9–12	OW+	6	6	x						x
Boutelle, K	USA	<5	N		50	8–12	OW+	5	5	x					x	
Crabtree, V	USA	5–25	Y		19	8–12	OB+	3	3	x				x		
Crocker, H	UK	5–25	N		72	8–12	OW+	6	6	x						x
Davis, A	USA	<5	N		58	Mean 9	OW+	8	8	x						
DeBar, L	USA	5–25	Y		208	12–17	OB+	5	12	x						x
Deforche, B	Belgium	5–25	N		20	11–18	OB+	5	5	x		x				
Fleischman, A	USA	5–25	Y	N	40	10–17	OB+	6	3/6	x						
Fjordmark, C	Sweden	5–25	N	N	93	10–11	OW+	18	18/28	x		x				
Horsteenge, G	The Netherlands	5–25	N	Y	122	11–18	OW+	3	6/18	x		x				

TABLE 2 Continued

Authors	UC Only	Components										Texting and Technology	Telemedicine	Specific diet	Incentives	Sleep	Other
		Nutrition Counseling	Activity Counseling	Nutrition Training	Activity Training	MI	Psychosocial	Mental health	Parenting	Community Rec Center							
Comparison is less than 5 h																	
Broccoli, S	x																
Davis, A		x	x			x								x			
Davoli, A		x	x							x							
Grieken, A	x																
Kong, A	x	x				x				x							
		x	x			x				x							
Love-Osborne, K	x																
McCallum, Z	x	x															
Novotny, R	x	x															
		x	x														
Parra-Medina, D		x	x														
		x	x														
Resnicow, K	x																
		x	x														
Rifas-Shiman, S	x																
		x	x														
Sherwood, N		x	x														
Small, L	x																
		x	x														
Stovitz, S	x																
		x	x														
Taveras, E	x																
		x	x														
Taveras, E	x																
		x	x														
Taylor, R																	
		x	x														
Wake, M	x																
		x	x														
Crespo N 2018																	
		x	x														
Moschonis G 2019	x																
		x															
Comparison is 5–25 h																	
Arauz Boudreau, A	x																
		x	x														
Boutelle, K	x																
		x	x														
Crabtree, V		x	x														
		x	x														
Croker, H	x																
		x	x														
Davis, A		x	x														
		x	x														
DeBar, L	x																
		x	x														
Deforche, B	x																
		x	x														
Fleischman, A		x	x														
		x	x														
Fiodmark, C	x																
		x	x														
		x	x														
Hofsteenge, G																	
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														
		x	x														



TABLE 2 Continued

Authors	Country	Intensity	Difference T1	Difference T2	N	Ages	Weight	Length (months)	Outcome (months)	Provider Types							
										PCP	Subspecialist	Nutrition	Mental Health	Psychosocial	Exercise	Research	Other
Kalavainen, M	Finland	5–25 <5	N	N	70	7–9	OB+	6	24/36	x	x	x					
Kalavainen	Finland	5–25 <5	Y	Y	70	7–9	OB+	6	6/12	x		x				x	
Martinez-Andrade, G.	Mexico	5–25 <5	N	N	306	2–5	OW+	1.5	3/6	x		x				x	
Nova, A	Italy	5–25 <5	Y	Y	186	3–12	OB+	24	6/12	x		x					x
O'Connor, T	USA	5–25 <5	N		40	5–8	OW/OB	6	7–8	x							x
Saelens, B	USA	5–25 <5	N		44	12–16	OW+	4	7	x							x
Shelton, D	Australia	5–25 <5	Y		43	3–10	OW+	3	3	x							
Stark, L	USA	5–25 <5	Y		151	2–5	OB	6	6	x		x	x				
Truby, H	Australia	5–25 <5	Y		87	10–17	OW+	3	3		x	x	x				
Verbeken, S	Belgium	5–25 <5	Y		44	9–14	S0	3	3								
Wake, M	Australia	5–25 <5	N		118	5–10	OW	6	12	x							x
Wilfley, D	USA	5–25 <5	N	N	150	7–12	OW+	4	8	x	x						
Wright, J	USA	5–25 <5	N		50	9–12	OB+	3	3	x							
Yakovlevitch-Gavan, M	Israel	5–25 <5	N	N	247	5–11	OW/OB	3	3/24	x							
Fedele, D. 2018	USA	5–25 <5	0	0	24	6–12	OW+	4	4/6	x	x	x	x				
Sherwood, N. 2019	USA	5–25 <5	0	0	421	5–10	OW	12	12/24	x		x				x	x
Comparison is 26–51 h																	
Bocca, G	The Netherlands	26–51 <5	N		75	3–5	OW+	4	36	x		x	x				
Bocca, G	The Netherlands	26–51 <5	Y	Y	75	3–5	OW+	4	4/12	x		x	x			x	
Bocca, G	The Netherlands	26–51 <5	Y	Y	75	3–5	OW+	4	4/12	x		x	x			x	
Nemet, D. 2005	Israel	26–51 <5	Y	Y	46	6–16	OB+	3	3/12	x		x	x				
Nemet, D. 2013	Israel	26–51 <5	Y		41	6–13	OB+	3	3	x		x	x			x	
Vos, R	The Netherlands	26–51 <5	Y	N	79	8–17	S0	24	3/12	x		x	x			x	
Vos, R	The Netherlands	26–51 <5	N	N	81	8–17	S0	12	3/12	x		x	x	x		x	
Comparison is 52+ hours																	
Weigel, C	Germany	26–51 <5	Y	Y	73	7–15	OB+	12	6/12	x		x				x	



TABLE 2 Continued

Authors	Components											
	UC Only	Nutrition Counseling	Activity Counseling	Nutrition Training	Activity Training	MI	Psychosocial	Mental health	Parenting	Community Rec Center	Texting and Technology	Telemedicine
Kalavainen, M		x	x					x	x			
Kalavainen		x	x									
Martinez-Andrade, G.	x	x	x									
Nova, A		x	x									
O'Connor, T	x	x	x									
Saelens, B		x	x									
Shelton, D	x	x	x									
Stark, L	x	x	x									
Truby, H		x	x									
Verbeken, S	x	x	x									
Wake, M	x	x	x									
Wilfley, D	x	x	x									
Wright, J	x	x	x									
Yackobovitch-Gavan, M	x	x	x									
Fedele, D. 2018		x	x									
Sherwood, N. 2019		x	x									
Comparison is 26–51 h												
Bocca, G		x	x									
Bocca, G		x	x									
Bocca, G		x	x									
Nemet, D. 2005		x	x									
Nemet, D. 2013		x	x									
Vos, R	x	x	x									
Vos, R		x	x									
Comparison is 52+ hours												
Weigel, C		x	x									

CDS, clinical decision support; FBI, family-based behavioral treatment; HW, healthy weight; LF, low fat; MI, motivational interviewing; OB, obese; OW, overweight; PCP, primary care provider; RD, registered dietitian; SO, severe obesity; UC, usual care; WLC, wait list control.

**TABLE 3** Description of Lifestyle and Diet Comparative Effectiveness Trials

Authors	Country	Intensity	Difference T1	Difference T2	N	Ages	Weight	Length (months)	Outcomes (months)	Provider Types							
										PCP	Subspecialist	Nutrition	Mental Health	Psychosocial	Exercise	Research	Other
Most intense comparator is less than 5 h																	
Armstrong, S	USA	<5	N		101	5–12	OB+	3	6	x		x					
Chen, J	USA	<5	Y	Y	40	13–18	OW+	3	3/6	x		x					x
Fonseca	Portugal	<5	N		80	12–18	OW+	3	3	x		x				x	x
Gourlan, M	France	<5	Y	N	62	11–18	OB+	6	3/6	x		x				x	
Looney, S	USA	<5	N		22	4–10	OW+	6	6	x		x				x	
Macdonell, K	USA	<5	N		44	13–17	OW+	3	3	x		x	x				x
		<5															
Taveras, E	USA	<5	N		721	2–12	OW+	12	12	x							
Walpole, B	Canada	<5	N		40	10–18	OW+	6	6					x			x
Bean 2018	USA	<5	N	N	99	11–18	OW+	10 wk	3/6					x			x
Most intense comparator is 5–25 h versus lower intensity																	
Bohlin, A	Sweden	<5	N	N	37	5–14	OB+	18	18/36	x							
Ford, A	UK	<5	N		106	9–18	OB+	12	12	x						x	
Garipeğaoglu 2009, M	Turkey	5–25	Y	N	80	6–14	OB+	3	3/12	x		x					
		5–25	N		20	NR	OB+	4	4			x					
Hills, A	Australia	<5	N		134	5–11	OB+	6	6/12	x		x					
Hughes, A	UK	<5	N	N	106	11–13	OB+	12	12	x		x					
Norman, G	USA	<5	Y		61	Mean 8	OW+	12	12	x		x					
Pedrosa, C	Portugal	5–25	N		33	2–5	OB	6	6/12	x							
Stark, L	USA	<5	Y	Y	40	6–11	OB	3	3	x				x			
Koziol- Kozakowska 2019	Poland	5–25	N		21	14–17	OB+	6	3/6	x		x	x				x
		5–25															
Kumar 2018	USA	<5	N	N	32	12–13	OW+	6	6		x						
Most intense comparator is 5–25 h versus same intensity																	
Akgül Gundogdu, N	Turkey	5–25	Y		68	5–16	S0	12	12								
Banks, J	UK	5–25	N		36	7–12	OW+	9	3/18	x		x				x	
Bathrellou, E	Greece	5–25	N	N	113	13–17	OB+	12	4/12	x		x				x	
Berkowitz, R	USA	5–25	Y	N	169	12–16	OB+	12	12	x		x				x	
Berkowitz, R	USA	5–25	N		26	9–14	OW+	4	4	x		x	x	x	x	x	x
		5–25															
Casazza, K	USA	5–25	N		103	Mean 9	OW+	8	8								
Davis, A	USA	5–25	N		27	8–21	OW+	6	6								
de Ferranti, S	USA	5–25	N		27	8–21	OW+	6	6								
		5–25															

TABLE 3 Continued

Components														
Authors	UC Only	Nutrition Counseling	Activity Counseling	Nutrition Training	Activity Training	MI	Psychosocial	Mental Health	Parenting	Community Rec Center	Texting and Technology	Telemedicine	Specific diet	Other
Most intense comparator is less than 5 h														
Armstrong, S		x	x								x			
Chen, J		x	x											
Fonseca	x													
		x	x			x					x			
Gourlian, M		x	x			x								
Looney, S	x	x	x			x								
Macdonell, K		x	x			x								
Taveras, E		x	x											
Walpole, B		x	x	x		x								
Bean 2018		x	x	x		x								x
Most intense comparator is 5–25 h versus lower intensity														
Bohlin, A		x	x		x									
Ford, A		x	x											x
Garipağaoğlu 2009, M														
Hills, A		x	x											
Hughes, A		x	x		x	x								
Norman, G		x	x											
Pedrosa, C		x	x											
Stark, L		x	x											
		x	x			x			x					
Koziol- Kozakowska 2019		x	x			x			x					
Kumar 2018	x	x	x											
Most intense comparator is 5–25 h versus same intensity														
Akgül Gundogdu, N		x	x			x								
Banks, J	x			x										
Bathrellou, E		x	x	x				x						
Berkowitz, R		x	x	x				x					x	
		x	x	x				x					x	
Berkowitz, R		x	x	x				x					x	
Casazza, K		x	x	x				x					x	
Davis, A		x	x	x									x	
de Ferranti, S		x	x					x						
		x	x										x	x

**TABLE 3 Continued**

Authors	Country	Intensity	Difference T1	Difference T2	N	Ages	Weight	Length (months)	Outcomes (months)	Provider Types							
										PCP	Subspecialist	Nutrition	Mental Health	Psychosocial	Exercise	Research	Other
de Niet, J	The Netherlands	5–25 SMS UC	N		141	Mean 10	OW+	9	12	x		x	x				
Demol, S	Israel	5–25 LC/IF LC/HF	N	N	55	12–18	OB+	3	3/12	x			x			x	
Ebbeling, C	USA	5–25 HC/LF Reduced GL	Y		14	13–21	OB+	12	12			x	x				
Krebs, N	USA	5–25 Low fat HP/LC	N	N	46	Mean 14	OB+	3	6/9							x	
Larsen, L	Denmark	5–25 LF model 1	N		80	5–9	OW+	24	24	x							x
Mirza, N	USA	5–25 Model 2 LGL	N	N	113	7–15	OB+	3	12/24	x			x				
Parillo, M	Italy	5–25 LF HGI	Y		22	Mean 10	OB+	6	6	x							
Partsalaki, I	Greece	5–25 LGI Keto	N		58	8–18	OB+	6	6			x	x				
Quattrin, T	USA	5–25 Low cal Intervention	Y	Y	96	2–5	OW+	6	3/6	x			x				x
Quattrin, T	USA	5–25 Attention control Attention control	Y		96	2–5	OW+	12	24	x							x
Quattrin, T	USA	5–25 FBT Attention control	Y	Y	96	2–5	OW+	12	18/24	x							x
Stettler, N	USA	5–25 Intervention Control	Y		172	8–12	OW	12	12	x			x				
Tjånn, A	Norway	5–25 Beverage Multiple	N		54	mean 14	OW+	3	3/12	x							
Williams, C	USA	5–25 Multidisc. Interval training	N	N	38	11–15	OB+	3	3	x			x			x	
Yakovlevich-Gavan	Israel	5–25 Free snack Restricted snack	N		71	12–18	OB+	3	3	x			x				x
Banos 2019	Spain	5–25 LGLF LCHF	N		27	Mean 10.4	OW+	10 wk	3				x				
Ek 2019	Sweden	5–25 HCLF GBT-E	Y		174	4–6	OB	12	12	x				x			
Forsell 2019	Sweden	5–25 Booster No booster	N		56	8–13	OB	12	4 years	x							
Njardvik 2018	Iceland	5–25 NDPT FBT-AAT	Y	Y	84	8–12	OB+	18 wk	12/24	x			x			x	
Stark 2019	USA	5–25 FBT LAUNCH	N	N	151	2–5	OB+	18 wk	x			x					
Most intense comparator is 26–51 h vs lower intensity		5–25 MI Standard care				2–5	OB+	6	6/12	x			x				
Díaz, R	Mexico	<5 Control Lifestyle	Y	Y	43	9–17	OB+	6	6/12	x							
Naar-King, S	USA	26–51 Shapedown Multisystemic	N		49	12–17	OB+	6	7	x							
Stark, L	USA	26–51 UC LAUNCH	Y	Y	18	2–5	OB	6	6/12	x							
Wilfley, D	USA	26–51 Control LOW	Y		172	7–11	OW+	8	8				x				
Most intense comparator is 26–51 h versus same intensity		26–51 HIGH				7–11	OW+										
Garnett, S	Australia	26–51 Mod carb/hi pro	N	N	111	10–17	OW+	12	3/6	x							

TABLE 3 Continued

[illegible]

TABLE 3 Continued

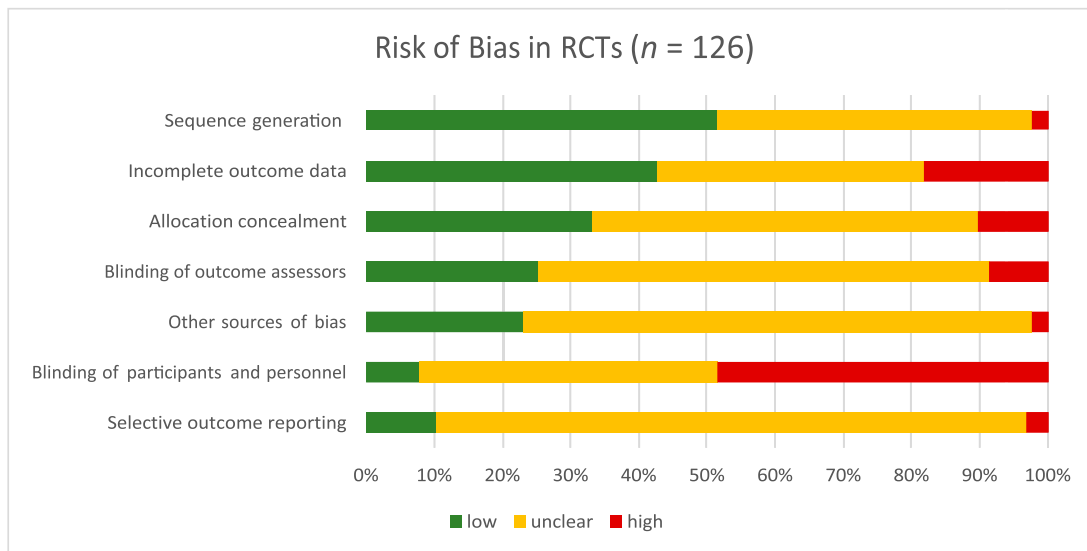
Authors	Country	Intensity	Intervention	Difference		N	Ages	Weight	Length (months)	Outcomes (months)	Provider Types							
				T1	T2						PCP	Subspecialist	Nutrition	Mental Health	Psychosocial	Exercise	Research	Other
Garnett, S	Australia	26-51	Hi carb/LF	N	N	111	10-17	OW+	12	6/12	X		X				X	
		26-51	Mod carb/hi pro									X		X			X	
Hystad, H	Norway	26-51	Hi carb/LF	N	N	83	7-12	OB+	24	6/24	X		X				X	
		26-51	Therapist									X		X			X	
Farpour- Lambert 2019	Switzerland	26-51	Self help	N	Y	74	7-11	SO	6	6/12	X		X				X	
		26-51	Individual									X		X			X	
		26-51	Group									X		X			X	
Sepulveda 2020	Spain	<5	Control						12		X							
		26-51	ENT REN	N	Y	51	8-12	OW+	6	Post/6	X		X		X		X	
26-51		ENT REN-F							6		X							
Most intense comparator is 52+ hours versus lower intensity																		
Anderson, Y	New Zealand	<5	Minimal intervention	N	N	138	5-16	SO	12	6/12	X		X					
		≥52	Whanau Pakari									X		X			X	
Baan-Slootweg, O	The Netherlands	5-25	Ambulatory	Y	N	90	8-18	SO	6	6/30	X		X			X		
		≥52	Inpatient									X		X			X	
Butte, N	USA	5-25	Next Steps	Y	N	549	2-12	OW+	12	3/12	X		X					
		26-51	MEND									X		X				X
Hoffman, J	USA	≥52	MEND/CAT CH								X		X					X
		5-25	HL	N	N	97	5-11	OB+	6	6	X		X		X		X	
Kokkvoli, A	Norway	≥52	HL + BCF								X		X					X
		5-25	Single family	N	N	91	6-12	OB+	12	3/12	X		X		X		X	
Kokkvoli, A	Norway	≥52	Multifamily								X		X					
		5-25		N	Y	91	6-12	OB+	24	12/24	X		X		X		X	
Lison, J	Spain	≥52									X		X					
		<5	Control	Y		110	6-16	OW+	6	6	X		X			X		
Savoye, M	USA	<5	Home based								X		X				X	
		≥52	Group									X		X			X	
Savoye, M	USA	<5	PWMP	Y	Y	174	8-16	OB+	12	12/24		X				X		
		≥52	Bright Bodies									X		X		X		
Serra-Paya, N	Spain	<5	PWMP	Y	Y	174	8-16	OB+	12	6/12	X		X			X		
		≥52	Bright Bodies									X		X		X		
Kokkvoli 2020	Norway	<5	Counseling	N		113	6-12	OW+	8	8	X		X				X	
		≥52	Nereu									X		X		X		
Most intense comparator is 52+ hours versus same intensity	The Netherlands	5-25	Individual	N		91	6-12	OW+	24	36	X		X				X	
		≥52	Group									X		X			X	
Makkes, S	France	≥52	Short stay	Y	N	80	8-19	SO	12	6/12		X						
		≥52	Long stay										X					
Rolland- Cachera, M	Germany	≥52	PROT -	N	N	121	11-16	SO	9	11/35	X		X			X		
		≥52	PROT +										X		X		X	
Warschburger, P	France	≥52	CBT	N	N	523	7-12	SO	3	6/12	X		X			X		
		≥52	Information									X		X		X		
Miguet 2019	Germany	≥52	MICT	N		43	11-15	OB+	4	4	X		X			X		
		≥52	HIT									X		X		X		
Warschburger 2018	AAT	≥52	AAT	N	N	232	8-16	SO	6 wk	6/12	X		X			X		
		≥52	Placebo training															

TABLE 3 Continued

Authors	Components													
	UC Only	Nutrition Counseling	Activity Counseling	Nutrition Training	Activity Training	MI	Psychosocial	Mental Health	Parenting	Community Rec Center	Texting and Technology	Telemedicine	Specific diet	Other
Garnett, S		x	x		x								x	
Hystad, H		x	x		x			x					x	
Farpour- Lambert 2019		x	x		x			x						
		x	x		x									
Sepulveda 2020	x	x	x		x			x						
Most intense comparator is 52+ hours versus lower intensity														
Anderson, Y		x	x		x			x		x				
Baan-Slootweg, O		x	x	x	x			x		x				
Butte, N		x	x		x			x						
Hoffman, J		x	x		x					x				
Kokkvoli, A		x	x		x									
Kokkvoli, A		x	x		x									
Lison, J	x				x									
Savoye, M		x	x		x									
Savoye, M		x	x		x									
Serra-Paya, N		x	x		x									
Kokkvoli 2020		x	x		x									
Most intense comparator is 52+ hours versus same intensity														
Makkes, S		x	x		x									
Rolland- Cachera, M		x	x		x									
Warschburger, P		x	x		x									
Miguet 2019		x	x		x									
Warschburger 2018	x	x	x		x									
MAT, appetite awareness training; BCF, Bull City Fit; CBT-E, enhanced cognitive behavior therapy; EPC, enhanced primary care; EUC, enhanced usual care; FBT, family-based treatment; HL, Healthy Lifestyles; HP, high protein; HGI, hypocaloric, low-glycemic-index; HF, high fat; HILT, high-intensity interval training; GM, growth monitoring; GL, glycemic load; LC, low carbohydrate; LF, low fat; LGL, low glycemic load; LGI, low glycemic index; MI, motivational interviewing; MR, meal replacements; MCT, moderate-intensity continuous training; NDPT, nurse, dietitian, and physiotherapist; NDT, nurse and dietitian; OB, obese; OW, overweight; PC, primary care; PCP, primary care provider; PWMP, personalized weight management program; SMS, short message service; SFA, solution-focused approach; SO, severe obesity; UC, usual care.														

AAT, appetite awareness training; BCF, Bull City Fit; CBE-E, enhanced cognitive behavior therapy; EPC, enhanced primary care; EUC, enhanced usual care; FBT, family-based treatment; HL, Healthy Lifestyles; HP, high protein; HGI, hypocaloric, low-glycemic index; HF, high fat; HIIT, high-intensity interval training; GM, growth monitoring; GL, glycemic load; LC, low carbohydrate; LF, low fat; LGL, low glycemic load; LGI, low glycemic index; MI, motivational interviewing; MR, meal replacements; MICT, moderate-intensity continuous training; NDPT, nurse, dietitian, and physiotherapist; NDI, nurse and dietitian; OB, obese; OW, overweight; PC, primary care; PCP, primary care provider; PWMP, personalized weight management program; SMS, short message service; SFA, solution-focused approach; SO, severe obesity; UC, usual care.





**FIGURE 2**  
Quality of lifestyle RCTs, as assessed using the Cochrane Risk of Bias Tool.

such as addressing sleep or motivational interviewing (MI), did not distinguish effective studies from noneffective studies for this limited number of contact hours. Although virtually all studies resulting in statistically significant BMI reduction included MI, many of the studies without significant effects also included MI.

More than 35% of the studies that provided 5 to 25 hours of contact hours demonstrated a statistically significant change in BMI outcomes in the desired direction. More than half focused on adolescents. The majority of these lifestyle interventions focused on children who had obesity and provided nutrition and physical activity counseling with the assistance of a nutrition provider. Additional components such as sleep or participation of a mental health provider, such as a clinical psychologist, did not distinguish effective from noneffective trials.

Although there were many fewer studies that provided 26 to 51 hours of intervention contact hours ( $n = 7$ ), 71% demonstrated effective

change in BMI over 3 to 24 months. More than half of these included children and adolescents with obesity or severe obesity who were between the ages of 3 and 17 years. In addition to nutrition and physical activity counseling, the interventions provided activity training—that is, the incorporation of exercise during sessions (rather than only counseling on physical activity). Three of the 5 with significant improvements in BMI addressed both mental health and parenting skills.

As referenced above, we identified only 1 RCT with contact hours that exceeded 51 hours. Although this study demonstrated an effective outcome after 1 year, it included a small sample size of 73 children ages 7 to 15 years in Germany. This study provided the components of both nutrition and physical activity counseling and training as well as addressing mental health.

Primary care providers were included in almost all studies, in both the treatment arm and the minimal-intervention comparison arm. Nutrition providers and mental

or behavioral health counselors were also common providers. Despite their frequency of use, none of these provider types distinguished interventions with significant improvements in BMI from those showing no differences. Other providers, such as exercise trainers or social workers, were commonly used in high-intensity interventions but did not, on their own, differentiate studies with improvements in BMI.

Overall, as the intensity of the treatment increased, the sample size of the study generally decreased, highlighting the challenges, even in a research setting, of delivering an intensive intervention to a large population. Interventions that were less intensive often included children with both overweight and obesity, whereas more intensive studies predominantly set the cut-point higher, only including children with obesity. The components of the various interventions include medical care, dietary and exercise counseling, psychosocial and mental health counseling, and MI. In addition, there were innovative strategies highlighted as well including text messaging,

**TABLE 4** Quality of Lifestyle RCTs, as Assessed Using the Cochrane Risk of Bias Tool

	Allocation Concealment	Blinding of Outcome Assessors	Blinding of Participants and Personnel	Incomplete Outcome Data	Other Sources of Bias	Selective Outcome Reporting	Sequence Generation
Akgul Gundogdu 2017	↓	↓	↑	↓	↓	↓	↓
Anderson 2017	↓	↓	↑	↓	↓	↓	↓
Arauz 2013	↓	↓	↑	↓	↓	↓	↓
Armstrong 2018	↓	↓	↓	↓	↓	↓	↓
Baan-Slootweg 2014	↓	↓	↓	↓	↓	↓	↓
Banks 2012	↓	↓	↑	↓	↓	↓	↓
Banos 2019	↓	↓	↑	↓	↓	↓	↓
Bathrellou 2010	↓	↓	↓	↓	↓	↓	↓
Bean 2018	↓	↓	↑	↓	↓	↓	↓
Berkowitz 2011	↓	↓	↓	↓	↓	↓	↓
Berkowitz 2013	↓	↓	↑	↓	↓	↓	↓
Bocca 2012	↓	↓	↑	↓	↓	↓	↓
Bocca 2014	↓	↓	↑	↓	↓	↓	↓
Bocca 2014	↓	↓	↑	↓	↓	↓	↓
Bohlin 2017	↓	↓	↑	↓	↓	↓	↓
Boutelle 2013	↓	↓	↑	↓	↓	↓	↓
Broccoli 2016	↓	↓	↑	↓	↓	↓	↓
Butte 2017	↓	↓	↓	↓	↓	↓	↓
Casazza 2012	↓	↓	↓	↓	↓	↓	↓
Chen 2017	↓	↓	↓	↓	↓	↓	↓
Crabtree 2010	↓	↓	↓	↓	↓	↓	↓
Crespo 2018	↓	↓	↑	↓	↓	↓	↓
Croker 2012	↓	↓	↑	↓	↓	↓	↓
D'Áaz 2010	↓	↓	↑	↓	↓	↓	↓
Davis 2011	↓	↓	↑	↓	↓	↓	↓
Davis 2013	↓	↓	↑	↓	↓	↓	↓
Davis 2016	↓	↓	↑	↓	↓	↓	↓
Davoli 2013	↓	↓	↓	↓	↓	↓	↓
DeBar 2012	↓	↓	↑	↓	↓	↓	↓
deFerranti 2015	↓	↓	↓	↓	↓	↓	↓
Deforche 2005	↓	↓	↑	↓	↓	↓	↓
Demol 2009	↓	↓	↑	↓	↓	↓	↓
deNiet 2012	↓	↓	↓	↓	↓	↓	↓
Ebbeling 2003	↓	↓	↓	↓	↓	↓	↓
Ek 2019	↓	↓	↓	↓	↓	↓	↓
Farpour-Lambert 2019	↓	↓	↑	↓	↓	↓	↓
Fedele 2018	↓	↓	↑	↓	↓	↓	↓
Fleischman 2016	↓	↓	↑	↓	↓	↓	↓
Flodmark 1993	↓	↓	↑	↓	↓	↓	↓
Fonseca 2016	↓	↓	↓	↓	↓	↓	↓
Ford 2009	↓	↓	↑	↓	↓	↓	↓
Forsell 2019	↓	↓	↓	↓	↓	↓	↓
Garipagaoglu 2009	↓	↓	↑	↓	↓	↓	↓
Garnett 2013	↓	↓	↑	↓	↓	↓	↓

TABLE 4 (continued)

Garnett 2014	◆	◆	◆	◆	◆	◆
Gourlan 2013	◆	◆	◆	◆	◆	◆
Grieken 2013	◆	◆	◆	◆	◆	◆
Hills 1988	◆	◆	◆	◆	◆	◆
Hoffman 2018	◆	◆	◆	◆	◆	◆
Hofsteenge 2014	◆	◆	◆	◆	◆	◆
Hughes 2008	◆	◆	◆	◆	◆	◆
Hystad 2013	◆	◆	◆	◆	◆	◆
Kalavainen 2007	◆	◆	◆	◆	◆	◆
Kalavainen 2011	◆	◆	◆	◆	◆	◆
Kokkvoll 2014	◆	◆	◆	◆	◆	◆
Kokkvoll 2015	◆	◆	◆	◆	◆	◆
Kokkvoll 2020	◆	◆	◆	◆	◆	◆
Kong 2013	◆	◆	◆	◆	◆	◆
Koziol-Kozakowska 2019	◆	◆	◆	◆	◆	◆
Krebs 2010	◆	◆	◆	◆	◆	◆
Kumar 2018	◆	◆	◆	◆	◆	◆
Larsen 2015	◆	◆	◆	◆	◆	◆
Lison 2012	◆	◆	◆	◆	◆	◆
Looney 2014	◆	◆	◆	◆	◆	◆
Love-Osborne 2014	◆	◆	◆	◆	◆	◆
Macdonell 2012	◆	◆	◆	◆	◆	◆
Makkes 2016	◆	◆	◆	◆	◆	◆
Martinez-Andrade 2014	◆	◆	◆	◆	◆	◆
McCallum 2007	◆	◆	◆	◆	◆	◆
Miguet 2019	◆	◆	◆	◆	◆	◆
Mirza 2013	◆	◆	◆	◆	◆	◆
Moschonis 2019	◆	◆	◆	◆	◆	◆
Naar-King 2009	◆	◆	◆	◆	◆	◆
Nemet 2005	◆	◆	◆	◆	◆	◆
Nemet 2013	◆	◆	◆	◆	◆	◆
Njardvik 2018	◆	◆	◆	◆	◆	◆
Norman 2016	◆	◆	◆	◆	◆	◆
Nova 2001	◆	◆	◆	◆	◆	◆
Novotny 2015	◆	◆	◆	◆	◆	◆
O'Connor 2013	◆	◆	◆	◆	◆	◆
Parillo 2012	◆	◆	◆	◆	◆	◆
Parra-Medina 2015	◆	◆	◆	◆	◆	◆
Partsalaki 2012	◆	◆	◆	◆	◆	◆
Pedrosa 2011	◆	◆	◆	◆	◆	◆
Quattrin 2012	◆	◆	◆	◆	◆	◆
Quattrin 2014	◆	◆	◆	◆	◆	◆
Quattrin 2017	◆	◆	◆	◆	◆	◆
Resnicow 2015	◆	◆	◆	◆	◆	◆
Rifas-Shiman 2017	◆	◆	◆	◆	◆	◆
Rolland-Cachera 2004	◆	◆	◆	◆	◆	◆
Saelens 2002	◆	◆	◆	◆	◆	◆
Savoye 2007	◆	◆	◆	◆	◆	◆

**TABLE 4** (continued)

Savoye 2011	↓	◇	↑	◇	◇	◇	↓
Sepulveda 2020	◇	↑	◇	↑	◇	↓	◇
Serra-Paya 2015	↓	↓	◇	◇	◇	◇	↓
Shelton 2007	◇	↓	◇	◇	◇	◇	↓
Sherwood 2015	◇	◇	◇	↓	◇	◇	◇
Sherwood 2019	↓	◇	◇	↓	◇	↓	↓
Small 2014	◇	◇	◇	↑	◇	◇	◇
Stark 2011	↓	↓	↑	↓	↓	◇	↓
Stark 2014	◇	◇	↑	↑	◇	◇	↓
Stark 2018	↓	↓	◇	◇	◇	◇	◇
Stark 2019	↓	↓	↑	◇	↓	↓	↓
Stettler 2015	↓	◇	↑	↑	◇	↑	◇
Stovitz 2014	◇	↓	◇	↓	◇	◇	◇
Taveras 2011	↑	↑	↑	↓	◇	◇	↓
Taveras 2015	↓	↑	↑	↓	◇	◇	↓
Taveras 2017	↓	↓	↓	↓	↓	◇	↓
Taylor 2015	◇	◇	◇	↓	↓	◇	↓
TjĀnna 2009	↓	↓	◇	↑	◇	◇	↓
Truby 2016	◇	◇	◇	↓	↓	◇	◇
Verbeke 2013	↓	↓	◇	◇	◇	◇	↓
Vos 2011	◇	◇	◇	◇	◇	◇	◇
Vos 2012	↓	◇	◇	◇	◇	◇	↓
Wake 2009	↓	◇	◇	↓	↓	◇	↓
Wake 2013	↓	↓	↑	↓	↓	◇	↓
Walpole 2013	↓	◇	↓	↓	↓	↓	↓
Warschburger 2016	↓	↓	↓	◇	◇	◇	↓
Warschburger 2018	◇	◇	◇	◇	↓	◇	◇
Weigel 2008	◇	◇	↑	↓	◇	◇	◇
Wilfley 2007	◇	◇	◇	↓	↓	◇	↓
Wilfley 2017	↓	↑	◇	↓	↓	◇	↓
Williams 2007	◇	◇	◇	↓	↑	◇	◇
Wright 2013	↓	◇	◇	↓	◇	◇	↓
Yackobovitch-Gavan	◇	◇	↑	↑	◇	◇	◇
Yackobovitch-Gavan	◇	◇	↑	↑	◇	◇	◇

Green arrow = low risk of bias; yellow diamond = unclear risk of bias; red arrow = high risk of bias.

telehealth, and sleep training. Behavioral components, such as nutrition and activity counseling, were nearly universally present in the interventions. No single intervention component was consistently associated with improved BMI outcomes, nor were any clusters of intervention components associated with improved BMI. Although most trials with statistically significant improvements

in BMI included diet and activity counseling, as well as direct activity sessions, many with these components did not demonstrate any significant differences.

#### Comparative Effectiveness Lifestyle RCTs

The lifestyle and diet comparative effectiveness trials (Table 3) are listed by the most intensive

comparator and included the intensity of all groups. The comparator arm of these studies varied, and the most commonly used included enhanced primary care, multidisciplinary clinic treatment, mailers, or group-based education. Many of the studies in this group compared different versions of a similar intervention (primary care versus enhanced primary care

versus primary care plus coaching), similar interventions delivered in different settings (inpatient versus outpatient, home versus clinic), or comparison of specific dietary strategies (low-fat versus low-carb). As seen with the studies that included a control group, the interventions that included children with more severe degrees of obesity tended to be more intensive by hours and setting (eg, inpatient) but shorter in duration as compared with less intensive interventions. No outcomes beyond 36 months were reported, although most were reported only at 6 or 12 months. Nearly all the studies included some type of nutrition and activity counseling for all comparator arms.

As with the minimal-intervention control studies, most comparative effectiveness studies included primary care providers in both study arms. Nutrition and mental and behavioral health providers were also common. In more intensive studies, exercise trainers and social workers were often used. No specific provider type was clearly associated with significant improvements in BMI.

Most comparative effectiveness studies included both nutrition and activity counseling, whereas fewer included direct provision of physical activity and nutrition training. These components were not clearly associated with improved BMI outcomes—many studies including activity and nutrition training did not find significant differences. All studies that included parenting training in the comparator demonstrated improved BMI; however, these were limited largely to very young children, 2 to 5 years of age. Otherwise, no single component of the intervention was consistently associated with positive BMI outcomes, regardless of intensity, and no clusters of intervention components

distinguished studies demonstrating significant improvements in BMI.

### Magnitude of Effects on BMI

Among the RCTs showing effectiveness, we also examined the magnitude of BMI change (Table 5). The magnitude of change varied widely, with lower-intensity interventions resulting in less BMI change. Several metrics were used to monitor change in children's relative adiposity during the obesity treatment trials. BMI was the most commonly used metric of weight change among the successful lifestyle and diet trials ( $n = 30$ ), followed by BMI SDS ( $n = 29$ ), absolute weight ( $n = 16$ ), BMI percentile ( $n = 12$ ), percentage over median BMI or other ( $n = 6$ ), and percentage of the 95th percentile ( $n = 1$ ). Table 5 presents detailed information about the magnitude of changes, limited only to the studies showing any statistically significant differences between included groups.

Differences in BMI change between treatment arms ranged from  $-4.30$  to  $-0.10$ . The greatest BMI changes ( $>2$  BMI unit reduction) were observed in trials of  $\geq 52$  contact hours, mostly delivered over 12 months and to children and adolescents with obesity.<sup>58,102,118,119</sup> The greatest differences in BMI reduction occurred in studies of older children and adolescents, with smaller reductions seen in younger children, as would be expected based on BMI for these groups. However, many studies included wide age ranges, encompassing early school age through adolescence.

Most BMI SDS changes ranged from  $-0.10$  to  $-0.25$  (14 of 29 studies), although 5 trials produced a BMI SDS change between  $-0.25$  and  $-0.50$ ,<sup>10,11,75,115,120</sup> and 3 trials produced a BMI SDS change  $>-0.50$ .<sup>47,58,122</sup> A difference of

$>0.25$  BMI SDS has been suggested as a clinically meaningful difference.<sup>134,135</sup> Differences between treatment arms in BMI percentile changes ranged from  $-0.6$  to  $-7.2$ . Difference between study arms for absolute change in weight (kg) varied from  $-1.6$  to  $-8.1$  kg, with larger weight loss observed in trials with more contact hours and among older children and adolescents who had obesity.

### Other Health Outcomes in Group 1

Many of the studies examined other health outcomes, in addition to BMI. Table 6 summarizes the other outcomes reported. These include other obesity-related metrics (eg, waist circumference), behaviors, glucose metabolism, lipids, blood pressure, psychosocial outcomes, other laboratory measures, mental health, and other outcomes.

#### Other Obesity-Related Metrics

The most commonly reported outcomes other than BMI were other measures of obesity, such as waist circumference or body fat percentage, which were reported in 56% of the included studies.<sup>9-11,15,16,23-29,33-35,37,39,46,51,55,57,58,63,65,67,70,71,73-75,77,79-83,85,86,88,89,91-102,105,106,108,110,112,113,117-121,124,127,128,132,133</sup> Of these studies, 50% ( $n = 35$ ) noted some significant reduction in obesity-related measures attributable to the intervention. These interventions are listed in Table 7. Of the studies showing significant changes, 16 reported improvements in waist circumference, 8 reported improvements in waist circumference-to-height ratio, and 8 reported improvements in body fat percentage. Other studies reported improved outcomes in fat mass, weight, skinfold, and waist circumference-to-height ratio. Fewer studies focusing primarily on adolescents demonstrated significant improvements in obesity-related

**TABLE 5** Magnitude of BMI Effect for Successful Lifestyle and Diet Trials

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS Reduction	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median	Calculated From
Gourlan, M	Most intense comparator is less than 5 h Motivational interviewing as a way to promote physical activity in obese adolescents: a randomized-controlled trial using self-determination theory as an explanatory framework	France	<5	62	11–18	OB+	6	0.31							
															x
Chen, J	Short-term efficacy of an innovative mobile phone technology-based intervention for weight management for overweight and obese adolescents: pilot study	USA	<5	40	13–18	OW+	3	6							
															x
Garipağaoğlu 2009, M	Most intense comparator is 5–25 h versus lower intensity treatment versus individual treatment in the management of childhood obesity: randomized, prospective clinical trial	Turkey	<5	80	6–14	OB+	3	6							
															x
Norman, G	Outcomes of a 1-y randomized controlled trial to evaluate a behavioral “stepped-down n” weight loss intervention for adolescent patients with obesity	USA	5–25	106	11–13	OB+	12	3							
															x

22

FROM THE AMERICAN ACADEMY OF PEDIATRICS



TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median Calculated From
Quattrin, T.	Efficacy of family-based weight control program for preschool children in primary care	USA	5–25	96	2–5	OW+	6	6	–3.20	–0.30				
			Difference						–1.60	–0.10				
			Intervention										–6.4	x
Quattrin, T.	Cost-effectiveness of family-based obesity treatment	USA	5–25	96	2–5	OW+	12	6						
			Attention control										–2.2	x
			Difference										–4.2	x
Quattrin, T.	Treatment outcomes of overweight children and parents in the medical home	USA	5–25	96	2–5	OW+	12	24					4.4	
			FBT										–2	
			Difference									7.1	–6.4	x
Stettler, N.	Prevention of excess weight gain in pediatric primary care: beverages only or multiple lifestyle factors. The Smart Step Study, a cluster-randomized clinical trial	USA	5–25	172	8–12	OW	12	24						
			Intervention										5.5	x
			Difference										–1.6	x
Ek 2019	A parent treatment program for preschoolers with obesity: a randomized controlled trial	Sweden	5–25	174	4–6	OB	12	12						
			Control										5.6	x
			Intervention										5.5	x
Ek 2019	A parent treatment program for preschoolers with obesity: a randomized controlled trial	Sweden	5–25	174	4–6	OB	12	12						
			Behavioral control										NS	
			Multi versus control										NS	
Ek 2019	A parent treatment program for preschoolers with obesity: a randomized controlled trial	Sweden	5–25	174	4–6	OB	12	12						
			Booster										–0.63	
			Standard										–0.54	
Ek 2019	A parent treatment program for preschoolers with obesity: a randomized controlled trial	Sweden	5–25	174	4–6	OB	12	12						
			No booster										0.56	
			Standard										0.78	

24

FROM THE AMERICAN ACADEMY OF PEDIATRICS

TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median	Calculated From
Farpour-Lambert 2019	programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children		26–51 <5	Group Control	6		12		NS	NS					
			Individual vs control												
			Group vs control				12		−0.77	−0.10					
			Individual vs group						−1.08	−0.08					
Sepulveda 2020	Feasibility, acceptability, and effectiveness of a multidisciplinary intervention in childhood obesity from primary care: Nutrition, physical activity, emotional regulation, and family	Spain	26–51	ENTREN	51	8–12	OW+	6		−0.4					
			26–51	ENTREN-F Difference				6		−0.83					
										−0.43					
Most intense comparator is 52+ hours versus lower intensity															
Butte, NF	Efficacy of a community-centered program for childhood obesity: TX CORD RCT	USA	5–25	Next Steps	549	2–12	OW+	12	0.17				−0.39		
			≥52	MEND/CATCH Difference				3	−0.25				−2.32		
			5–25	Single family	91	6–12	OB+	24	−0.42			NS	−1.93		x
Kokkvoli, A.	Health in overweight children: 2-y follow-up of Finnmark Activity School—a randomized trial	Norway	≥52	Multifamily Difference				24	NS	−0.20					x
										−0.12					x

TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median or Other	Calculated From
Lison, Jf	Exercise intervention in childhood obesity: a randomized controlled trial comparing hospital- versus home-based groups	Spain	<5	110	6–16	OW +	6		1.60	-0.01		7.8			x
			<5						-1.20	-0.23		-0.3			x
			≥52						-0.40	-0.16		1.2			x
			C versus home						-2.80	-0.22		-8.1			x
Savoie, M	Long-term results of an obesity program in an ethnically diverse pediatric population	USA	C versus group				6		-2.00	-0.15		-6.6			x
			<5	174	8–16	OB +	12		1.90	-0.05		12.0			
			≥52						-0.90	-0.20		5.9			
			Bright Bodies Difference				24		-2.80	-0.16		-6.1			
Savoie, M	Effects of a weight management program on body composition and metabolic parameters in overweight children: a randomized controlled trial	USA	<5	174	8–16	OB +	12		1.60			7.7			
			≥52						-1.70			0.3			
			Bright Bodies Difference				12		-3.30			-7.4			
Most intense comparator is 52+ hours versus same intensity															
Makkes, S	One-year effects of 2 intensive inpatient treatments for severely obese children and adolescents	The Netherlands	ds	80	8–19	S0	12		-0.30						x
			≥52												
			Long stay Difference				6		-0.50						x
									-0.22						

TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS Reduction	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median Calculated From
Comparison is less than 5 h Broccoli, S	Motivational interviewing to treat overweight children: 24-month follow-up of a randomized controlled trial	Italy	<5 UC	372	4–7	OW	12		0.78					
Resnicow, K	Motivational interviewing and dietary counseling for obesity in primary care: an RCT	USA	<5 MI Difference UC	645	2–8	OW/OB	24	12	0.46 –0.32	NS	–1.8			
Kong, As	School-based health center intervention improves BMI in overweight and obese adolescents	USA	<5 PCP <5 PCP + RD UC versus PCP UC versus PCP + RD ACTION	51	14–17	OW+	6	24			–3.8 –4.9 NS –3.1 –0.3			
Taveras, Em	Comparative effectiveness of childhood obesity interventions in pediatric primary care: a cluster-randomized clinical trial	USA	<5 UC Difference UC	549	6–12	OW+	12	6	1.20	–0.04	0.2 –0.6	NS		
			<5 CDS <5 CDS + coach UC versus CDS UC vs CDS + coach CDS vs CDS + coach						0.70 0.90 –0.51 –0.34	–0.10 –0.08 –0.06 –0.05	NS			

TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median	Calculated From
Taylor, Rw	A tailored family-based obesity intervention: a randomized trial	New Zealand	<5 UC	206	4–8	OW+	24		1.20	–0.12					x
Comparison is 5–25 h Crabtree, V	A trans-theoretical, case management approach to the treatment of pediatric obesity	USA	<5 Tailored Difference					24	0.80 –0.34	–0.27 –0.12					x
			<5 UC	19	8–12	OB+	3				–0.3				x
			5–25 Case management Difference								–1.5				x
DeBar, LI	A primary care-based, multicomponent lifestyle intervention for overweight adolescent females	USA	<5 UC	208	12–17	OB+	5	3	NS	–0.08	–1.2				x x x
Fleischman, A	Creating an integrated care model for childhood obesity: a randomized pilot study utilizing telehealth in a community primary care setting	USA	5–25 Intervention Difference					12		–0.15 –0.07 –0.05	NS NS –0.3				x
			<5 PCP	40	10–17	OB+	6								
			5–25 PCP + Telehealth Difference							–0.11 –0.06 0.03	–0.8 –0.6	NS			x
Hofsteenge, Gh	Long-term effect of the Go4it group treatment for obese adolescents: a randomized controlled trial	The Netherlands	ds <5 Control	122	11–18	OW+	3	3	NS						
			5–25 Go4it Difference					18	NS	–0.07 –0.16		NS			x

TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median Calculated From
Kalavainen, M	Long-term efficacy of group-based treatment of childhood obesity compared with routinely given individual counseling	Finland	<5	70	7–9	OB+	6		0.00	–0.20		1.8		–1.8
Nova, A	Long-term management of obesity in pediatric office practice: experimental evaluation of 2 different types of intervention	Italy	5–25	186	3–12	OB+	24	6	–0.80	–0.30	–0.10	0.5	No P	–6.8
			<5											–5.00
Shelton, D	Randomized controlled trial: a parent-based group education program for overweight children	Australia	5–25	43	3–10	OW+	3	12	0.10					–8.5
			<5											–5.58
Stark, Ij	Clinic and home-based behavioral intervention for obesity in preschoolers: a randomized trial	USA	5–25	151	2–5	OB	6	3	–1.60	–1.70	–0.13			x
			<5											x
Truby, H	A randomized controlled trial of 2 different macronutrient profiles on weight, body composition and metabolic parameters in obese adolescents seeking weight loss	Australia	5–25	87	10–17	OW+	3	6	–0.32	–0.05	–0.27	–0.19		
			5–25											



TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS Reduction	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median Calculated From
Verbeken, S	Executive function training with game elements for obese children: a novel treatment to enhance self-regulatory abilities for weight-control	Belgium	5–25 LF	44	9–14	S0	3		–1.58 –1.75 NS	–0.13 –0.14 NS				1.2
			5–25 Low carb											
			C vs SLF											
			C vs LC											
Comparison is 26–51 hours	Results of a multidisciplinary treatment program in 3-year-old to 5-year-old overweight or obese children: a randomized controlled clinical trial	The Netherlands	5–25 Executive function Difference	75	3–5	OW+	4	3	0.00	–0.30			–0.5 –1.7	x x
			Multidisc.											
			<5											
Bocca, G	A multidisciplinary intervention program has positive effects on quality of life in overweight and obese preschool children	The Netherlands	26–51 UC	75	3–5	OW+	4	12	–1.00 –1.00	–0.60 –0.30 –0.30		NS		
			Difference											
			<5											
			Multidisc.											
			26–51 UC					12		–0.60 –0.30				
			Difference											

TABLE 5 Continued

Authors	Title	Country	Intensity	N	Ages	Weight	Length (months)	Outcome (months)	BMI Reduction	BMI SDS	BMI Percentile	Kg	% of 95th Percentile or Other	% Over Median	Calculated From
Vos, R. C.	Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial	The Netherlands	<5	79	8–17	S0	24								
Weigel, C.	Comparison is 52 + hours Childhood obesity: concept, feasibility, and interim results of a local group-based, long-term treatment program	Germany	26–51	73	7–15	OB+	12	12	2.80	0.26					x
			FBT Difference												
			<5												
			≥52												
			Intervention Difference				12		–1.50	–0.34				x	
									–4.30	–0.60				x	
AAT, appetite awareness training; C, control; CDS, clinical decision support; EUC, enhanced usual care; FBT, family-based treatment; H, high; HV, home visits; HGI, hypocaloric, low-glycemic-index; GL, glycemic load; LC, low carbohydrate; LF, low fat; LGI, low glycemic index; MR, meal replacements; OB, obese; OW, overweight; PC, primary care; PCP, primary care provider; PWMP, personalized weight management program; NS, not significant; SFA, solution-focused approach; SLF, structured low fat; S0, severe obesity; UC, usual care; WLC, wait list control.															

metrics, compared with those primarily including younger children. However, many studies included a wide age range (eg, 6–17 years).

### Behaviors

Almost half (48%) of included studies reported on changes in obesity-related behaviors, primarily changes in diet or physical activity, virtually all self- or parent-reported.<sup>8–10,12–14,17–21,23,29,31–38,41–45,48,49,51,52,56,57,60,61,63,64,67,69,75–77,85,87,90,93,94,99,103,104,106,107,113,117,120–124,129,130,132</sup> Of these, half (31 of 61) reported significant improvements attributable to the intervention. These interventions are listed in Table 8. Three trials observed significant improvements in multiple behaviors, including both physical activity and diet. Twenty trials observed significant improvements in diet, including reduced caloric intake, fast food consumption, desserts, sugary beverages, sweets, and glycemic load, and improved intake of fiber, family meals, vegetables, and fruit. Finally, 10 trials observed improvements in physical activity, including increased moderate-to-vigorous physical activity and reduced television viewing.

Nearly all of the 31 interventions that noted significant changes in health-related behaviors were led by a primary care provider, and about half of these involved a nutrition provider (13 of 31 trials). Nine of the interventions that changed health behaviors involved other health professionals, including 5 interventions that involved a mental health specialist and 2 interventions that involved an exercise specialist. About half of the interventions that reported significant improvements in dietary intake involved a nutrition provider, and the rest of the

**TABLE 6** Summary of Other Reported Outcomes

Outcomes	
Number reporting other obesity	70 (56)
Percent of these with positive effects	50
Number reporting behaviors	61 (48)
Percent of these with positive effects	51
Number reporting glucose	34 (27)
Percent of these with positive effects	29
Number reporting lipids	31 (25)
Percent of these with positive effects	32
Number reporting blood pressure	29 (23)
Percent of these with positive effects	17
Number reporting psychosocial outcomes	25 (20)
Percent of these with positive effects	36
Number reporting other laboratories	8 (6)
Percent of these with positive effects	13
Number reporting mental health	6 (5)
Percent of these with positive effects	33
Number reporting other outcomes	23 (18)
Percent of these with positive effects	39

Data presented as *n* (%) unless otherwise noted.

interventions that improved eating behaviors were led by a primary care provider. In general, all behaviors were more amenable to change in the preschool-aged children (6 of 9 trials resulted in improved behaviors), with more inconsistency during middle childhood and adolescence (25 of 52 trials resulted in improved behaviors). There were no observable patterns in length of treatment as a determinant of effectively changing behaviors (ie, 16 of 29 interventions  $\geq 6$  months in duration noted behavior change vs 14 of 31 interventions  $< 6$  months in duration). Additionally, specific behavior changes did not consistently predict studies showing improvements in BMI outcomes.

#### Glucose Metabolism

Twenty-seven percent of the included studies reported on some form of glucose metabolism, including fasting glucose, insulin, or homeostatic model assessment for insulin resistance.<sup>8,20,26,29,35,52,</sup>

55,61,63,65,71,74,77,79–81,83,85, 88,89,92,97–100,105,107,110–113,118,119,127

Of these, 10 of 34 studies (29%) observed significant improvements, including 6 of 30 reporting a significant reduction in fasting glucose, insulin, or homeostatic model assessment for insulin resistance attributable to the intervention and 4 additional studies showing significant improvements in multiple measures. These interventions are listed in Table 9. Forty percent (4 of 10) of the trials that reported a significant improvement in glucose or insulin metabolism were specific dietary interventions, 5 trials were intensive lifestyle modification studies, and 1 study occurred in the inpatient setting. Most studies including glucose metabolism as an outcome focused on older children and adolescents. Those focusing on younger children did not typically demonstrate significant improvements in glucose metabolism.

#### Lipids

Of the included studies, 25% reported on lipid outcomes, including total cholesterol, low-

density lipoprotein (LDL), high-density lipoprotein (HDL), or triglycerides.<sup>8,20,26,29,52,55,61,65, 71,74,77,79,80,83,85,88,89,92,97–100, 105,110–113,118,119,127,132</sup> Of these,

one-third (10 of 31) reported significant improvements in lipids attributable to the intervention. These interventions are listed in Table 10. The most common lipid improvement observed was a decrease in triglyceride levels, which occurred in 4 of the 10 studies. HDL and LDL were also positively impacted, with an increase in HDL in 5 studies and a decrease in LDL in 4 studies. Total cholesterol improvement was only observed in 3 of the studies. Three studies (1 inpatient and 2 intensive outpatient group intervention studies) demonstrated improvement in 2 or more lipid parameters. Forty of the trials with a significant positive impact on lipids focused on specific dietary interventions, 5 trials were intensive outpatient lifestyle modification studies, and 1 study occurred in the inpatient setting. Of the 21 studies that did not report a significant improvement in lipid outcomes, about half observed a trend in improved lipids, most notably for a decrease in triglyceride levels. As with studies including glucose metabolism, most measuring lipids focused primarily on older children and adolescents.

#### Other Laboratory Values

Only 6% of studies reported on other laboratory values, such as alanine aminotransferase (A or aspartate aminotransferase (AST)).<sup>8,52,65,77,83, 97,98,100</sup> Of these, only reported improvements attributable to the intervention in 1 or more of the measures (C-peptide). These interventions are listed in Table 11.

#### Blood Pressure

Of the included studies, 23% reported on blood pressure

**TABLE 7** Trials Reporting Other Obesity Outcomes

Authors	Title	Country	N	Ages	Weight	Length (Months)	Positive Outcome	Measure
Anderson 2017	A novel home-based intervention for child and adolescent obesity: the results of the Whanau Pakari Randomized Controlled Trial	New Zealand	138	5–16	S0	12	N	
Baan-Slootweg 2014	Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial	The Netherlands	90	8–18	S0	6	Y	FM
Berkowitz 2013	Treatment of adolescent obesity comparing self-guided and group lifestyle modification programs: a potential model for primary care	USA	169	12–16	OB+	12	N	
Berkowitz 2011	Meal replacements in the treatment of adolescent obesity: a randomized controlled trial	USA	113	13–17	OB+	12	N	
Bocca 2014	Three-year follow-up of 3-y-old to 5-y-old children after participation in a multidisciplinary or a usual-care obesity treatment program	The Netherlands	75	3–5	OW+	4	Y	Multiple
Bocca 2012	Results of a multidisciplinary treatment program in 3-y-old to 5-y-old overweight or obese children: a randomized controlled clinical trial	The Netherlands	75	3–5	OW+	4	Y	WC
Bocca 2014	A multidisciplinary intervention program has positive effects on quality of life in overweight and obese preschool children	The Netherlands	75	3–5	OW+	4	Y	WC
Butte 2017	Efficacy of a community- versus primary care-centered program for childhood obesity: TX CORD RCT	USA	549	2–12	OW+	12	N	
Casazza 2012	Reduced carbohydrate diet to improve metabolic outcomes and decrease adiposity in obese peripubertal African American girls	USA	26	9–14	OW+	4	N	
Chen 2017	Short-term efficacy of an innovative mobile phone technology-based intervention for weight management for overweight and obese adolescents: pilot study	USA	40	13–18	OW+	3	N	
Croker 2012	Family-based behavioral treatment of childhood obesity in a UK National Health Service setting: randomized controlled trial	UK	72	8–12	OW+	6	N	
de Ferranti 2015	Providing food to treat adolescents at risk for cardiovascular disease	USA	27	8–21	OW+	6	N	
Demol 2009	Low-carbohydrate (low and high-fat) versus high-carbohydrate low-fat diets in the treatment of obesity in adolescents	Israel	55	12–18	OB+	3	N	
Diaz 2010	Lifestyle intervention in primary care settings improves obesity parameters among Mexican youth	Mexico	43	9–17	OB+	12	Y	Multiple
Ebbeling 2003	A reduced-glycemic load diet in the treatment of adolescent obesity	USA	14	13–21	OB+	12	Y	FM
Fleischman 2016	Creating an integrated care model for childhood obesity: a randomized pilot study utilizing telehealth in a community primary care setting	USA	40	10–17	OB+	6	N	
Flodmark 1993	Prevention of progression to severe obesity in a group of obese schoolchildren treated with family therapy	Sweden	93	10–11	OW+	18	Y	Skinfold
Ford 2009	Treatment of childhood obesity by retraining eating behavior: randomized controlled trial	UK	106	9–18	OB+	12	Y	BF%
Garnett 2014	Improved insulin sensitivity and body composition, irrespective of macronutrient intake, after a 12 mo intervention in adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	N	
Garnett 2013	Optimal macronutrient content of the diet for adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	Y	waist to height
Grieken 2013	Population-based childhood overweight prevention: outcomes of the 'Be Active, Eat Right' Study	The Netherlands	637	5	OW	24	N	
Hills 1998	Obesity management via diet and exercise intervention	Australia	20	NR	OB+	4	Y	Skinfold
Hoffman 2018	An integrated clinic-community partnership for child obesity treatment: a randomized Pilot Trial	USA	97	5–11	OB+	6	Y	WC

TABLE 7 Continued

Authors	Title	Country	N	Ages	Weight	Length (Months)	Positive Outcome	Measure
Hofsteenge 2014	Long-term effect of the Go4it group treatment of obese adolescents: a randomized controlled trial	The Netherlands	122	11–18	OW+	3	N	
Hughes 2008	Randomized, controlled trial of a best-practice individualized behavioral program for treatment of childhood overweight: Scottish Childhood Overweight Treatment Trial (SCOTT)	UK	134	5–11	OB+	6	N	
Hystad 2013	A randomized study on the effectiveness of therapist-led v. self-help parental intervention for treating childhood obesity	Norway	83	7–12	OB+	24	N	
Kalavainen 2007	Clinical efficacy of group-based treatment of childhood obesity compared with routinely given individual counseling	Finland	70	7–9	OB+	6	Y	Weight for height
Kalavainen 2011	Long-term efficacy of group-based treatment of childhood obesity compared with routinely given individual counseling	Finland	70	7–9	OB+	6	Y	Weight for height
Kokkvoli 2014	Single versus multiple-family intervention in childhood overweight—Finnmark Activity School: a randomized trial	Norway	91	6–12	OB+	12	Y	Multiple
Kokkvoli 2015	Health in overweight children: 2-y follow-up of Finnmark Activity School—a randomized trial	Norway	91	6–12	OB+	24	Y	Multiple
Kong 2013	School-based health center intervention improves BMI in overweight and obese adolescents	USA	51	14–17	OW+	12	Y	WC
Krebs 2010	Efficacy and safety of a high protein, low carbohydrate diet for wt loss in severely obese adolescents	USA	46	Mean 14	OB+	3	N	
Larsen 2015	Early intervention for childhood overweight: a randomized trial in general practice	Denmark	80	5–9	OW+	24	Y	WtHR
Lison 2012	Exercise intervention in childhood obesity: a randomized controlled trial comparing hospital-versus home-based groups	Spain	110	6–16	OW+	6	Y	BF%
Makkes 2016	One-year effects of 2 intensive inpatient treatments for severely obese children and adolescents	The Netherlands	80	8–19	S0	12	N	
Naar-King 2009	A randomized pilot study of multisystemic therapy targeting obesity in African-American adolescents	USA	49	12–17	OB+	6	N	
Nemet 2005	Short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention for the treatment of childhood obesity	Israel	46	6–16	OB+	3	Y	BF%
Nemet 2013	Effects of a multidisciplinary childhood obesity treatment intervention on adipocytokines, inflammatory and growth mediators	Israel	41	6–13	OB+	3	Y	WC
Norman 2016	Outcomes of a 1-y randomized controlled trial to evaluate a behavioral 'stepped-down' weight loss intervention for adolescent patients with obesity	USA	106	11–13	OB+	12	N	
Novotny 2015	Pacific kids DASH for health (PacDASH) randomized, controlled trial with DASH eating plan plus physical activity improves fruit and vegetable intake and diastolic blood pressure in children	USA	85	5–8	HW/OW	9	N	
Parra-Medina 2015	Promoting weight maintenance among overweight and obese Hispanic children in a rural practice	USA	118	5–14	OB+	4.5	Y	WC
Partsalaki 2012	Metabolic impact of a ketogenic diet compared with a hypocaloric diet in obese children and adolescents	Greece	58	8–18	OB+	6	N	
Pedrosa 2011	Markers of metabolic syndrome in obese children before and after 1-y lifestyle intervention program	Portugal	61	Mean 8	OW+	12	Y	WC to height
Rolland-Cachera 2004	Massive obesity in adolescents: dietary interventions and behaviors associated with weight regain at 2 y follow-up	France	121	11–16	S0	9	N	

TABLE 7 Continued

Authors	Title	Country	N	Ages	Weight	Length (Months)	Positive Outcome	Measure
Savoye 2011	Long-term results of an obesity program in an ethnically diverse pediatric population	USA	174	8–16	OB+	12	Y	BF%
Savoye 2007	Effects of a weight management program on body composition and metabolic parameters in overweight children: a randomized controlled trial	USA	174	8–16	OB+	12	Y	BF%
Serra-Paya 2015	Effectiveness of a multicomponent intervention for overweight and obese children (nereu program): a randomized controlled trial	Spain	113	6–12	OW+	8	N	
Small 2014	The preliminary effects of a primary care-based randomized treatment trial with overweight and obese young children and their parents	USA	60	4–8	OW+	4	Y	WC
Stettler 2015	Prevention of excess weight gain in pediatric primary care: beverages only or multiple lifestyle factors. The Smart Step Study, a cluster-randomized clinical trial	USA	172	8–12	OW	12	Y	Skinfold
Taylor 2015	A tailored family-based obesity intervention: a randomized trial	New Zealand	206	4–8	OW+	24	Y	Multiple
Tjonna 2009	Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents	Norway	54	Mean 14	OW+	3	N	
Truby 2016	A randomized controlled trial of 2 different macronutrient profiles on weight, body composition and metabolic parameters in obese adolescents seeking weight loss	Australia	87	10–17	OW+	3	Y	Multiple
Vos 2011	Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial	The Netherlands	79	8–17	S0	12	Y	WC
Wake 2013	Shared care obesity management in 3–10 y old children: 12 mo outcomes of HopSCOTCH randomized trial	Australia	118	5–10	OW	6	N	
Walpole 2013	Motivational interviewing to enhance self-efficacy and promote weight loss in overweight and obese adolescents: a randomized controlled trial	Canada	40	10–18	OW+	6	N	
Weigel 2008	Childhood obesity: concept, feasibility, and interim results of a local group-based, long-term treatment program	Germany	73	7–15	OB+	12	Y	Fat mass
Williams 2007	Weight control among obese adolescents: a pilot study	USA	38	11–15	OB+	3	N	
Yakovlevitch-Gavan 2008	Influence of weight-loss diets with different macronutrient compositions on health-related quality of life in obese youth	Israel	71	12–18	OB+	3	N	Fat mass
Crespo 2018	A randomized controlled trial to prevent obesity among Latino pediatric patients	USA	291	5–10	OW+	12	Y	DXA % fat
Moschonis 2019	Assessment of the effectiveness of a computerized decision-support tool for health professionals for the prevention and treatment of childhood obesity. Results from a randomized controlled trial	Greece	65	6–12	OW+	1(?)	N	
Kozlowski-Kozakowska 2019	A comparison of the impact of 2 methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children- crossover preliminary study	Poland	40	6–11	OB	3	Y	W/H % excess, WC
Kumar 2018	Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial	USA	21	14–17	OB+	6	N	
Banos 2019	Efficacy of a cognitive and behavioral treatment of childhood obesity supported by the ETIOBE web platform	Spain	27	Mean 10.4	OW+	10 weeks	N	
Ek 2019	A parent treatment program for preschoolers with obesity: a randomized controlled trial	Sweden	174	4–6	OB	12	Y	WC
Forsell 2019	Four-year outcome of randomly assigned lifestyle treatments in primary care of children with obesity	Sweden	56	8–13	OB	12	N	

TABLE 7 Continued

Authors	Title	Country	N	Ages	Weight	Length (Months)	Positive Outcome	Measure
Stark 2019	Maintenance following a randomized trial of a clinic and home-based behavioral intervention of obesity in preschoolers	USA	151	2–5	OB+	6	Y	%95th
Farpour-Lambert 2019	Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children	Switzerland	74	7–11	S0	6	Y	WC, fat %
Sepulveda 2020	Feasibility, acceptability, and effectiveness of a multidisciplinary intervention in childhood obesity from primary care: Nutrition, physical activity, emotional regulation, and family	Spain	51	8–12	OW+	6	N	
Kokkvoil 2020	No additional long-term effect of group versus individual family intervention in the treatment of childhood obesity-A randomized trial	Norway	91	6–12	OW+	24	N	
Miguet 2019	Effect of HIIT versus MICT on body composition and energy intake in dietary restrained and unrestrained adolescents with obesity	France	43	11–15	OB+	4	N	

HW, healthy weight; HIIT, high intensity interval training; MICT, moderate intensity continuous training; OB, obese; OW, overweight; S0, severe obesity

outcomes.<sup>16,26,29,37,55,58,61,65,71,73,75,77,80,83,85,86,88,89,92,97,105,110–113,118,</sup>

<sup>119,127</sup> Of these, 17% reported a positive effect attributable to the intervention in either systolic or diastolic blood pressure. These interventions are listed in Table 12. The 5 interventions that showed improvements targeted different age groups and differing levels of obesity severity. One was focused on macronutrient intake, and the other 4 included substantial physical activity components.

#### Psychosocial Outcomes

Of the included studies, 20% reported on a psychosocial outcome, most commonly quality of life.<sup>8,11,16,18,20,22,32,42,51,54,56,59,63,66,73,78,84,90,93,126,128–130,133</sup> Of these, 36% reported a positive effect attributable to the intervention. These interventions are listed in Table 13.

#### Quality of Life

Of the 19 studies that reported on quality of life, 8 studies observed improvements and 11 studies did not observe any differences; no studies showed a decrease in quality of life. Studies demonstrating improvements were primarily higher-intensity studies with low-intensity comparisons. There were no apparent differences in participant age, weight status, or treatment duration between the studies that did versus did not detect significant changes in quality of life. Thirteen of the studies used the Pediatric Quality of Life (PedsQL), which assesses health-related quality of life in the domains of physical, emotional, social, and school functioning; 4 of these studies observed significant improvements in this scale, whereas 9 did not.

#### Self-efficacy

Two studies reported on self-efficacy, and both observed

improvements. Both studies used the Child Dietary Self-Efficacy Scale; additionally, 1 used the Weight Efficacy Lifestyle questionnaire and 1 used the Self-efficacy Scale for Children's Physical Activity.

#### Other Psychosocial Outcomes

Other reported psychosocial outcome results varied. Four studies found no significant difference between the study groups and psychosocial outcomes, including problematic eating behaviors, well-being, mood disorder symptoms, body satisfaction, internalization of social-cultural attitudes toward appearance, and self-esteem. One study showed improvements in intrinsic regulation after a motivational interviewing intervention.

#### Mental Health

Only 5% of the studies reported on a mental health outcome, most commonly depression.<sup>16,20,63,71,109,120</sup> Interventions are listed in Table 14. Of these, only 2 reported any improvement attributable to the intervention in 1 or more of the measures.<sup>63,120</sup> One study observed reductions in both internalizing and externalizing behavioral and emotional problems at 12 months among children ages 5 to 16 years, of age, and the other a reduction in anxiety among those 8 to 12 years of age at 6 months. Interestingly, the participants in all 5 trials were in the healthy range on the mental health assessments; further, each study had eligibility criteria that excluded participants with significant psychological conditions, psychiatric disorders, or mental health problems, or receiving current psychological or psychiatric counseling including medication. None of the studies showed worsening of mental health outcomes.

#### Other Outcomes

Of the included studies, 18% reported on other outcomes,



**TABLE 8** Trials Reporting Behavior Outcomes

Authors Behaviors	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Anderson 2017	A novel home-based intervention for child and adolescent obesity: the results of the Whanau Pakari randomized controlled trial	New Zealand	138	5–16	S0	12	N	
Arauz 2013	Latino families, primary care, and childhood obesity: a randomized controlled trial	USA	26	9–12	OW+	6	N	
Armstrong 2018	Texting motivational interviewing: a randomized controlled trial of motivational interviewing text messages designed to augment childhood obesity treatment	USA	101	5–12	OB+	3	N	
Bocca 2014	Three-year follow-up of 3-y-old to 5-y-old children after participation in a multidisciplinary or a usual-care obesity treatment program	The Netherlands	75	3–5	OW+	4	N	
Bocca 2012	Results of a multidisciplinary treatment program in 3-y-old to 5-y-old overweight or obese children: a randomized controlled clinical trial	The Netherlands	75	3–5	OW+	4	Y	Fiber intake
Boutelle 2013	Guided self-help for the treatment of pediatric obesity	USA	50	8–12	OW+	5	N	
Broccoli 2016	Motivational interviewing to treat overweight children: 24-month follow-up of a randomized controlled trial	Italy	372	4–7	OW	12	Y	Multiple
Chen 2017	Short-term efficacy of an innovative mobile phone technology-based intervention for weight management for overweight and obese adolescents: pilot study	USA	40	13–18	OW+	3	N	
Crabtree 2010	A transtheoretical, case management approach to the treatment of pediatric obesity	USA	19	8–12	OB+	3	N	
Davis 2011	The use of TeleMedicine in the treatment of pediatric obesity: feasibility and acceptability	USA	17	10	OW+	2	N	
Davis 2016	Treating rural pediatric obesity through telemedicine versus telephone: outcomes from a cluster randomized controlled trial	USA	103	Mean 9	OW+	8	N	
Davis 2013	Treating rural pediatric obesity through telemedicine: outcomes from a small randomized controlled trial	USA	58	Mean 9	OW+	8	N	
Davoli 2013	Pediatrician-led motivational interviewing to treat overweight children: an RCT	Italy	372	4–7	OW	12	Y	Multiple
de Ferranti 2015	Providing food to treat adolescents at risk for cardiovascular disease	USA	27	8–21	OW+	6	Y	diet
DeBar 2012	A primary care-based, multicomponent lifestyle intervention for overweight adolescent females	USA	208	12–17	OB+	5	Y	Family meals, fast food
Deforche 2005	Posttreatment phone contact: a weight maintenance strategy in obese youngsters	Belgium	20	11–18	OB+	5	Y	PA
Fleischman 2016	Creating an integrated care model for childhood obesity: a randomized pilot study utilizing telehealth in a community primary care setting	USA	40	10–17	OB+	6	Y	GL
Ford 2009	Treatment of childhood obesity by retraining eating behavior: randomized controlled trial	UK	106	9–18	OB+	12	N	
Garipağaoğlu 2009	Family-based group treatment versus individual treatment in the management of childhood obesity: randomized, prospective clinical trial	Turkey	80	6–14	OB+	3	N	
Gourlan 2013	Motivational interviewing as a way to promote physical activity in obese adolescents: a randomized-controlled trial using self-determination theory as an explanatory framework	France	62	11–18	OB+	6	Y	PA
Hughes 2008	Randomized, controlled trial of a best-practice individualized behavioral program for treatment of childhood overweight: Scottish Childhood Overweight Treatment Trial (SCOTT)	UK	134	5–11	OB+	6	Y	PA
Hystad 2013	A randomized study on the effectiveness of therapist-led v. self-help parental intervention for treating childhood obesity	Norway	83	7–12	OB+	24	N	
Kong 2013	School-based health center intervention improves BMI in overweight and obese adolescents	USA	51	14–17	OW+	12	Y	TV



TABLE 8 Continued

Authors Behaviors	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Krebs 2010	Efficacy and safety of a high protein, low carbohydrate diet for weight loss in severely obese adolescents	USA	46	Mean 14	OB+	3	Y	Diet
Looney 2014	Examining the effect of 3 low-intensity pediatric obesity interventions: a pilot randomized controlled trial	USA	22	4–10	OW+	6	N	
Macdonell 2012	A pilot study of motivational interviewing targeting wt-related behaviors in overweight or obese African American adolescents	USA	44	13–17	OW+	3	Y	Fast food
Martinez-Andrade 2014	Feasibility and impact of Creciendo Sanos, a clinic-based pilot intervention to prevent obesity among preschool children in Mexico City	Mexico	306	2–5	OW+	1.5	Y	Vegetables
McCallum 2007	Outcome data from the LEAP (Live, Eat and Play) trial: a randomized controlled trial of a primary care intervention for childhood overweight or mild obesity	Australia	163	Mean 7	OW	3	Y	Diet
Mirza 2013	Effects of a low glycemic load or a low-fat dietary intervention on body weight in obese Hispanic American children and adolescents: a randomized controlled trial	USA	113	7–15	OB+	3	Y	GI
Nemet 2005	Short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention for the treatment of childhood obesity	Israel	46	6–16	OB+	3	Y	PA
Nemet 2013	Effects of a multidisciplinary childhood obesity treatment intervention on adipocytokines, inflammatory and growth mediators	Israel	41	6–13	OB+	3	Y	PA
Nova 2001	Long-term management of obesity in pediatric office practice: experimental evaluation of 2 different types of intervention	Italy	186	3–12	OB+	24	N	
Novotny 2015	Pacific Kids DASH for health (PacDASH) randomized, controlled trial with DASH eating plan plus physical activity improves fruit and vegetable intake and diastolic blood pressure in children	USA	85	5–8	HW/OW	9	Y	F and V
O'Connor 2013	Feasibility of an obesity intervention for pediatric primary care targeting parenting and children: helping HAND	USA	40	5–8	OW/OB	6	Y	TV
Pedrosa 2011	Markers of metabolic syndrome in obese children before and after 1-y lifestyle intervention program	Portugal	61	Mean 8	OW+	12	N	
Rifas-Shiman 2017	T wo-year follow-up of a primary care-based intervention to prevent and manage childhood obesity: the High Five for Kids study	USA	445	2–5	OW+	12	N	
Rolland-Cachera 2004	Massive obesity in adolescents: dietary interventions and behaviors associated with weight regain at 2 y follow-up	France	121	11–16	S0	9	N	
Saelens 2002	Behavioral weight control for overweight adolescents initiated in primary care	USA	44	12–16	OW+	4	N	
Serra-Paya 2015	Effectiveness of a multicomponent intervention for overweight and obese children (nereu program): a randomized controlled trial	Spain	113	6–12	OW+	8	Y	Multiple
Shelton 2007	Randomized controlled trial: a parent-based group education program for overweight children	Australia	43	3–10	OW+	3	Y	Kcal
Sherwood 2015	Pediatric primary care-based obesity prevention for parents of preschool children: a pilot study	USA	60	Mean 3	OW+	4	Y	MVPA
Stark 2014	A pilot randomized controlled trial of a behavioral family-based intervention with and without home visits to decrease obesity in preschoolers	USA	33	2–5	OB	6	Y	Diet
Stark 2011	A pilot randomized controlled trial of a clinic and home-based behavioral intervention to decrease obesity in preschoolers	USA	18	2–5	OB	6	Y	Diet
Stovitz 2014	Stage 1 treatment of pediatric overweight and obesity: a pilot and feasibility randomized controlled trial	USA	71	4–9	OW+	3	N	

TABLE 8 Continued

Authors Behaviors	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Taveras 2011	Randomized controlled trial to improve primary care to prevent and manage childhood obesity: the High Five for Kids study	USA	445	2–6	OW+	12	Y	TV
Taylor 2015	A tailored family-based obesity intervention: a randomized trial	New Zealand	206	4–8	OW+	24	Y	Multiple
Truby 2016	A randomized controlled trial of 2 different macronutrient profiles on weight, body composition and metabolic parameters in obese adolescents seeking weight loss	Australia	87	10–17	OW+	3	Y	Diet
Wake 2009	Outcomes and costs of primary care surveillance and intervention for overweight or obese children: the LEAP 2 randomized controlled trial	Australia	258	5–10	OW	3	N	
Wake 2013	Shared care obesity management in 3–10 y old children: 12 mo outcomes of HopS00TCH randomized trial	Australia	118	5–10	OW	6	N	
Warschburger 2016	Empowering Parents of Obese Children (EPOC): a randomized controlled trial on additional long-term weight effects of parent training	Germany	523	7–12	S0	3	N	
Williams 2007	Weight control among obese adolescents: a pilot study	USA	38	11–15	OB+	3	N	
Wright 2013	Randomized trial of a family-based, automated, conversational obesity treatment program for underserved populations	USA	50	9–12	OB+	3	N	
Yackobovitch-Gavan 2018	Intervention for childhood obesity based on parents only or parents and child compared with follow-up alone	Israel	247	5–11	OW/OB	3	N	
Moschonis 2019	Assessment of the effectiveness of a computerised decision-support tool for health professionals for the prevention and treatment of childhood obesity. Results from a randomized controlled trial	Greece	65	6–12	OW+	1(?)	Y	A few specific dietary behaviors
Sherwood 2019	The Healthy Homes/Healthy Kids 5-10 Obesity Prevention Trial: 12 and 24-mo outcomes	USA	421	5–10	OW	12	Y	Energy intake
Bean 2018	Impact of motivational interviewing on outcomes of an adolescent obesity treatment: results from the MI Values randomized controlled pilot trial	USA	99	11–18	OW+	10 weeks	N	
Banos 2019	Efficacy of a cognitive and behavioral treatment of childhood obesity supported by the ETIOBE web platform	Spain	27	Mean 10.4	OW+	10 weeks	Y	PA self-efficacy
Stark 2019	Maintenance following a randomized trial of a clinic and home-based behavioral intervention of obesity in preschoolers	USA	151	2–5	OB+	6	N	Caloric intake
Sepulveda 2020	Feasibility, acceptability, and effectiveness of a multidisciplinary intervention in childhood obesity from primary care: Nutrition, physical activity, emotional regulation, and family	Spain	51	8–12	OW+	6	N	
Miguet 2019	Effect of HIIT versus MICT on body composition and energy intake in dietary restrained and unrestrained adolescents with obesity	France	43	11–15	OB+	4	N	
Warschburger 2018	Evaluation of an approach-avoidance training intervention for children and adolescents with obesity: a randomized placebo-controlled prospective trial	Germany	232	8–16	S0	6 weeks	Y	Eating behavior

F, fruits; GI, glycemic index; GL, glycemic load; MVPA, moderate to vigorous physical activity; OB, obese; OW, overweight; PA, physical activity; S0, severe obesity.

**TABLE 9** Trials Reporting Glucose Metabolism Outcomes

Authors Glucose	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Anderson 2017	A novel home-based intervention for child and adolescent obesity: the results of the Whanau Pakari randomized controlled trial	New Zealand	138	5–16	S0	12	N	
Arauz 2013	Latino families, primary care, and childhood obesity: a randomized controlled trial	USA	26	9–12	OW+	6	N	
Baan-Slootweg 2014	Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial	The Netherlands	90	8–18	S0	6	Y	Insulin
Berkowitz 2011	Meal replacements in the treatment of adolescent obesity: a randomized controlled trial	USA	113	13–17	OB+	12	N	
Casazza 2012	Reduced carbohydrate diet to improve metabolic outcomes and decrease adiposity in obese peripubertal African American girls	USA	26	9–14	OW+	4	N	
de Ferranti 2015	Providing food to treat adolescents at risk for cardiovascular disease	USA	27	8–21	OW+	6	Y	FPG
DeBar 2012	A primary care-based, multicomponent lifestyle intervention for overweight adolescent females	USA	208	12–17	OB+	5	N	
Demol 2009	Low-carbohydrate (low and high-fat) versus high-carbohydrate low-fat diets in the treatment of obesity in adolescents	Israel	55	12–18	OB+	3	N	
Diaz 2010	Lifestyle intervention in primary care settings improves obesity parameters among Mexican youth	Mexico	43	9–17	OB+	12	N	
Ebbeling 2003	A reduced-glycemic load diet in the treatment of adolescent obesity	USA	14	13–21	OB+	12	Y	HOMA
Ford 2009	Treatment of childhood obesity by retraining eating behavior: randomized controlled trial	UK	106	9–18	OB+	12	N	
Garnett 2014	Improved insulin sensitivity and body composition, irrespective of macronutrient intake, after a 12 mo intervention in adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	N	
Garnett 2013	Optimal macronutrient content of the diet for adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	Y	Multiple
Hoffman 2018	An integrated clinic-community partnership for child obesity treatment: a randomized pilot trial	USA	97	5–11	OB+	6	N	
Hofsteenge 2014	Long-term effect of the Go4it group treatment of obese adolescents: a randomized controlled trial	The Netherlands	122	11–18	OW+	3	N	
Kong 2013	School-based health center intervention improves BMI in overweight and obese adolescents	USA	51	14–17	OW+	12	N	*Glucose worse
Krebs 2013	Efficacy and safety of a high protein, low carbohydrate diet for weight loss in severely obese adolescents	USA	46	Mean 14	OB+	3	N	
Makkes 2016	One-year effects of 2 intensive inpatient treatments for severely obese children and adolescents	The Netherlands	80	8–19	S0	12	N	
Mirza 2013	Effects of a low glycemic load or a low-fat dietary intervention on body weight in obese Hispanic American children and adolescents: a randomized controlled trial	USA	113	7–15	OB+	3	N	
Nemet 2013	Effects of a multidisciplinary childhood obesity treatment intervention on adipocytokines, inflammatory and growth mediators	Israel	41	6–13	OB+	3	Y	HOMA
Norman 2016	Outcomes of a 1-y randomized controlled trial to evaluate a behavioral “stepped-down” weight loss intervention for adolescent patients with obesity	USA	106	11–13	OB+	12	N	
Parillo 2012	Metabolic changes after a hypocaloric, low-glycemic-index diet in obese children	Italy	22	Mean 10	OB+	6	N	

TABLE 9 Continued

Authors Glucose	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Partsalaki 2012	Metabolic impact of a ketogenic diet compared with a hypocaloric diet in obese children and adolescents	Greece	58	8–18	OB +	6	N	
Pedrosa 2011	Markers of metabolic syndrome in obese children before and after 1-y lifestyle intervention program	Portugal	61	Mean 8	OW +	12	N	
Savoye 2011	Long-term results of an obesity program in an ethnically diverse pediatric population	USA	174	8–16	OB +	12	Y	Multiple
Savoye 2007	Effects of a weight management program on body composition and metabolic parameters in overweight children: a randomized controlled trial	USA	174	8–16	OB +	12	Y	Multiple
Tjonna 2009	Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents	Norway	54	Mean 14	OW +	3	N	
Truby 2006	A randomized controlled trial of 2 different macronutrient profiles on weight, body composition and metabolic parameters in obese adolescents seeking weight loss	Australia	87	10–17	OW +	3	Y	HOMA
Vos 2011	Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial	The Netherlands	79	8–17	S0	12	Y	Multiple
Yakovlevitch-Gavan 2018	Intervention for childhood obesity based on parents only or parents and child compared with follow-up alone	Israel	247	5–11	OW/OB	3	N	
Kozioł-Kozakowska 2019	A comparison of the impact of 2 methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children: crossover preliminary study	Poland	40	6–11	OB	3	N	
Kumar 2018	Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial	USA	21	14–17	OB +	6	N	
Farpour-Lambert 2019	Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children	Switzerland	74	7–11	S0	6	N	
Kokkvoli 2020	No additional long-term effect of group versus individual family intervention in the treatment of childhood obesity-A randomized trial	Norway	91	6–12	OW +	24	Y	Insulin

FF0, fasting plasma glucose; HOMA, Homeostatic Model Assessment; OB, obese; OW, overweight; S0, severe obesity.

primarily parent BMI and child's cardiovascular fitness (eg, maximal oxygen consumption [VO<sub>2</sub> max] or 3-minute step test).<sup>12,22,30,43,55–57,64,65,76,83,92,97,98,100,</sup>

106,109,114,120,122–124,127 These interventions are listed in Table 15. Nine trials measured parental weight or BMI outcomes at the end of the interventions; of these, 2 reported decreases in parental weight or BMI, and the remaining 7 studies reported no significant change. The 2 studies reporting a decrease in parental weight or BMI were family-based interventions in 2- to 5-year-olds, both of which included a parenting component. The remaining studies measuring parent weight and BMI included interventions ranging from self-help to telemedicine, clinic community partnership, parent group education, and primary care. None of the studies that observed no change in parents' weight and BMI outcomes had a parenting component.

### BMI Outcomes of Pharmaceutical RCTs (Group 2)

Randomized trials of pharmaceutical treatments, primarily metformin, demonstrated greater BMI reduction than lifestyle intervention alone. Of the 27 included studies (Table 16),<sup>136–162</sup> 74% showed some positive effect of the medication on BMI or BMI SDS.

### Quality of Pharmaceutical RCTs

Overall, the quality of the pharmaceutical RCTs exceeded that of the lifestyle interventions, because participants could be blinded. Despite this, in nearly half of studies, participants and personnel were not blinded. See Fig 3 for the summary and Table 17 for additional details.

Metformin was the most commonly studied medication, with 12 placebo-controlled trials<sup>137,141,143,146,148,151,152,155,158,160–162</sup> and

**TABLE 10** Trials Reporting Lipid Outcomes

Authors	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Arauz 2013	Latino families, primary care, and childhood obesity: a randomized controlled trial	USA	26	9–12	OW+	6	N	
Baan-Slootweg 2014	Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial	The Netherlands	90	8–18	SO	6	Y	Multiple
Berkowitz 2011	Meal replacements in the treatment of adolescent obesity: a randomized controlled trial	USA	113	13–17	OB+	12	N	
Casazza 2012	Reduced carbohydrate diet to improve metabolic outcomes and decrease adiposity in obese peripubertal African American girls	USA	26	9–14	OW+	4	Y	TG
de Ferranti 2015	Providing food to treat adolescents at risk for cardiovascular disease	USA	27	8–21	OW+	6	Y	HDL
Diaz 2010	Lifestyle intervention in primary care settings improves obesity parameters among Mexican youth	Mexico	43	9–17	OB+	12	N	
DeBar 2012	A primary care-based, multicomponent lifestyle intervention for overweight adolescent females	USA	208	12–17	OB+	5	N	
Demol 2019	Low-carbohydrate (low and high-fat) versus high-carbohydrate low-fat diets in the treatment of obesity in adolescents	Israel	55	12–18	OB+	3	N	
Ford 2009	Treatment of childhood obesity by retraining eating behavior: randomized controlled trial	UK	106	9–18	OB+	12	Y	HDL
Garnett 2013	Optimal macronutrient content of the diet for adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	N	
Garnett 2014	Improved insulin sensitivity and body composition, irrespective of macronutrient intake, after a 12 mo intervention in adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	N	
Hoffman 2018	An integrated clinic-community partnership for child obesity treatment: a randomized pilot trial	USA	97	5–11	OB+	6	N	
Hofsteenge 2014	Long-term effect of the Go4it group treatment of obese adolescents: a randomized controlled trial	The Netherlands	122	11–18	OW+	3	N	
Kong 2013	School-based health center intervention improves BMI in overweight and obese adolescents	USA	51	14–17	OW+	12	N	
Krebs 2010	Efficacy and safety of a high protein, low carbohydrate diet for weight loss in severely obese adolescents	USA	46	Mean 14	OB+	3	N	
Makkes 2016	One-year effects of 2 intensive inpatient treatments for severely obese children and adolescents	The Netherlands	80	8–19	SO	12	N	
Norman 2016	Outcomes of a 1-y randomized controlled trial to evaluate a behavioral “stepped-down” weight loss intervention for adolescent patients with obesity	USA	106	11–13	OB+	12	Y	LDL (girls)
Parillo 2012	Metabolic changes after a hypocaloric, low-glycemic-index diet in obese children	Italy	22	Mean 10	OB+	6	Y	TG
Partsalaki 2012	Metabolic impact of a ketogenic diet compared with a hypocaloric diet in obese children and adolescents	Greece	58	8–18	OB+	6	N	
Pedrosa 2011	Markers of metabolic syndrome in obese children before and after 1-y lifestyle intervention program	Portugal	61	Mean 8	OW+	12	Y	Multiple
Savoye 2011	Long-term results of an obesity program in an ethnically diverse pediatric population	USA	174	8–16	OB+	12	Y	Multiple
Savoye 2007	Effects of a weight management program on body composition and metabolic parameters in overweight children: a randomized controlled trial	USA	174	8–16	OB+	12	N	Multiple

TABLE 10 Continued

Authors	Title	Country	N	Ages	Weight	Length (months)	Positive Outcome	Measure
Tjonna 2009	Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents	Norway	54	Mean 14	OW +	3	N	
Truby 2016	A randomized controlled trial of 2 different macronutrient profiles on weight, body composition and metabolic parameters in obese adolescents seeking weight loss	Australia	87	10–17	OW +	3	N	
Vos 2011	Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial	The Netherlands	79	8–17	S0	12	N	
Williams 2007	Weight control among obese adolescents: a pilot study	USA	38	11–15	OB +	3	N	
Yackobovitch-Gavan 2018	Intervention for childhood obesity based on parents only or parents and child compared with follow-up alone	Israel	247	5–11	OW/OB	3	N	
Kozioł-Kozakowska 2019	A comparison of the impact of 2 methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children- crossover preliminary study	Poland	40	6–11	OB	3	N	
Kumar 2018	Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial	USA	21	14–17	OB +	6	Y	HDL
Farpour-Lambert 2019	Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children	Switzerland	74	7–11	S0	6	N	
Kokkvoli 2020	No additional long-term effect of group versus individual family intervention in the treatment of childhood obesity-a randomized trial	Norway	91	6–12	OW +	24	Y	TC, HDL, LDL

OB, obese; OW, overweight; S0, severe obesity; TG, triglycerides; TC, total cholesterol.

5 additional trials without placebo (most commonly lifestyle-only).<sup>138–140,145,156</sup> No study examined children younger than 6 years, and most focused on adolescents. All studies required children to have obesity, with many limiting to children with severe obesity. In 12 of these 17 studies, metformin showed improved BMI in metformin compared with the comparison group, including both placebo controls and lifestyle comparison.<sup>137,138,140,141,143,145,148,151,156,158,160,161</sup>; 1 showed no improvement compared with oral contraceptive pills.<sup>139</sup> Other studies showed reduced BMI using mixed carotenoids ( $n = 1$ ),<sup>142</sup> orlistat ( $n = 2$ ),<sup>144,154</sup> exenatide ( $n = 2$ ),<sup>149,150</sup> ephedrine + caffeine ( $n = 1$ ),<sup>153</sup> metformin + Policaptil Gel Retard ( $n = 1$ ),<sup>159</sup> and metformin + rosiglitazone ( $n = 1$ ).<sup>136</sup> Two showed no difference using topiramate ( $n = 1$ )<sup>147</sup> or rhGH ( $n = 1$ ; no difference).<sup>157</sup> Only 5 studies included results beyond 6 months, showing improved BMI with metformin at 12 months<sup>160</sup> and 18 months,<sup>137</sup> improved BMI with orlistat at 12 months,<sup>144</sup> improved BMI with Policaptil Gel Retard at 24 months,<sup>159</sup> and improved BMI with metformin + rosiglitazone at 2 years.<sup>161</sup> Magnitudes of BMI reduction were generally similar to those of lifestyle interventions.

### BMI Outcomes of Observational Studies of Lifestyle and Diet (Group 3)

Observational studies of lifestyle and diet were often based on reports of clinical experience. Of the 43 included studies,<sup>163–206</sup> 54% ( $n = 23$ ) showed some improvement in BMI outcomes compared with the nonintervention group (Table 18). Many of these studies used nonrandomized waitlist controls, historical controls, or an identified group of children seen by PCPs.

**TABLE 11** Trials Reporting Other Laboratory Outcomes

Authors	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Arauz 2013	Latino families, primary care, and childhood obesity: a randomized controlled trial	USA	26	9–12	OW+	6	N	AST/ALT
Baan-Slootweg 2014	Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial	The Netherlands	90	8–18	S0	6	N	AST/ALT
de Ferranti 2015	Providing food to treat adolescents at risk for cardiovascular disease	USA	27	8–21	OW+	6	N	ALT
Truby 2016	A randomized controlled trial of 2 different macronutrient profiles on weight, body composition, and metabolic parameters in obese adolescents seeking weight loss	Australia	87	10–17	OW+	3	N	ALT
Kozioł-Kozakowska 2019	A comparison of the impact of 2 methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children-crossover preliminary study	Poland	40	6–11	OB	3	N	
Kumar 2018	Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial	USA	21	14–17	OB+	6	N	
Farpour-Lambert 2019	Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children	Switzerland	74	7–11	S0	6	N	
Kokkvoli 2020	No additional long-term effect of group versus individual family intervention in the treatment of childhood obesity-a randomized trial	Norway	91	6–12	OW+	24	Y	C-peptide

OB, obese; OW, overweight; S0, severe obesity.

As detailed in Appendix 5, studies often showed significant reductions in BMI measures within groups, even if between-group differences were not significant. Compared with the RCTs of lifestyle and diet, the observational studies typically had larger sample sizes and longer follow-up periods, although this was not universal. Studies with the longest follow-up periods varied: 5 showed no effect at 2 years,<sup>164, 183–185</sup> 5 showed improvement at 2 years,<sup>170,192,197,201,205</sup> 1 showed improvement at 3 years,<sup>191</sup> and 1 showed improvement at 5 years.<sup>172</sup> Because these studies are observational, selection effects should be carefully considered, particularly when comparison groups comprise children who were not referred for treatment or who declined to participate in treatment. The marked difference in the number of observational studies showing BMI improvement (54%) compared with the RCTs (35%) may reflect this selection bias or may indicate publication bias.

#### BMI Outcomes of Observational Studies of Pharmaceutical Treatment (Group 4)

Observational studies of pharmaceutical treatment were often based on reports of children receiving different clinical care. Of the 8 included studies,<sup>207–214</sup> 50% showed some effectiveness compared with the nonintervention group (Table 19). In these studies, 4 compared metformin to lifestyle<sup>207,208,210–212</sup>; 2 of these showed improved BMI for those using metformin.<sup>208,210</sup> Metformin was not significantly different from omega-3 fatty acid supplements.<sup>209</sup> Metformin + Policaptil Gel Retard was associated with greater BMI loss than metformin alone,<sup>213</sup> as was phentermine compared with lifestyle intervention.<sup>212</sup> These studies were primarily conducted with adolescents with obesity and



**TABLE 12** Trials Reporting Blood Pressure Outcomes

Authors	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Baan-Slootweg 2014	Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial	The Netherlands	90	8–18	SO	6	N	
Berkowitz 2011	Meal replacements in the treatment of adolescent obesity: a randomized controlled trial	USA	113	13–17	OB+	12	N	
Butte 2017	Efficacy of a community- versus primary care-centered program for childhood obesity: TX CORD RCT	USA	549	2–12	OW+	12	Y	9–12 only
Chen 2017	Short-term efficacy of an innovative mobile phone technology-based intervention for weight management for overweight and obese adolescents: pilot study	USA	40	13–18	OW+	3	N	
Croker 2012	Family-based behavioral treatment of childhood obesity in a UK National Health Service setting: randomized controlled trial	UK	72	8–12	OW+	6	N	
de Ferranti 2015	Providing food to treat adolescents at risk for cardiovascular disease	USA	27	8–21	OW+	6	N	
Diaz 2010	Lifestyle intervention in primary care settings improves obesity parameters among Mexican youth	Mexico	43	9–17	OB+	12	Y	
Ford 2009	Treatment of childhood obesity by retraining eating behavior: randomized controlled trial	UK	106	9–18	OB+	12	N	
Garnett 2013	Optimal macronutrient content of the diet for adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	Y	
Garnett 2014	Improved insulin sensitivity and body composition, irrespective of macronutrient intake, after a 12 mo intervention in adolescents with prediabetes; RESIST a randomized control trial	Australia	111	10–17	OW+	12	N	
Hoffman 2018	An integrated clinic-community partnership for child obesity treatment: a randomized pilot trial	USA	97	5–11	OB+	6	N	
Hofsteenge 2014	Long-term effect of the Go4it group treatment of obese adolescents: a randomized controlled trial	The Netherlands	122	11–18	OW+	3	N	
Kong 2013	School-based health center intervention improves BMI in overweight and obese adolescents	USA	51	14–17	OW+	12	N	
Makkes 2016	One-year effects of 2 intensive inpatient treatments for severely obese children and adolescents	The Netherlands	80	8–19	SO	12	N	
Norman 2016	Outcomes of a 1-y randomized controlled trial to evaluate a behavioral “stepped-down” weight loss intervention for adolescent patients with obesity	USA	106	11–13	OB+	12	N	
Novotny 2015	Pacific Kids DASH for health (PacDASH) randomized, controlled trial with DASH eating plan plus physical activity improves fruit and vegetable intake and diastolic blood pressure in children	USA	85	5–8	HW/OW	9	Y	
Parillo 2012	Metabolic changes after a hypocaloric, low-glycemic-index diet in obese children	Italy	22	Mean 10	OB+	6	N	
Partsalaki 2012	Metabolic impact of a ketogenic diet compared with a hypocaloric diet in obese children and adolescents	Greece	58	8–18	OB+	6	N	
Padrosa 2011	Markers of metabolic syndrome in obese children before and after 1-y lifestyle intervention program	Portugal	61	Mean 8	OW+	12	N	
Savoye 2011	Long-term results of an obesity program in an ethnically diverse pediatric population	USA	174	8–16	OB+	12	Y	
Savoye 2007	Effects of a weight management program on body composition and metabolic parameters in overweight children: a randomized controlled trial	USA	174	8–16	OB+	12	N	
Tjonna 2009	Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents	Norway	54	Mean 14	OW+	3	N	
Vos 2011	Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial	The Netherlands	79	8–17	SO	12	N	
Weigel 2008	Childhood obesity: concept, feasibility, and interim results of a local group-based, long-term treatment program	Germany	73	7–15	OB+	12	N	
Yackobovitch-Gavan 2018	Intervention for childhood obesity based on parents only or parents and child compared with follow-up alone	Israel	247	5–11	OW/OB	3	N	



TABLE 12 Continued

Authors	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Kozl-Kozakowska 2019	A comparison of the impact of 2 methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children-crossover preliminary study	Poland	40	6–11	OB	3	N	
Forsell 2019	Four-year outcome of randomly assigned lifestyle treatments in primary care of children with obesity	Sweden	56	8–13	OB	12	N	
Farpour-Lambert 2019	Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children	Switzerland	74	7–11	SO	6	N	
Kokkvoli 2020	No additional long-term effect of group versus individual family intervention in the treatment of childhood obesity—a randomized trial	Norway	91	6–12	OW +	24	N	

HW, healthy weight; OB, obese; OW, overweight; SO, severe obesity.

some included diets with low glycemic indices as well as medication.

### BMI Outcomes of Surgical Interventions (Group 5)

Most studies of surgical interventions were observational in nature (Table 20). Of the 11 included studies,<sup>215–225</sup> 7 compared surgical intervention (eg, Roux-en-Y bypass or laparoscopic adjustable gastric band [LAGB]) to lifestyle-only intervention or controls. All of these studies demonstrated significant reduced BMI among those receiving surgical treatment compared with lifestyle. One study showed greater BMI reduction at 2 years among adolescents receiving vertical sleeve gastrectomy (VSG), compared with intragastric weight loss device or lifestyle, although the difference across all 3 groups was not significant. Three additional studies compared 2 surgical interventions. One study showed greater BMI reduction at 3 years for those receiving gastric bypass compared with VSG. A second showed much greater BMI reduction at 12 months for VSG compared with LAGB. The third shows greater BMI reduction at 5 years for gastric bypass and VSG compared with LAGB. Most surgical interventions resulted in significant BMI loss—consistently about 15 BMI units or 30% BMI reduction.

### Subquestions Relevant to all Interventions

#### Effects for Specific Subgroups

Few interventions specifically analyzed the effects of their interventions on subgroups, such as by age, sex, or obesity severity classification. Some studies showed differences by sex, but the findings were inconsistent. Often children with obesity were considered as 1 group, regardless of severity, making it difficult to understand

differential effects based on classes of obesity.

#### Sustained Treatment Effect

Of the lifestyle RCTs, 57 included at least 1 follow-up measure. There was a lower likelihood of success at a subsequent time point (33%) than at the first time point (35%). However, several studies ( $n = 26$ ) reported outcomes beyond 12 months; 22 reported outcomes at 2 years or later, with 36 months being the longest time frame. Only 6 of these studies showed any success of the intervention at this later time point. Two of these were primary-care based MI studies with <5 hours of contact.<sup>40,51</sup> Two others were high-intensity ( $\geq 52$  hours) family-based interventions.<sup>96,118</sup> An additional 2 reports of the same population demonstrated success among 2- to 5-year-olds in medium-intensity (5–25 hours) family-based treatment.<sup>114,115</sup>

#### Barriers, Engagement, and Attrition

Overall, attrition from the interventions was high. Attrition of greater than 25% was not uncommon. Although global attrition was usually reported, factors associated with attrition were not. Lack of follow-up data on dropouts prevents a clear understanding of whether attrition is related to obesity severity or initial success in treatment. Many studies commented on barriers to participation in the interventions, but few specifically measured these. One study specifically measured barriers to adherence, identifying transportation time and expenses as barriers.<sup>31</sup>

## DISCUSSION

### Summary of the Evidence

Most of the studies ( $n = 109$ ) included in this review were randomized trials of lifestyle or diet interventions, with fewer studies on

**TABLE 13** Trials Reporting Psychosocial Outcomes

Authors Psychosocial	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Anderson 2017	A novel home-based intervention for child and adolescent obesity: the results of the Whanau Pakari randomized controlled trial	New Zealand	138	5–16	SO	12	Y	QoL
Arauz 2013	Latino families, primary care, and childhood obesity: a randomized controlled trial	USA	26	9–12	OW+	6	N	
Banks 2012	Evaluating the transferability of a hospital-based childhood obesity clinic to primary care: a randomized controlled trial	UK	68	5–16	SO	12	N	
Bocca 2014	A multidisciplinary intervention program has positive effects on quality of life in overweight and obese preschool children	The Netherlands	75	3–5	OW+	4	Y	QoL
Butte 2017	Efficacy of a community- versus primary care-centered program for childhood obesity: TX CORD RCT	USA	549	2–12	OW+	12	N	QoL
Croker 2012	Family-based behavioral treatment of childhood obesity in a UK National Health Service setting: randomized controlled trial	UK	72	8–12	OW+	6	N	QoL
Davis 2013	Treating rural pediatric obesity through telemedicine: outcomes from a small randomized controlled trial	USA	58	Mean 9	OW+	8	N	
DeBar 2012	A primary care-based, multicomponent lifestyle intervention for overweight adolescent females	USA	208	12–17	OB+	5	N	QoL
De Niet 2012	The effect of a short message service maintenance treatment on BMI and psychological well-being in overweight and obese children: a randomized controlled trial	The Netherlands	141	Mean 10	OW+	9	Y	CHQ
Fonseca 2016	Effectiveness analysis of an internet-based intervention for overweight adolescents: next steps for researchers and clinicians	Portugal	80	12–18	OW+	3	N	QoL
Gourlan 2013	Motivational interviewing as a way to promote physical activity in obese adolescents: a randomized-controlled trial using self-determination theory as an explanatory framework	France	62	11–18	OB+	6	N	
Hughes 2008	Randomized, controlled trial of a best-practice individualized behavioral program for treatment of childhood overweight: Scottish Childhood Overweight Treatment Trial (SCOTT)	UK	134	5–11	OB+	6	Y	QoL
McCallum 2007	Outcome data from the LEAP (Live, Eat and Play) trial: a randomized controlled trial of a primary care intervention for childhood overweight or mild obesity	Australia	163	Mean 7	OW	3	N	
Saelens 2002	Behavioral weight control for overweight adolescents initiated in primary care	USA	44	12–16	OW+	4	Y	Behavioral skills
Taveras 2017	Comparative effectiveness of clinical-community childhood obesity interventions: a randomized clinical trial	USA	721	2–12	OW+	12	N	
Taylor 2015	A tailored family-based obesity intervention: a randomized trial	New Zealand	206	4–8	OW+	24	N	QoL
Vos 2012	The effect of family-based multidisciplinary cognitive behavioral treatment on health-related quality of life in childhood obesity	The Netherlands	81	8–17	SO	12	Y	QoL
Wake 2013	Shared care obesity management in 3–10 y old children: 12 mo outcomes of HopSCOTCH randomized trial	Australia	118	5–10	OW	6	N	QoL

TABLE 13 Continued

Authors Psychosocial	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Wake 2009	Outcomes and costs of primary care surveillance and intervention for overweight or obese children: the LEAP 2 randomized controlled trial	Australia	258	5–10	OW	3	Y	QoL
Walpole 2013	Motivational interviewing to enhance self-efficacy and promote weight loss in overweight and obese adolescents: a randomized controlled trial	Canada	40	10–18	OW+	6	N	Self-efficacy
Warschburger 2016	Empowering Parents of Obese Children (EPOC): a randomized controlled trial on additional long-term weight effects of parent training	Germany	523	7–12	SO	3	N	
Wilfey 2007	Efficacy of maintenance treatment approaches for childhood overweight: a randomized controlled trial	USA	150	7–12	OW+	4	Y	Multiple
Yakovlevitch-Gavan 2008	Influence of weight-loss diets with different macronutrient compositions on health-related quality of life in obese youth	Israel	71	12–18	OB+	3	N	
Warschburger 2018	Evaluation of an approach-avoidance training intervention for children and adolescents with obesity: a randomized placebo-controlled prospective trial	Germany	232	8–16	SO	6 weeks	Y	QoL
Fedele 2018	A behavioral family intervention for children with overweight and asthma	USA	24	6–12	OW+	4	N	

CHQ, Child Health Questionnaire; QoL, quality of life; OB, obese; OW, overweight; SO, severe obesity.

pharmaceutical treatments or surgical interventions. Following the guidelines endorsed by the American Academy of Pediatrics in 2007,<sup>226</sup> the interventions would largely qualify as stage 1 (those with minimal intervention comparators of <5 hours) or stages 2 or 3 (those utilizing a multidisciplinary team including dietitians and nutritionists and multicomponent behavioral treatment approach with higher intensity), with few examining stage 4 (pharmaceutical or surgical intervention, with no very low calorie diets). We did not assess interventions that occurred entirely outside of the clinical setting but instead focused on those approaches that included the pediatric outpatient clinical setting in some meaningful way. Most of the clinical settings were pediatric primary care practices, although pediatric weight management programs were also common. Although we included prevention studies in our search strategy, only treatment studies including children with overweight or obesity met criteria.

Almost half of the lifestyle and diet RCTs demonstrated clinically significant changes in BMI or BMI SDS. Interventions demonstrating improved BMI typically including a nutritionist along with physical activity and nutrition counseling (if less than 26 hours of contact time), or actual physical activity training as part of the visit along with behavioral health support (if at least 26 hours of contact hours). The more intense studies typically included only children and adolescents with obesity, and those studies with fewer contact hours included children and adolescents who had overweight or obesity. Higher-intensity studies were more effective in reducing BMI. However, the few studies demonstrating long-term effectiveness included low-intensity MI in primary care as well

**TABLE 14** Trials Reporting Mental Health Outcomes

Authors Mental health	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Anderson 2017	A novel home-based intervention for child and adolescent obesity: the results of the Whanau Pakari randomized controlled trial	New Zealand	138	5–16	S0	12	Y	CBCL
Berkowitz 2011	Meal replacements in the treatment of adolescent obesity: a randomized controlled trial	USA	113	13–17	OB+	12	N	
Croker 2012	Family-based behavioral treatment of childhood obesity in a UK National Health Service setting: randomized controlled trial	UK	72	8–12	OW+		N	
DeBar 2012	A primary care-based, multicomponent lifestyle intervention for overweight adolescent females	USA	208	12–17	OB+	5	N	
Njardvik 2018	Incorporating appetite awareness training within family-based behavioral treatment of pediatric obesity: a randomized controlled pilot study	Iceland	84	8–12	OB+	18 weeks	N	
Sepulveda 2020	Feasibility, acceptability, and effectiveness of a multidisciplinary intervention in childhood obesity from primary care: nutrition, physical activity, emotional regulation, and family	Spain	51	8–12	OW+	6	Y	Anxiety

CBCL, Child Behavior Check List; OB, obese; OW, overweight; S0, severe obesity.

as high-intensity family-based treatment. No other intervention components were consistently associated with positive results. Some studies tested novel strategies to deliver counseling to families, including telehealth and sleep training, which represent promising areas of future research to fill the gap in supporting families in between face-to-face counseling sessions, but these were not clearly associated with BMI reduction.

The most notable finding of the RCTs of interventional lifestyle treatment studies (both with controls and comparative effectiveness studies) is simply how few ( $n = 28$ ) of them meet the currently recommended USPSTF standard of at least 26 hours of contact time. The implication is twofold. First, many published studies do not clearly calculate contact hours. Clear standards should be set to consistently operationalize and report the delivered dose. Second, it demonstrates the difficulty of successfully translating the high-intensity research-setting interventions into real-world situations. In fact, even in ideal research conditions, there was significant attrition of participants, evidence of the difficulty in consistently delivering a higher number of contact hours.

Obesity is a chronic disease, but very few of the interventions delivered care consistent with the chronic care model.<sup>227</sup> This model considers not just health care provision, but patient factors, accessibility of healthy food and activity spaces, and the broader social context in which people live, as well as the importance ongoing connection between health care and community. Interventions in all categories of intensity delivered the intervention over the short-term (2 months) to midterm (24 months).

**TABLE 15** Trials Reporting Other Outcomes

Authors	Title	Country	N	Ages	Weight	Length (months)	Positive outcome	Measure
Armstrong 2018	Texting motivational interviewing: a randomized controlled trial of motivational interviewing text messages designed to augment childhood obesity treatment	USA	101	5–12	OB+	3	N	Parent BMI
Baan-Slootweg 2014	Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial	The Netherlands	90	8–18	S0	6	N	V02
Boutelle 2013	Guided self-help for the treatment of pediatric obesity	USA	50	8–12	OW+	5	N	Parent BMI
Davis 2016	Treating rural pediatric obesity through telemedicine versus telephone: outcomes from a cluster randomized controlled trial	USA	103	Mean 9	OW+	8	N	Parent BMI
Hoffman 2018	An integrated clinic-community partnership for child obesity treatment: a randomized pilot trial	USA	97	5–11	OB+	6	N	Parent BMI
Love-Osborne 2014	School-based health center-based treatment of obese adolescents: feasibility and BMI effects	USA	165	Mean 16	OW+	6	N	Fitness
Quattrin 2017	Cost-effectiveness of family-based obesity treatment	USA	96	2–5	OW+	12	Y	Parent BMI
Shelton 2007	Randomized controlled trial: a parent-based group education program for overweight children	Australia	43	3–10	OW+	3	N	Parent BMI
Stark 2014	A pilot randomized controlled trial of a behavioral family-based intervention with and without home visits to decrease obesity in preschoolers	USA	33	2–5	OB	6	Y	Parenting style
Stark 2011	A pilot randomized controlled trial of a clinic and home-based behavioral intervention to decrease obesity in preschoolers	USA	18	2–5	OB	6	Y	Parent weight
Tjonna 2009	Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents	Norway	54	Mean 14	OW+	3	Y	Fitness
Vos 2011	Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial	The Netherlands	79	8–17	S0	12	Y	Fitness
Wake 2009	Outcomes and costs of primary care surveillance and intervention for overweight or obese children: the LEAP 2 randomized controlled trial	Australia	258	5–10	OW	3	N	Parent BMI
Wake 2013	Shared care obesity management in 3–10 y old children: 12 mo outcomes of HopSCOTCH randomized trial	Australia	118	5–10	OW	6	N	Parent BMI
Fedele 2018	A behavioral family intervention for children with overweight and asthma	USA	24	6–12	OW+	4	N	
Kozlowski-Kozakowska 2019	A comparison of the impact of 2 methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children: crossover preliminary study	Poland	40	6–11	OB	3	Y	Jump length
Kumar 2018	Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial	USA	21	14–17	OB+	6	Y	Mindful eating
Njardvik 2018	Incorporating appetite awareness training within family-based behavioral treatment of pediatric obesity: a randomized controlled pilot study	Iceland	84	8–12	OB+	18 weeks	N	
Stark 2019	Maintenance following a randomized trial of a clinic and home-based behavioral intervention of obesity in preschoolers	USA	151	2–5	OB+	6	Y	Parent caloric intake
Farpour-Lambert 2019	Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in prepubertal children	Switzerland	74	7–11	S0	6	N	
Sepulveda 2020	Feasibility, acceptability, and effectiveness of a multidisciplinary intervention in childhood obesity from primary care: nutrition, physical activity, emotional regulation, and family	Spain	51	8–12	OW+	6	Y	Family functioning
Kokkvoli 2020	No additional long-term effect of group versus individual family intervention in the treatment of childhood obesity—a randomized trial	Norway	91	6–12	OW+	24	N	
Miguet 2019	Effect of HIT versus MICT on body composition and energy intake in dietary restrained and unrestrained adolescents with obesity	France	43	11–15	OB+	4	N	

OB, obese; OW, overweight; S0, severe obesity.

**TABLE 16** Summary of Randomized Pharmaceutical Trials

Authors	Title	Country	N	Weight	Ages	Drug	Placebo	Other	Difference		Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors	Other
Aa 2016	Long-term treatment with metformin in obese, insulin-resistant adolescents: results of a randomized double-blind placebo-controlled trial	The Netherlands	42	S0	10–16	Metformin	x		Y		x		x						x
Akcam 2011	Therapeutic effect of metformin and vitamin E versus prescriptive diet in obese adolescents with fatty liver	Turkey	67	OB+	9–17	Metformin		x	Y		x	x	x		x				
Allen 2005	Randomized controlled trial evaluating response to metformin versus standard therapy in the treatment of adolescents with polycystic ovary syndrome	USA	31	OB+	12–21	Metformin versus OCP		x	N			x	x		x				
Atabek 2008	Use of metformin in obese adolescents with hyperinsulinemia: a 6-mo, randomized, double-blind, placebo-controlled clinical trial	Turkey	120	OB+	9–17	Metformin		x	Y		x	x	x	x	x				
Burgert 2008	Short-term metabolic and cardiovascular effects of metformin in markedly obese adolescents with normal glucose tolerance	USA	28	NR	13–18	Metformin	x		Y		x	x	x	x	x				
Canas 2017	Effects of mixed carotenoids on adipokines and abdominal adiposity in children: a pilot study	USA	17	OB+	8–11	Mixed carotenoids	x		Y		x	x	x						

TABLE 16 Continued

Authors	Title	Country	N	Weight	Ages	Drug	Placebo		Difference			Other							
							Other	T1	T2	Obesity	Lipids	Glucose	BP	Laboratories	Psychosocial	Mental Health	Behaviors	Other	
Casteels 2010	Metformin therapy to reduce weight gain and visceral adiposity in children and adolescents with neurogenic or myogenic motor deficit	Belgium	36	OB+	8+	Metformin	x		Y		x		x						
Chanoine 2005	Effect of orlistat on weight and body composition in obese adolescents: a randomized controlled trial	USA and Canada	533	S0	12–16	Orlistat	x		Y		x		x		x				
Clarson 2009	Metformin in combination with structured lifestyle intervention improved BMI in obese adolescents, but did not improve insulin resistance	Canada	25	OB+	10–16	Metformin		x	Y				x		x				
Evia-Viscarra 2012	The effects of metformin on inflammatory mediators in obese adolescents with insulin resistance: controlled randomized clinical trial	Mexico	26	OB+	9–18	Metformin	x		N		x				x				
Fox 2016	Meal replacements followed by topiramate for the treatment of adolescent severe obesity: a pilot randomized controlled trial	USA	28	S0	12–18	Topiramate	x		N		x		x		x		x		

TABLE 16 Continued

Authors	Title	Country	N	Weight	Ages	Drug	Placebo	Other	Difference		Obesity	Lipids	Glucose	BP	Laboratories	Other	Psychosocial	Mental Health	Behaviors	Other
Freemark 2001	The effects of metformin on BMI and glucose tolerance in obese adolescents with fasting hyperinsulinemia and a family history of type 2 diabetes	USA	29	OB+	12–19	Metformin	x		Y			x	x	x		x				
Kelly 2012	Exenatide as a weight-loss therapy in extreme pediatric obesity: a randomized, controlled pilot study	USA	11	S0	8–19	Exenatide		x	Y		x	x	x	x		x				
Kelly 2013	The effect of Glucagon-like peptide-1 receptor agonist therapy on BMI in adolescents with severe obesity	USA	22	S0	12–19	Exenatide	x		Y		x	x	x							
Kendall 2013	Metformin in obese children and adolescents: the MOCA trial	UK	124	S0	8–18	Metformin	x		Y	Y	x	x	x	x		x				
Mauras 2012	Metformin use in children with obesity and normal glucose tolerance-effects on cardiovascular markers and intrahepatic fat	USA	42	OB+	7–18	Metformin	x		N		x	x	x	x						
Molnar 2000	Safety and efficacy of treatment with an ephedrine and caffeine mixture. The first double-blind placebo-controlled pilot study in adolescents	Hungary	26	OB+	14–18	Ephedrine	x		Y			x	x	x		x				



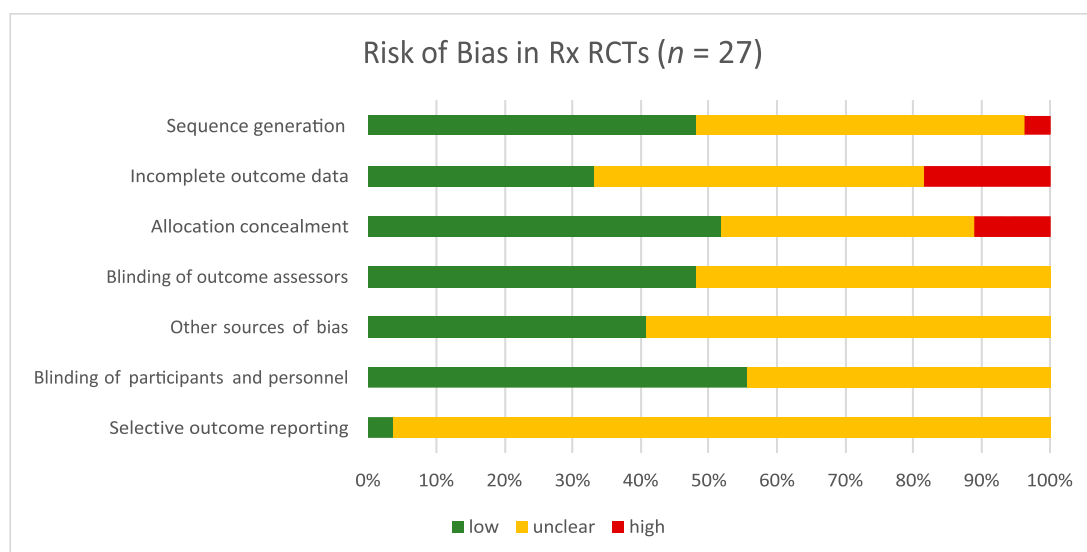
TABLE 16 Continued

Authors	Title	Country	N	Weight	Ages	Drug	Placebo	Difference		Other	Other			Mental				
								T1	T2		Obesity	Lipids	Glucose		BP	Laboratories	Psychosocial	Health
Ozkan 2004	Addition of orlistat to conventional treatment in adolescents with severe obesity	Turkey	30	S0	10–16	Orlistat		x	Y			x						x
Pastor-Villaescusa 2017	Metformin for obesity in prepubertal and pubertal children: a randomized controlled trial	Spain	67	OB +	7–14	Metformin	x		N			x	x	x			x	
Rynders 2012	Lifestyle intervention improves fitness independent of metformin in obese adolescents	USA	16	OB +	10–17	Metformin		x	Y			x		x				x
Slattery 2014	Effects of recombinant human growth hormone (rhGH) administration on body composition and cardiovascular risk factors in obese adolescent girls	USA	12	OB +	13–21	rhGH	x		N			x	x	x			x	
Srinivasan 2006	Randomized, controlled trial of metformin for obesity and insulin resistance in children and adolescents: improvement in body composition and fasting insulin	Australia	22	OB +	9–18	Metformin	x		Y			x		x	x			
Stagi 2015	Policaptil Gel Retard significantly reduces body mass index and hyperinsulinism and may decrease the risk of type 2 diabetes mellitus (T2DM) in obese children and adolescents with	Italy	120	OB +	8–14	Metformin + Policaptil Gel Retard		x	Y			x	x	x	x			x

TABLE 16 Continued

Authors	Title	Country	N	Weight	Ages	Drug	Placebo	Difference			Other	Psychosocial	Mental Health	Other Behaviors
								T1	T2	Obesity	Lipids	Glucose	BP	Laboratories
Wilson 2010	family history of obesity and T 2DM Metformin extended release treatment of adolescent obesity: a 48-wk randomized, double-blind, placebo-controlled trial with 48-wk follow-up	USA	54	OB+	13–18	Metformin	x	Y		x	x	x		x
Yanovski 2011	Effects of metformin on body weight and body composition in obese insulin-resistant children: a randomized clinical trial	USA	100	OB+	6–12	Metformin	x	Y		x	x	x	x	x
TODAY Study Group 2013	Treatment effects on measures of body composition in the TODAY clinical trial	USA	NR	OW+	10–17	Metformin + Rosiglitazone	x	Y	Y	x				
Bassols 2019	Effects of metformin administration on endocrine-metabolic parameters, visceral adiposity and cardiovascular risk factors in children with obesity and risk markers for metabolic syndrome: A pilot study	Spain	18	S0	6–13	Metformin	Yes	N	N	x	x	x		

NR, not reported; OB, obese; OW, overweight; S0, severe obesity.



**FIGURE 3**  
Quality of pharmaceutical RCTs, as assessed using the Cochrane Risk of Bias Tool.

Interestingly, lower-intensity studies, largely based in primary care, tended to be longer-term as compared with the more intensive interventions delivered in specialty settings. Although that finding likely reflects the resources required to deliver an intervention, the result is that children with less severe degrees of obesity in effect are receiving less intensive, longer-term care than children with severe obesity who are receiving more intensive, shorter-term care. Although this strategy might be acceptable for low-risk patients, a chronic disease approach would suggest that children with severe obesity should receive intensive and long-term care.

This review prioritized a reduction in BMI or BMI SDS as the primary outcome and traditional comorbidities as secondary outcomes. However, there may have been unmeasured factors that would better predict response to treatment in addition to basic demographic information. Several studies collected psychosocial variables at baseline and at varying endpoints; these variables may be

used also as predictors or moderators of outcomes to learn who is most likely to benefit from obesity treatment. In addition, several factors related to long-term progression of obesity were not collected by any of the studies contained in this review. For example, weight bias—and in particular, internalization of weight bias—is known to negatively impact an individual's likelihood of seeking care, which may limit their ability to obtain treatment of obesity and related illnesses into the future. A recent systematic review identified 74 studies assessing the relationship between weight bias internalization and health; this review identified a strong, negative relationship between weight bias and mental health.<sup>228</sup>

The majority of interventions used patient or family education about health behaviors, provider education, and experiential exercise and/or nutrition opportunities. However, additional strategies may be important to understand who benefits from child obesity interventions but were not consistently observed in this review. For example, in a meta-

analysis of interventions used in chronic-disease programs among adults, the factors most closely related to positive outcomes were not patient or provider education, but digital engagement strategies, such as text-message reminders, and a host of social and financial incentives inspired by the field of behavioral economics.<sup>229</sup>

It is also important to consider other outcomes based on the family's expectations, culture, and desired changes. Family-centered outcomes may include improving the child's self-esteem, coping with bullying, and quality of life, which were measured to some extent in the studies reviewed but with no consistent pattern of improvement. Further, the way to quantify and track children's weight remains a subject of controversy. Improvements in health (blood pressure, glycemic control) and in fitness might also be important outcomes to collect. Although some studies reported these as secondary outcomes, the lack of power reporting makes it difficult to

**TABLE 17** Quality of Pharmaceutical RCTs, as Assessed Using the Cochrane Risk of Bias Tool

	Allocation Concealment	Blinding of Outcome Assessors	Blinding of Participants and Personnel	Incomplete Outcome Data	Other Sources of Bias	Selective Outcome Reporting	Sequence Generation
Aa 2016	↓	↓	↓	◇	◇	◇	↓
Akcam 2011	◇	◇	◇	◇	◇	◇	◇
Allen 2005	↓	◇	◇	↓	◇	◇	↓
Atabek 2008	◇	◇	◇	↓	◇	◇	◇
Burgert 2008	↓	↓	↓	◇	◇	◇	◇
Canas 2017	◇	◇	↓	◇	◇	◇	◇
Casteels 2010	↓	◇	↓	↓	◇	◇	◇
Chanoine 2005	↓	↓	↓	◇	◇	◇	↓
Clarson 2009	◇	◇	◇	◇	◇	◇	↓
Evia-Viscarra 2012	↓	↓	↓	↓	↓	◇	↓
Fox 2016	↓	◇	↓	◇	↓	◇	↓
Freemark 2001	↓	◇	◇	↓	↓	◇	◇
Kelly 2012	◇	◇	◇	◇	◇	◇	◇
Kelly 2013	◇	↓	↓	↓	↓	◇	◇
Kendall 2013	↓	↓	↓	◇	↓	◇	↓
Mauras 2012	◇	◇	◇	↑	◇	◇	◇
Molnar 2000	◇	↓	↓	↓	↓	◇	◇
Ozkan 2004	↑	◇	◇	↑	◇	◇	↑
Pastor-Villaescusa 2017	↓	↓	↓	◇	↓	◇	↓
Rynders 2012	◇	◇	◇	↑	◇	◇	◇
Slattery 2014	↑	↓	◇	↑	◇	◇	◇
Srinivasan 2006	↓	↓	↓	◇	↓	◇	↓
Stagi 2015	↑	◇	◇	↓	◇	◇	↓
TODAY	◇	◇	◇	◇	◇	◇	◇
Wilson 2010	↓	↓	↓	◇	↓	◇	↓
Yanovski 2011	↓	↓	↓	↓	↓	◇	↓
Bassols 2019	↓	↓	↓	↑	↓	↓	↓

Green arrow = low risk of bias; yellow diamond = unclear risk of bias; red arrow = high risk of bias.

understand the true impact of interventions.

Anthropometric measurements, such as height and weight, are easiest to obtain in a clinical setting, yet these have limitations in tracking changes in adiposity over time.<sup>230</sup> Absolute change in BMI or weight (kg) are useful indicators in short-term trials when height is stable, but because children's height rapidly changes over time, BMI needs to be adjusted based on age and biological sex.<sup>231</sup> BMI was the most commonly used metric in the present review but

was also used in long-term trials, including those over 12 to 24 months, without adjustment for age or biological sex. Although BMI SDS was the second most frequently used metric of weight change in the included interventions, BMI SDS is not recommended for detecting changes in weight at the upper end of the spectrum among children with severe obesity.<sup>232</sup> Absolute BMI, BMI percentage of the 95th percentile, change in percentage of the 95th percentile, and BMI as a percentage of the median BMI for age and biological sex are indicated

as useful to monitor patient-level change in severe obesity over time.<sup>231</sup> An important future direction is to integrate these more sensitive weight metrics into electronic health record portals in a way that providers and families understand and can monitor, alongside other outcomes that both the family and health care provider deem to be important.

A unique contribution of this review is the inclusion of comparative effectiveness studies; indeed, half of the lifestyle interventions were

**TABLE 18** Summary of Observational Lifestyle and Diet Studies

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Adam 2009	Effects of a combined inpatient-outpatient treatment of obese children and adolescents	Germany	237	OB+	8–15	Y									x
Anderson 2015	Effectiveness of current interventions in obese New Zealand children and adolescents	New Zealand	290	S0	3–16	N									
Braet 2003	Inpatient treatment of obese children: a multicomponent program without stringent calorie restriction	Belgium	66	OB+	10–17	Y							x	x	x
Braet 1997	Follow-up results of different treatment programs for obese children	Belgium	259	OW+	7–16	Y	N								
Bruyndonckx 2015	Diet, exercise, and endothelial function in obese adolescents	Belgium	48	S0	12–18	Y		x	x	x	x				
Chamay-Weber 2016	Obesity management in adolescents: comparison of a low-intensity face-to-face therapy provided by a trained pediatrician with an intensive multidisciplinary group therapy	Switzerland	231	OB+	11–18	N									
Chen 2013	iStart smart: a primary-care based and	USA	41	OW+	7–12	Y		x			x				x

TABLE 18 Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Cheng 2014	community partnered childhood obesity management program for Chinese- American children: feasibility study 2-year BMI changes of children referred for multidisciplinary weigh management	USA	583	OW+	2–18	Y	Y								
Cloutier 2015	Outcomes from a pediatric primary care weight management program: steps to growing up healthy	USA	418	NR	2–4	Y									x
Danielsson 2016	Five-year outpatient program that provided children with continuous behavioral obesity treatment enjoyed high success rate	Sweden	213	OB+	4–13	Y									
Eliakim 2004	Parental obesity and higher preintervention BMI reduce the likelihood of a multidisciplinary childhood obesity program to succeed—a clinical observation	Israel	114	OB+	6–16	Y	Y	x							

TABLE 18 Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Eliakim 2002	The effect of a combined intervention on BMI and fitness in obese children and adolescents - a clinical experience	Israel	202	OB+	Children and adolescents	Y		x							x
Endevelt 2014	An intensive family intervention clinic for reducing childhood obesity	Israel	1043	OW+	5-14	Y		x							
Gortmaker 2015	Evaluation of a primary care intervention on BMI: the Maine Youth Overweight Collaborative	USA	506	NR	2-18	N									
Hinchman 2006	Kaiser Permanente Georgia's experience with operation zero: a group medical appointment to address pediatric overweight	USA	42	NR	11-17	N		x							
Lipana 2013	Telemedicine and face-to-face care for pediatric obesity	USA	112	NR	NR	N									x
Manild 2013	A controlled study of lifestyle treatment in primary care for children with obesity	Sweden	193	OB+	8-13	Y		x	x	x		x			

TABLE 18 Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Nemet 2014	A combined nutritional-behavioral physical activity intervention for the treatment of childhood obesity—a 7-y summary	Israel	816	OB+	6–16	N	N	x							
Nowicka 2008	Family Weight School treatment: 1-y results in obese adolescents	Sweden	88	OB+	12–19	N									
Nuutinen 1991	Long-term effects of counseling on nutrient intake and weight loss in obese children	Finland	45	OB+	6–16	N									x
Nuutinen 1992	Weight loss, body composition and risk factors for cardiovascular disease in obese children: long-term effects of two treatment strategies	Finland	28	OW+	6–15	N	N	x	x	x					
Reinehr 2003	Long-term follow-up of overweight children: after training, after a single consultation session, and without treatment	Germany	247	OW+	6–15	N	N								
Reinehr 2009	Lifestyle intervention in obese children is associated with a decrease of the metabolic	Germany	474	OB+	10–16	Y			x	x	x				



**TABLE 18** Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Reybrouck 1990	Exercise therapy and hypocaloric diet in the treatment of obese children	Belgium	25	OB +	3.9–16.4	Y									
Schwartz 2007	Office-based motivational interviewing to prevent childhood obesity: a feasibility study	USA	61	OW	3–7	N									X
Sousa 2015	Controlled trial of an Internet-based intervention for overweight teens (NextStep): effectiveness analysis	Portugal	71	OB +	12–18	N		X					X		X
Spieth 2000	A low-glycemic index diet in the treatment of pediatric obesity	USA	97	NR	Mean 10	Y		X							
Tanas 2007	A family-based education program for obesity: a 3-year study	Italy	190	OW +	3–18	Y									
Taveras 2017	Clinical effectiveness of the Massachusetts childhood obesity research demonstration initiative among	USA	3765	OW +	2–12	Y									

TABLE 18 Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Tripicchio 2017	low-income children Technology components as adjuncts to family-based pediatric obesity treatment in low-income minority youth	USA	48	OW+	2–18	N									x
Tucker 2013	Reducing pediatric overweight: nurse-delivered motivational interviewing in primary care	USA	125	OW+	4–18	Y	N								x
Tyler 2016	A primary care intervention to improve weight in obese children: A feasibility study	USA	47	OB+	8–12	N	N	x	x	x	x		x		
Uysal 2014	Components of the metabolic syndrome are negative predictors of weight loss in obese children with lifestyle intervention	Germany	1017	OB+	Median 11.1	N		x	x	x	x				
Van Helst 2011	Effects of a multidisciplinary rehabilitation program on pediatric obesity: the CEMHaVi program	France	74	OB+	7–17	Y					x				
Videira-Silva 2017	The effect of a physical activity consultation on BMI z- score of overweight adolescents: results from a	Portugal	396	OW+	10–17	Y		x							

TABLE 18 Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
	pediatric outpatient obesity clinic														
Wald 2011	Treating childhood obesity in primary care	USA	78	OB+	9–12	N		x							
Warschburger 2001	Conceptualization and evaluation of a cognitive- behavioral training program for children and adolescents with obesity	Germany	197	OW+	9+	Y									
Yoshinaga 2004	Prevention of mildly overweight children from development of more overweight condition	Japan	280	OB+	6–11	Y		x	x		x				
Bailey-Davis 2019	Feasibility of enhancing well- child visits with family nutrition and physical activity risk assessment on BMI	USA	6048		Unclear	2–9	N								
Coles 2018	Breaking barriers: adjunctive use of the Ontario Telemedicine Network (OTN) to reach adolescents with obesity living in remote locations	Canada	100	S0	12–18	N							x		
Derwig 2019	Child-centred health dialogue for primary prevention of	Sweden	776	OW	4	N									

TABLE 18 Continued

Authors	Title	Country	N	Weight	Ages	Difference T1	Difference T2	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors
Hagman 2020	obesity in Child Health Services - a feasibility study Promising results from an implemented treatment model for pediatric obesity	Sweden	3762	OB	6–12	Y			x	x	x	x			
Tucker 2019	Evaluation of a primary care weight management program in children aged 2(–)5 y: changes in feeding practices, health behaviors, and BMI	USA	119	OW+	2–5	N									x

NR, not reported; OB, obese; OW, overweight; SO, severe obesity.

comparative effectiveness trials. The USPSTF 2018 report only included trials that had a minimal or control comparator arm. Comparative effectiveness studies can reveal important findings on differential effects of treatments based on adjunct components, specific dietary plans, delivery of treatment in different settings, or directly comparing interventions of different intensity or content. Although the interventions with higher intensity in terms of contact hours typically produced greater weight loss, there were no specific intervention components that consistently explained stronger effects. Therefore, more comparative effectiveness trials are required to identify the critical ingredients of lifestyle or diet interventions, to compare pharmaceutical versus lifestyle versus surgical approaches as well as combinations, and to understand whether some intervention approaches are more effective among certain populations or patients. In general, it is challenging to interpret findings from comparative effectiveness studies without an established margin of equivalence (ie, what is a meaningful difference in BMI change between the 2 comparator arms) or an established threshold for a clinically meaningful reduction in BMI or BMI SDS (ie, 1 intervention achieved clinically meaningful reduction whereas the other did not).

### Barriers to Treatment

Trials faced problems with high attrition and low adherence, particularly among the more intensive interventions with more frequent contacts. Multicomponent approaches had smaller sample sizes indicative of the challenges of deploying a large-scale pragmatic clinical trial. For example, none of the minimal-intervention control studies that examined interventions

**TABLE 19** Summary of Observational Pharmaceutical Studies

Authors	Title	Country	N	Weight	Ages	Comparison 1	Comparison 2	Difference t1?	Difference t2?	Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors	Other
Aa 2016	The effect of eighteen-month metformin treatment in obese adolescents: comparison of results obtained in daily practice with results from a clinical trial	The Netherlands	42	OB+	10–16	Metformin	Lifestyle	N					x					
Harden 2007	Effects of lifestyle intervention and metformin on weight management and markers of metabolic syndrome in obese adolescents	USA	63	OB+	11–18	Metformin	Lifestyle	Y	Y	x	x	x	x					
Juarez-Lopez 2013	Omega-3 polyunsaturated fatty acids reduce insulin resistance and triglycerides in obese children and adolescents	Mexico	201	OB+	10–12	Metformin	Omega-3	N		x	x	x	x					
Krzystek-Korpacka 2011	The effect of a 1-year weight reduction program on serum uric acid in overweight and obese children and adolescents	Poland	113	OW+	10–17	Metformin	Lifestyle	Y		x	x	x						x
Marques 2016	Metformin effectiveness and safety in the management of overweight and obese nondiabetic children and adolescents: metabolic benefits of the continuous exposure to metformin at 12 and 24 mo	Portugal	74	OW+	8–17	Metformin	Lifestyle	N	N		x		x					
Ryder 2017	Effect of phentermine on weight reduction in a pediatric weight management clinic	USA	191	OB+	11.9–17.7	Phentermine	Lifestyle	Y	Y									x
Stagi 2017	Retrospective evaluation of metformin and/or metformin plus a new polysaccharide complex in treating severe hyperinsulinism and insulin resistance in obese children and adolescents with metabolic syndrome	Italy	120	OB+	8.2–14.5	Metformin	Metformin + Policaptil Gel Retard	Y										

TABLE 19 Continued

Authors	Title	Country	N	Weight	Agés	Comparison 1	Comparison 2	Difference t1?	Difference t2?	Other Obesity	Other Lipids	Glucose	BP	Laboratories	Psychosocial	Mental Health	Behaviors	Other
Lentferink 2018	Long-term metformin treatment in adolescents with obesity and insulin resistance, results of an open label extension study	Netherlands	31	OB		Metformin extension	No metformin	N	N	x	x	x	x		x		x	

OB, obese; OW, overweight.

with more than 25 hours of contact had a sample size larger than 100. Research studies do pose additional burdens to families and providers beyond clinical treatment, including strictly following a clinical protocol that includes eligibility screening, consenting, and assessment visits. However, the adherence and motivation challenges will persist outside of research studies in traditional clinical practices, particularly the logistical challenges of high-intensity treatment.<sup>233,234</sup> Future studies should gather more information on the predictors of treatment success as well as the facilitators and barriers to adherence, both in terms of families meeting their commitment to scheduled counseling sessions as well as families changing their behaviors and sustaining this outside of the sessions. Moreover, more accessible strategies that link patients to providers, such as telehealth or phone call counseling and texting, could be important to consider to realistically achieve additional contact hours. With the emergence of additional health technologies, opportunities will exist that did not at the time that these studies were conducted.

### Limitations of the Included Studies

#### Short Follow-up Periods

Few studies included follow-up visits to determine whether weight loss was sustained, and the longest study period involved 36 months of follow-up, which is a stark contrast to the data available on adult weight loss interventions out to 10 years. In children, the desired outcomes may be to plateau weight gain or to arrest the development of obesity-related cardiovascular and metabolic disease until adulthood. Longer-term data are needed to establish sufficient weight loss or cardiovascular improvements than can affect health into adulthood. Also, most of the lifestyle, diet,

pharmaceutical, and surgery trials excluded children with mobility impairments, chronic diseases, and mental health conditions; therefore, there is less evidence on effective weight management approaches for these populations despite their elevated risk for obesity.

#### Limited Description of Intervention Components, Dose, and Duration

Published intervention studies often provided limited information about the dose, duration, and specifics of the intervention components and implementation procedures. This lack of detail significantly limits the opportunity to inform recommendations in practice. More details are needed on what is effective intervention content, behavior change techniques, and successful efforts to improve retention and family motivation. This information is critical if we are to create replicable findings and application of evidence. Drilling down to the essential ingredients of an effective lifestyle or diet intervention and how those components affect comorbidities is also important so that providers can focus on the critical content. This is particularly important when faced with limited contact hours because of family transportation or scheduling barriers or limited personnel or resources and financial constraints. Further, determining potential synergies among diet, lifestyle, pharmaceutical, and surgical interventions is important to develop individualized treatment plans that may start with more or less aggressive strategies depending on the child's weight and health status, motivation, and readiness. Lifestyle interventions are core to good health but need to exist in context.

#### Inclusion Criteria Limit Translation to Clinical Care

Additionally, many studies had relatively restrictive inclusion criteria, excluding children with

**TABLE 20** Summary of Surgical Studies

Authors	Title	Country	N	Weight	Ages	Comparison 1	Comparison 2	Comparison 3	Difference t1?	Difference t2?	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors	Other
Gothberg 2014	Laparoscopic Roux-en-Y gastric bypass in adolescents with morbid obesity—surgical aspects and clinical outcome	Sweden	162	S0	13–18	Bypass	Controls		Y										x
Inge 2016	Weight loss and health status 3 years after bariatric surgery in adolescents	USA	273	S0	13–19	RNY	SG		N			x		x					
Inge 2018	Comparison of surgical and medical therapy for type 2 diabetes in severely obese adolescents	USA	93	S0	13–18	RNY	Metformin		Y		x	x	x	x	x				
Manco 2017	The benefit of sleeve gastrectomy in obese adolescents on nonalcoholic steatohepatitis and hepatic fibrosis	Italy	62	S0	13–17	SG	Device		N		x	x	x	x	x				x
O'Brien 2010	Laparoscopic adjustable gastric banding in severely obese adolescents: a randomized trial	Australia	50	S0	14–18	Band	Lifestyle		Y		x	x	x	x					
Olbers 2012	T wo-year outcome of laparoscopic Roux-en-Y gastric bypass in adolescents with severe obesity: results from a Swedish Nationwide Study (AMOS)	Sweden	162	S0	13–18	Bypass	Lifestyle		Y		x	x	x	x	x				
Olbers 2017	Laparoscopic Roux-en-Y gastric bypass in adolescents with severe obesity (AMOS): a prospective, 5-year, Swedish nationwide study	Sweden	153	S0	13–18	RYGB	Controls		Y			x	x	x	x				x

TABLE 20 Continued

Authors	Title	Country	N	Weight	Ages	Comparison 1	Comparison 2	Comparison 3	Difference t1?	Difference t2?	Other Obesity	Lipids	Glucose	BP	Other Laboratories	Psychosocial	Mental Health	Behaviors	Other
Pedroso 2015	Laparoscopic vertical sleeve gastrectomy significantly improves short term weight loss as compared with laparoscopic adjustable gastric band placement in morbidly obese adolescent patients	USA	132	S0	12.7–21.4	LAGB	VSG		Y			x	x						
Ryder 2018	Factors associated with long-term weight-loss maintenance following bariatric surgery in adolescents with severe obesity	USA	80	S0	<21	RNY	Lifestyle		Y										
Henfridsson 2019		Sweden	147	S0	Mean 16	LRYGB	Lifestyle		Y		x							x	
Inge 2018		USA	544	S0	12–19	AGB	RYGB	Sleeve	Y	Y									x

S0, severe obesity.

comorbidities (including mental health conditions), children with physical activity limitations, or those using medications. In clinical practice, these children often have the greatest need for support in addressing obesity.

### Gaps in the Field

This review identified several critical gaps in the field that should be considered in the development of future studies. The most important gaps include: (1) systems context for interventions, (2) assessment of harms, (3) economics and sustainability, (4) heterogeneity of treatment effects, and (5) patient engagement.

First, current intervention studies include minimal consideration of the systems surrounding them. Although the goal of most research is to limit the influence of external factors, child obesity results from the interactions within a complex system. The social context for families will be critical to understanding which interventions work, for whom they work, and the situations in which they work.

Second, most studies provided no or very limited assessment of harms or unintended consequences. In general, behavioral interventions carry low risk of harms; however, this is not well-documented in the existing literature, as few studies report adverse events. Restrictive dieting is known to lead to disordered eating patterns, is associated with adult obesity, and may worsen the quality of a child's food intake. Likewise, short-term weight loss has been shown to lead to weight regain above the initial weight, making it less clear whether a short period of weight loss adds more benefit than the likely common weight regain. These unintended consequences are less likely for nonrestrictive eating



interventions; however, failure to assess and report this does not allow for reassurance and may ultimately limit dissemination. In addition, families living in low-resource environments may suffer financially by switching to foods that cost more and may lead to unintended consequences. Little is known about the psychological effects on children of increasing their awareness of their own condition of obesity.

Third, the economics of the interventions were rarely considered, including challenges with sustainability and payment mechanisms. Access to care is severely limited by inconsistent and insufficient payment for effective treatment options.<sup>235</sup> In the United States, the USPSTF is authorized by Congress to assign grades to the state of the evidence regarding treatment options for diseases; grades of A or B are mandated by the Affordable Care Act that patients pay no deductibles or copayments and do not participate in cost-sharing.<sup>236</sup> The USPSTF assigned a B grade to recommend clinicians screen children 6 years and older for obesity and offer or refer them to comprehensive, intensive behavioral interventions to promote improvements in weight status.<sup>1</sup> Despite this mandate, many insurance providers are not paying for these services. For example, a Children's Hospital Association survey conducted in 2013 surveyed 218 children's hospitals.<sup>237</sup> Of the 118 that responded, only 52 reported providing comprehensive, multidisciplinary weight management consistent with USPSTF recommendations, and half of these programs were fewer than 20 weeks in length. Importantly, 84% of children's hospitals that had weight management programs

reported operating at a financial loss, with about half of physicians being fully reimbursed by Medicaid or commercial plans and far less reimbursement available for other health care providers, such as registered dietitians or behavioral counselors. However, as payment models shift from fee-for-service toward population-based payment models, there are promising avenues toward securing reimbursement consistent with legislative mandates for comprehensive obesity treatment.<sup>235</sup>

Fourth, the current research does not provide sufficient information about the heterogeneity of treatment effects for obesity interventions. Studies generally did not identify demographic or social factors beyond biological sex, age, race, and ethnicity. Geographical region, food insecurity, poverty, and adverse childhood experiences (ACEs) may all be important and possibly salient factors in explaining treatment outcomes. Identifying clusters of comorbidities and obesity risk behaviors as well as duration and timing of onset of obesity during childhood and adolescence would also allow within-study results to be analyzed for potential heterogeneous responses to obesity treatment. Family and child readiness to change would also be useful to characterize the population entering the study and the potential for efficacy by these factors. Finally, severity of obesity must be considered in understanding treatment effects. Given that severe forms of obesity have increased, examining this group in future studies, rather than condensing all forms of obesity together, will be important.

Finally, current interventions include limited input from children, families, and caregivers regarding development, refinement, and implementation. Few studies included patients and families in the development of interventions, limiting the ability to ensure they are meeting the preferences and unique needs of the populations. True patient engagement could bring new insight and improve the quality of interventions and their effectiveness. This patient perspective is particularly important for the Medicaid population with their limited financial resources and unmet social needs. Despite the implementation of strong, evidence-based interventions and engagement of kids and families, overcoming financial and social barriers is critical to the success of interventions.

## CONCLUSIONS

Contrary to the conventional wisdom that childhood and adolescent obesity interventions are ineffective, almost half of the diet and lifestyle RCTs included in this review were effective in reducing adiposity, at least in the short-term. Given the heterogeneity of the intervention types, intensity, duration, and individuals involved in delivering the intervention, it is nearly impossible at this time to specify the "optimal" childhood obesity treatment. However, it is clear that the more intense the intervention, based on hours of contact, the greater the benefit to the child in terms of BMI reduction, while keeping in mind that the more intense interventions are more costly and can impact fewer total number of people. This report highlights the promise of childhood obesity treatment but also the challenging way forward.

Interventions must be sustained financially to be effective and must leverage innovative strategies to keep families engaged throughout treatment. It is also reassuring to see some benefit of lower-intensity interventions delivered in primary care, particularly those that use MI. Moving forward, a shared resource of metrics by which to compare interventions but also to predict success at the individual level will advance the science more rapidly.

## ACKNOWLEDGMENT

We thank Chelsea Kracht, PhD, for her help in reviewing abstracts.

## ABBREVIATIONS

ALT: alanine aminotransferase  
AST: aspartate aminotransferase  
HDL: high-density lipoprotein  
KQ: key question  
LAGB: laparoscopic adjustable gastric band  
LDL: low-density lipoprotein  
MI: motivational interviewing  
PCP: primary care provider  
RCT: randomized controlled trial  
SDS: standard deviation score  
USPSTF: US Preventive Services Task Force  
VSG: vertical sleeve gastrectomy

taking into account individual circumstances, may be appropriate.

All technical reports from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.

**DOI:** <https://doi.org/10.1542/peds.2022-060642>

Please address correspondence to [asheley.skinner@duke.edu](mailto:asheley.skinner@duke.edu)

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2023 by the American Academy of Pediatrics

**FUNDING:** Some support for the technical report came from the Strengthening Public Health Systems and Services QT18-1802 through the National Partnerships to Improve and Protect the Nation's Health grant from the Centers for Disease Control and Prevention.

**FINANCIAL/CONFLICT OF INTEREST DISCLOSURES:** The authors have indicated they have no potential conflicts of interest to disclose.

**COMPANION PAPER:** Companions to this article can be found online at <http://www.pediatrics.org/cgi/doi/10.1542/peds.2022-060640>, <http://www.pediatrics.org/cgi/doi/10.1542/peds.2022-060641>, and <http://www.pediatrics.org/cgi/doi/10.1542/peds.2022-060643>.

## REFERENCES

1. O'Connor EA, Evans CV, Burda BU, Walsh ES, Eder M, Lozano P. Screening for obesity and intervention for weight management in children and adolescents: evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2017;317(23):2427–2444
2. Kirk S, Armstrong S, King E, et al. Establishment of the Pediatric Obesity Weight Evaluation Registry: a national research collaborative for identifying the optimal assessment and treatment of pediatric obesity. *Child Obes*. 2017;13(1):9–17
3. Flynn JT, Kaelber DC, Baker-Smith CM, et al; Subcommittee on Screening and Management of High Blood Pressure in Children. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics*. 2017;140(3):e20181739
4. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. *Pediatrics*. 2011;128(Suppl 5):S213–S256
5. Vos MB, Abrams SH, Barlow SE, et al. NASPGHAN clinical practice guideline for the diagnosis and treatment of nonalcoholic fatty liver disease in children: recommendations from the Expert Committee on NAFLD (ECON) and the North American Society of Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN). *J Pediatr Gastroenterol Nutr*. 2017;64(2):319–334
6. Marcus CL, Brooks LJ, Draper KA, et al; American Academy of Pediatrics. Diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2012;130(3):e714–e755
7. Skinner AC, Staiano AE, Armstrong SC, et al. Technical report. Appraisal of clinical care practices for child obesity. Part II: comorbidities. *Pediatrics*. 2023;151(2):e2022060643
8. Arauz Boudreau AD, Kurowski DS, Gonzalez WI, Dimond MA, Oreskovic NM. Latino families, primary care, and childhood obesity: a randomized

- controlled trial. *Am J Prev Med*. 2013;44(3 Suppl 3):S247–S257
9. Bocca G, Corpeleijn E, van den Heuvel ER, Stolk RP, Sauer PJ. Three-year follow-up of 3-year-old to 5-year-old children after participation in a multidisciplinary or a usual-care obesity treatment program. *Clin Nutr*. 2014;33(6):1095–1100
10. Bocca G, Corpeleijn E, Stolk RP, Sauer PJ. Results of a multidisciplinary treatment program in 3-year-old to 5-year-old overweight or obese children: a randomized controlled clinical trial. *Arch Pediatr Adolesc Med*. 2012;166(12):1109–1115
11. Bocca G, Kuitert MW, Sauer PJ, Stolk RP, Flapper BC, Corpeleijn E. A multidisciplinary intervention programme has positive effects on quality of life in overweight and obese preschool children. *Acta Paediatr*. 2014;103(9):962–967
12. Boutelle KN, Norman GJ, Rock CL, Rhee KE, Crow SJ. Guided self-help for the treatment of pediatric obesity. *Pediatrics*. 2013;131(5):e1435–e1442
13. Broccoli S, Davoli AM, Bonvicini L, et al. Motivational interviewing to treat overweight children: 24-month follow-up of a randomized controlled trial. *Pediatrics*. 2016;137(1)
14. Crabtree VM, Moore JB, Jacks DE, Cerrito P, Topp RV. A transtheoretical, case management approach to the treatment of pediatric obesity. *J Prim Care Community Health*. 2010;1(1):4–7
15. Crespo NC, Talavera GA, Campbell NR, et al. A randomized controlled trial to prevent obesity among Latino paediatric patients. *Pediatr Obes*. 2018;13(11):697–704
16. Croker H, Viner RM, Nicholls D, et al. Family-based behavioural treatment of childhood obesity in a UK National Health Service setting: randomized controlled trial. *Int J Obes*. 2012;36(1):16–26
17. Davis AM, James RL, Boles RE, Goetz JR, Belmont J, Malone B. The use of TeleMedicine in the treatment of paediatric obesity: feasibility and acceptability. *Matern Child Nutr*. 2011;7(1):71–79
18. Davis AM, Sampilo M, Gallagher KS, Landrum Y, Malone B. Treating rural pediatric obesity through telemedicine: outcomes from a small randomized controlled trial. *J Pediatr Psychol*. 2013;38(9):932–943
19. Davoli AM, Broccoli S, Bonvicini L, et al. Pediatrician-led motivational interviewing to treat overweight children: an RCT. *Pediatrics*. 2013;132(5):e1236–e1246
20. DeBar LL, Stevens VJ, Perrin N, et al. A primary care-based, multicomponent lifestyle intervention for overweight adolescent females. *Pediatrics*. 2012;129(3):e611–e620
21. Deforche B, De Bourdeaudhuij I, Tanghe A, Deboode P, Hills AP, Bouckaert J. Post-treatment phone contact: a weight maintenance strategy in obese youngsters. *Int J Obes*. 2005;29(5):543–546
22. Fedele DA, Janicke DM, McQuaid EL, et al. A behavioral family intervention for children with overweight and asthma. *Clin Pract Pediatr Psychol*. 2018;6(3):259–269
23. Fleischman A, Hourigan SE, Lyon HN, et al. Creating an integrated care model for childhood obesity: a randomized pilot study utilizing telehealth in a community primary care setting. *Clin Obes*. 2016;6(6):380–388
24. Flodmark CE, Ohlsson T, Rydén O, Sveger T. Prevention of progression to severe obesity in a group of obese schoolchildren treated with family therapy. *Pediatrics*. 1993;91(5):880–884
25. van Grieken A, Veldhuis L, Renders CM, et al. Population-based childhood overweight prevention: outcomes of the 'Be active, eat right' study. *PLoS One*. 2013;8(5):e65376
26. Hofsteenge GH, Chinapaw MJ, Delemarre-van de Waal HA, Weijs PJ. Long-term effect of the Go4it group treatment for obese adolescents: a randomised controlled trial. *Clin Nutr*. 2014;33(3):385–391
27. Kalavainen MP, Korppi MO, Nuutinen OM. Clinical efficacy of group-based treatment for childhood obesity compared with routinely given individual counseling. *Int J Obes*. 2007;31(10):1500–1508
28. Kalavainen M, Korppi M, Nuutinen O. Long-term efficacy of group-based treatment for childhood obesity compared with routinely given individual counselling. *Int J Obes*. 2011;35(4):530–533
29. Kong AS, Sussman AL, Yahne C, Skipper BJ, Burge MR, Davis SM. School-based health center intervention improves body mass index in overweight and obese adolescents. *J Obes*. 2013;2013:575016
30. Love-Osborne K, Fortune R, Sheeder J, Federico S, Haemer MA. School-based health center-based treatment for obese adolescents: feasibility and body mass index effects. *Child Obes*. 2014;10(5):424–431
31. Martínez-Andrade GO, Cespedes EM, Rifas-Shiman SL, et al. Feasibility and impact of Creciendo Sanos, a clinic-based pilot intervention to prevent obesity among preschool children in Mexico City. *BMC Pediatr*. 2014;14:77
32. McCallum Z, Wake M, Gerner B, et al. Outcome data from the LEAP (Live, Eat and Play) trial: a randomized controlled trial of a primary care intervention for childhood overweight/mild obesity. *Int J Obes*. 2007;31(4):630–636
33. Moschonis G, Michalopoulou M, Tsoutsouloupoulou K, et al. Assessment of the effectiveness of a computerised decision-support tool for health professionals for the prevention and treatment of childhood obesity. Results from a randomised controlled trial. *Nutrients*. 2019;11(3):706
34. Nemet D, Barkan S, Epstein Y, Friedland O, Kowen G, Eliakim A. Short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention for the treatment of childhood obesity. *Pediatrics*. 2005;115(4):e443–e449
35. Nemet D, Oren S, Pantanowitz M, Eliakim A. Effects of a multidisciplinary childhood obesity treatment intervention on adipocytokines, inflammatory and growth mediators. *Horm Res Paediatr*. 2013;79(6):325–332
36. Nova A, Russo A, Sala E. Long-term management of obesity in paediatric office practice: experimental evaluation

- of two different types of intervention. *Ambul Child Health*. 2001;7(3-4): 239–247
37. Novotny R, Nigg CR, Li F, Wilkens LR. Pacific kids DASH for health (PacDASH) randomized, controlled trial with DASH eating plan plus physical activity improves fruit and vegetable intake and diastolic blood pressure in children. *Child Obes*. 2015;11(2): 177–186
  38. O'Connor TM, Hilmers A, Watson K, Baranowski T, Giardino AP. Feasibility of an obesity intervention for paediatric primary care targeting parenting and children: helping HAND. *Child Care Health Dev*. 2013;39(1): 141–149
  39. Parra-Medina D, Mojica C, Liang Y, Ouyang Y, Ramos AI, Gomez I. Promoting weight maintenance among overweight and obese Hispanic children in a rural practice. *Child Obes*. 2015;11(4):355–363
  40. Resnicow K, McMaster F, Bocian A, et al. Motivational interviewing and dietary counseling for obesity in primary care: an RCT. *Pediatrics*. 2015;135(4):649–657
  41. Rifas-Shiman SL, Taveras EM, Gortmaker SL, et al. Two-year follow-up of a primary care-based intervention to prevent and manage childhood obesity: the High Five for Kids study. *Pediatr Obes*. 2017;12(3):e24–e27
  42. Saelens BE, Sallis JF, Wilfley DE, Patrick K, Cella JA, Buchta R. Behavioral weight control for overweight adolescents initiated in primary care. *Obes Res*. 2002;10(1):22–32
  43. Shelton D, Le Gros K, Norton L, Stanton-Cook S, Morgan J, Masterman P. Randomised controlled trial: A parent-based group education programme for overweight children. *J Paediatr Child Health*. 2007;43(12):799–805
  44. Sherwood NE, JaKa MM, Crain AL, Martinson BC, Hayes MG, Anderson JD. Pediatric primary care-based obesity prevention for parents of preschool children: a pilot study. *Child Obes*. 2015;11(6):674–682
  45. Sherwood NE, Levy RL, Seburg EM, et al. The Healthy Homes/Healthy Kids 5-10 Obesity Prevention Trial: 12 and 24-month outcomes. *Pediatr Obes*. 2019;14(8):e12523
  46. Small L, Bonds-McClain D, Melnyk B, Vaughan L, Gannon AM. The preliminary effects of a primary care-based randomized treatment trial with overweight and obese young children and their parents. *J Pediatr Health Care*. 2014;28(3):198–207
  47. Stark LJ, Spear Filigno S, Bolling C, et al. Clinic and home-based behavioral intervention for obesity in pre-schoolers: a randomized trial. *J Pediatr*. 2018;192:115–121.e1
  48. Stovitz SD, Berge JM, Wetzsteon RJ, Sherwood NE, Hannan PJ, Himes JH. Stage 1 treatment of pediatric overweight and obesity: a pilot and feasibility randomized controlled trial. *Child Obes*. 2014;10(1):50–57
  49. Taveras EM, Gortmaker SL, Hohman KH, et al. Randomized controlled trial to improve primary care to prevent and manage childhood obesity: the High Five for Kids study. *Arch Pediatr Adolesc Med*. 2011;165(8):714–722
  50. Taveras EM, Marshall R, Kleinman KP, et al. Comparative effectiveness of childhood obesity interventions in pediatric primary care: a cluster-randomized clinical trial. *JAMA Pediatr*. 2015;169(6):535–542
  51. Taylor RW, Cox A, Knight L, et al. A tailored family-based obesity intervention: a randomized trial. *Pediatrics*. 2015;136(2):281–289
  52. Truby H, Baxter K, Ware RS, et al. A randomized controlled trial of two different macronutrient profiles on weight, body composition and metabolic parameters in obese adolescents seeking weight loss. *PLoS One*. 2016;11(3):e0151787
  53. Verbeken S, Braet C, Goossens L, van der Oord S. Executive function training with game elements for obese children: a novel treatment to enhance self-regulatory abilities for weight-control. *Behav Res Ther*. 2013;51(6): 290–299
  54. Vos RC, Huisman SD, Houdijk EC, Pijl H, Wit JM. The effect of family-based multidisciplinary cognitive behavioral treatment on health-related quality of life in childhood obesity. *Qual Life Res*. 2012;21(9):1587–1594
  55. Vos RC, Wit JM, Pijl H, Houdijk EC. Long-term effect of lifestyle intervention on adiposity, metabolic parameters, inflammation and physical fitness in obese children: a randomized controlled trial. *Nutr Diabetes*. 2011;1(10):e9
  56. Wake M, Baur LA, Gerner B, et al. Outcomes and costs of primary care surveillance and intervention for overweight or obese children: the LEAP 2 randomised controlled trial. *BMJ*. 2009;339:b3308
  57. Wake M, Lycett K, Clifford SA, et al. Shared care obesity management in 3-10 year old children: 12 month outcomes of HopSCOTCH randomised trial. *BMJ*. 2013;346:f3092
  58. Weigel C, Kokocinski K, Lederer P, Dotsch J, Rascher W, Knerr I. Childhood obesity: concept, feasibility, and interim results of a local group-based, long-term treatment program. 2008;40(6):369–373
  59. Wilfley DE, Stein RI, Saelens BE, et al. Efficacy of maintenance treatment approaches for childhood overweight: a randomized controlled trial. *JAMA*. 2007;298(14):1661–1673
  60. Wright JA, Phillips BD, Watson BL, Newby PK, Norman GJ, Adams WG. Randomized trial of a family-based, automated, conversational obesity treatment program for underserved populations. *Obesity (Silver Spring)*. 2013;21(9):E369–E378
  61. Yackobovitch-Gavan M, Wolf Linhard D, Nagelberg N, et al. Intervention for childhood obesity based on parents only or parents and child compared with follow-up alone. *Pediatr Obes*. 2018;13(11):647–655
  62. Akgul Gundogdu N, Sevig EU, Guler N. The effect of the solution-focused approach on nutrition-exercise attitudes and behaviours of overweight and obese adolescents: randomised controlled trial. *J Clin Nurs*. 2018; 27(7-8):e1660–e1672
  63. Anderson YC, Wynter LE, Grant CC, et al. A novel home-based intervention for child and adolescent obesity: the results of the Whanau Pakari randomized controlled trial. *Obesity (Silver Spring)*. 2017;25(11):1965–1973



64. Armstrong S, Mendelsohn A, Bennett G, Taveras EM, Kimberg A, Kemper AR. Texting motivational interviewing: a randomized controlled trial of motivational interviewing text messages designed to augment childhood obesity treatment. *Child Obes.* 2018; 14(1):4–10
65. van der Baan-Slootweg O, Benninga MA, Beelen A, et al. Inpatient treatment of children and adolescents with severe obesity in the Netherlands: a randomized clinical trial. *JAMA Pediatr.* 2014;168(9):807–814
66. Banks J, Sharp DJ, Hunt LP, Shield JP. Evaluating the transferability of a hospital-based childhood obesity clinic to primary care: a randomised controlled trial. *Br J Gen Pract.* 2012;62(594):e6–e12
67. Baños RM, Oliver E, Navarro J, et al. Efficacy of a cognitive and behavioral treatment for childhood obesity supported by the ETIOBE web platform. *Psychol Health Med.* 2019;24(6): 703–713
68. Bathrellou E, Yannakoulia M, Papanikolaou K, et al. Parental involvement does not augment the effectiveness of an intense behavioral program for the treatment of childhood obesity. *Hormones (Athens).* 2010;9(2):171–175
69. Bean MK, Ingersoll KS, Powell P, et al. Impact of motivational interviewing on outcomes of an adolescent obesity treatment: results from the MI Values randomized controlled pilot trial. *Clin Obes.* 2018;8(5):323–326
70. Berkowitz RI, Rukstalis MR, Bishop-Gilyard CT, et al. Treatment of adolescent obesity comparing self-guided and group lifestyle modification programs: a potential model for primary care. *J Pediatr Psychol.* 2013;38(9):978–986
71. Berkowitz RI, Wadden TA, Gehrman CA, et al. Meal replacements in the treatment of adolescent obesity: a randomized controlled trial. *Obesity (Silver Spring).* 2011;19(6):1193–1199
72. Bohlin A, Hagman E, Klaesson S, Danielsson P. Childhood obesity treatment: telephone coaching is as good as usual care in maintaining weight loss - a randomized controlled trial. *Clin Obes.* 2017;7(4):199–205
73. Butte NF, Hoelscher DM, Barlow SE, et al. Efficacy of a community- versus primary care- centered program for childhood obesity: TX CORD RCT. *Obesity (Silver Spring).* 2017;25(9): 1584–1593
74. Casazza K, Cardel M, Dulin-Keita A, et al. Reduced carbohydrate diet to improve metabolic outcomes and decrease adiposity in obese peripubertal African American girls. *J Pediatr Gastroenterol Nutr.* 2012; 54(3):336–342
75. Chen JL, Guedes CM, Cooper BA, Lung AE. Short-term efficacy of an innovative mobile phone technology-based intervention for weight management for overweight and obese adolescents: pilot study. *Interact J Med Res.* 2017;6(2):e12
76. Davis AM, Sampilo M, Gallagher KS, et al. Treating rural paediatric obesity through telemedicine vs. telephone: outcomes from a cluster randomized controlled trial. *J Telemed Telecare.* 2016;22(2):86–95
77. de Ferranti SD, Milliren CE, Denhoff ER, et al. Providing food to treat adolescents at risk for cardiovascular disease. *Obesity (Silver Spring).* 2015;23(10):2109–2117
78. de Niet J, Timman R, Bauer S, et al. The effect of a short message service maintenance treatment on body mass index and psychological well-being in overweight and obese children: a randomized controlled trial. *Pediatr Obes.* 2012;7(3):205–219
79. Demol S, Yackobovitch-Gavan M, Shalitin S, Nagelberg N, Gillon-Keren M, Phillip M. Low-carbohydrate (low & high-fat) versus high-carbohydrate low-fat diets in the treatment of obesity in adolescents. *Acta Paediatr.* 2009;98(2):346–351
80. Díaz RG, Esparza-Romero J, Moya-Camarena SY, Robles-Sardín AE, Valencia ME. Lifestyle intervention in primary care settings improves obesity parameters among Mexican youth. *J Am Diet Assoc.* 2010;110(2): 285–290
81. Ebbeling CB, Leidig MM, Sinclair KB, Hangen JP, Ludwig DS. A reduced-glycemic load diet in the treatment of adolescent obesity. *Arch Pediatr Adolesc Med.* 2003;157(8):773–779
82. Ek A, Lewis Chamberlain K, Sorjonen K, et al. A parent treatment program for preschoolers with obesity: a randomized controlled trial. *Pediatrics.* 2019;144(2):e20183457
83. Farpour-Lambert NJ, Martin XE, Bucher Della Torre S, et al. Effectiveness of individual and group programmes to treat obesity and reduce cardiovascular disease risk factors in pre-pubertal children. *Clin Obes.* 2019;9(6):e12335
84. Fonseca H, Prioste A, Sousa P, Gaspar P, Machado MC. Effectiveness analysis of an internet-based intervention for overweight adolescents: next steps for researchers and clinicians. *BMC Obes.* 2016;3:15
85. Ford AL, Bergh C, Södersten P, et al. Treatment of childhood obesity by retraining eating behaviour: randomised controlled trial. *BMJ.* 2009; 340:b5388
86. Forsell C, Gronowitz E, Larsson Y, Kjellberg BM, Friberg P, Måild S. Four-year outcome of randomly assigned lifestyle treatments in primary care of children with obesity. *Acta Paediatr.* 2019;108(4):718–724
87. Garipağaoğlu M, Sahip Y, Darendeliler F, Akdikmen O, Kopuz S, Sut N. Family-based group treatment versus individual treatment in the management of childhood obesity: randomized, prospective clinical trial. *Eur J Pediatr.* 2009;168(9):1091–1099
88. Garnett SP, Gow M, Ho M, et al. Optimal macronutrient content of the diet for adolescents with prediabetes; RESIST a randomised control trial. *J Clin Endocrinol Metab.* 2013;98(5): 2116–2125
89. Garnett SP, Gow M, Ho M, et al. Improved insulin sensitivity and body composition, irrespective of macronutrient intake, after a 12 month intervention in adolescents with pre-diabetes; RESIST a randomised control trial. *BMC Pediatr.* 2014;14:289
90. Gourlan M, Sarrazin P, Trouilloud D. Motivational interviewing as a way to promote physical activity in obese

- adolescents: a randomised-controlled trial using self-determination theory as an explanatory framework. *Psychol Health*. 2013;28(11):1265–1286
91. Hills AP, Parker AW. Obesity management via diet and exercise intervention. *Child Care Health Dev*. 1988;14(6):409–416
92. Hoffman J, Frerichs L, Story M, et al. An integrated clinic-community partnership for child obesity treatment: a randomized pilot trial. *Pediatrics*. 2018;141(1):e20171444
93. Hughes AR, Stewart L, Chapple J, et al. Randomized, controlled trial of a best-practice individualized behavioral program for treatment of childhood overweight: Scottish Childhood Overweight Treatment Trial (SCOTT). *Pediatrics*. 2008;121(3):e539–e546
94. Hystad HT, Steinsbekk S, Ødegård R, Wichstrøm L, Gudbrandsen OA. A randomised study on the effectiveness of therapist-led v. self-help parental intervention for treating childhood obesity. *Br J Nutr*. 2013; 110(6):1143–1150
95. Kokkvoll A, Grimsgaard S, Odegaard R, Flaegstad T, Njølstad I. Single versus multiple- family intervention in childhood overweight—Finnmark Activity School: a randomised trial. *Arch Dis Child*. 2014;99(3):225–231
96. Kokkvoll A, Grimsgaard S, Steinsbekk S, Flægstad T, Njølstad I. Health in overweight children: 2-year follow-up of Finnmark Activity School—a randomised trial. *Arch Dis Child*. 2015; 100(5):441–448
97. Kokkvoll AS, Grimsgaard S, Flaegstad T, et al. No additional long-term effect of group vs individual family intervention in the treatment of childhood obesity—a randomised trial. *Acta Paediatr*. 2020;109(1):183–192
98. Koziol-Kozakowska A, Wójcik M, Furtak A, Januś D, Starzyk JB. A comparison of the impact of two methods of nutrition-behavioral intervention on selected auxological and biochemical parameters in obese prepubertal children-crossover preliminary study. *Int J Environ Res Public Health*. 2019; 16(16):2841
99. Krebs NF, Gao D, Gralla J, Collins JS, Johnson SL. Efficacy and safety of a high protein, low carbohydrate diet for weight loss in severely obese adolescents. *J Pediatr*. 2010;157(2): 252–258
100. Kumar S, Croghan IT, Biggs BK, et al. Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial. *Children (Basel)*. 2018;5(7):93
101. Larsen LM, Hertel NT, Mølgaard C, Christensen RD, Husby S, Jarbøl DE. Early intervention for childhood overweight: a randomized trial in general practice. *Scand J Prim Health Care*. 2015;33(3):184–190
102. Lisón JF, Real-Montes JM, Torró I, et al. Exercise intervention in childhood obesity: a randomized controlled trial comparing hospital-versus home-based groups. *Acad Pediatr*. 2012;12(4):319–325
103. Looney SM, Raynor HA. Examining the effect of three low-intensity pediatric obesity interventions: a pilot randomized controlled trial. *Clin Pediatr (Phila)*. 2014;53(14):1367–1374
104. Macdonell K, Brogan K, Naar-King S, Ellis D, Marshall S. A pilot study of motivational interviewing targeting weight-related behaviors in overweight or obese African American adolescents. *J Adolesc Health*. 2012;50(2):201–203
105. Makkes S, Renders CM, Bosmans JE, van der Baan-Slootweg OH, Hoekstra T, Seidell JC. One-year effects of two intensive inpatient treatments for severely obese children and adolescents. *BMC Pediatr*. 2016;16:120
106. Miguet M, Fearnbach NS, Metz L, et al. Effect of HIIT versus MICT on body composition and energy intake in dietary restrained and unrestrained adolescents with obesity. *Appl Physiol Nutr Metab*. 2020;45(4):437–445
107. Mirza NM, Palmer MG, Sinclair KB, et al. Effects of a low glycemic load or a low-fat dietary intervention on body weight in obese Hispanic American children and adolescents: a randomized controlled trial. *Am J Clin Nutr*. 2013;97(2):276–285
108. Naar-King S, Ellis D, Kolmodin K, et al. A randomized pilot study of multisystemic therapy targeting obesity in African-American adolescents. *J Adolesc Health*. 2009;45(4):417–419
109. Njardvik U, Gunnarsdottir T, Olafsdottir AS, Craighead LW, Boles RE, Bjarnason R. Incorporating appetite awareness training within family-based behavioral treatment of pediatric obesity: a randomized controlled pilot study. *J Pediatr Psychol*. 2018;43(9): 1017–1027
110. Norman G, Huang J, Davila EP, et al. Outcomes of a 1-year randomized controlled trial to evaluate a behavioral ‘stepped-down’ weight loss intervention for adolescent patients with obesity. *Pediatr Obes*. 2016; 11(1):18–25
111. Parillo M, Licenziati MR, Vacca M, De Marco D, Iannuzzi A. Metabolic changes after a hypocaloric, low-glycemic-index diet in obese children. *J Endocrinol Invest*. 2012;35(7): 629–633
112. Partsalaki I, Karvela A, Spiliotis BE. Metabolic impact of a ketogenic diet compared to a hypocaloric diet in obese children and adolescents. *J Pediatr Endocrinol Metab*. 2012;25 (7-8):697–704
113. Pedrosa C, Oliveira BM, Albuquerque I, Simões-Pereira C, Vaz-de-Almeida MD, Correia F. Markers of metabolic syndrome in obese children before and after 1-year lifestyle intervention program. *Eur J Nutr*. 2011;50(6): 391–400
114. Quattrin T, Cao Y, Paluch RA, Roemmich JN, Ecker MA, Epstein LH. Cost-effectiveness of family-based obesity treatment. *Pediatrics*. 2017;140(3): e20162755
115. Quattrin T, Roemmich JN, Paluch R, Yu J, Epstein LH, Ecker MA. Treatment outcomes of overweight children and parents in the medical home. *Pediatrics*. 2014;134(2):290–297
116. Quattrin T, Roemmich JN, Paluch R, Yu J, Epstein LH, Ecker MA. Efficacy of family-based weight control program for preschool children in primary care. *Pediatrics*. 2012;130(4):660–666
117. Rolland-Cachera MF, Thibault H, Souberbielle JC, et al. Massive obesity in adolescents: dietary interventions and behaviours associated with weight regain at 2 y follow-up. *Int J Obes Relat Metab Disord*. 2004;28(4):514–519

118. Savoye M, Nowicka P, Shaw M, et al. Long-term results of an obesity program in an ethnically diverse pediatric population. *Pediatrics*. 2011;127(3):402–410
119. Savoye M, Shaw M, Dziura J, et al. Effects of a weight management program on body composition and metabolic parameters in overweight children: a randomized controlled trial. *JAMA*. 2007;297(24):2697–2704
120. Sepúlveda AR, Solano S, Blanco M, Lacruz T, Veiga O. Feasibility, acceptability, and effectiveness of a multidisciplinary intervention in childhood obesity from primary care: Nutrition, physical activity, emotional regulation, and family. *Eur Eat Disord Rev*. 2020;28(2):184–198
121. Serra-Paya N, Ensenyat A, Castro-Viñuales I, et al. Effectiveness of a multi-component intervention for overweight and obese children (nereu program): a randomized controlled trial. *PLoS One*. 2015;10(12):e0144502
122. Stark LJ, Clifford LM, Towner EK, et al. A pilot randomized controlled trial of a behavioral family-based intervention with and without home visits to decrease obesity in preschoolers. *J Pediatr Psychol*. 2014;39(9):1001–1012
123. Stark LJ, Spear S, Boles R, et al. A pilot randomized controlled trial of a clinic and home-based behavioral intervention to decrease obesity in preschoolers. *Obesity (Silver Spring)*. 2011;19(1):134–141
124. Stark LJ, Filigno SS, Kichler JC, et al. Maintenance following a randomized trial of a clinic and home-based behavioral intervention of obesity in preschoolers. *J Pediatr*. 2019;213:128–136.e3
125. Stettler N, Wrotniak BH, Hill DL, et al. Prevention of excess weight gain in paediatric primary care: beverages only or multiple lifestyle factors. The Smart Step Study, a cluster-randomized clinical trial. *Pediatr Obes*. 2015;10(4):267–274
126. Taveras EM, Marshall R, Sharifi M, et al. Comparative effectiveness of clinical-community childhood obesity interventions a randomized clinical trial. *JAMA Pediatr*. 2017;171(8):e171325
127. Tjønnå AE, Stølen TO, Bye A, et al. Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents. *Clin Sci (Lond)*. 2009;116(4):317–326
128. Walpole B, Dettmer E, Morrongiello BA, McCrindle BW, Hamilton J. Motivational interviewing to enhance self-efficacy and promote weight loss in overweight and obese adolescents: a randomized controlled trial. *J Pediatr Psychol*. 2013;38(9):944–953
129. Warschburger P, Gmeiner M, Morawietz M, Rinck M. Evaluation of an approach-avoidance training intervention for children and adolescents with obesity: a randomized placebo-controlled prospective trial. *Eur Eat Disord Rev*. 2018;26(5):472–482
130. Warschburger P, Kroeller K, Haerting J, Unverzagt S, van Egmond-Fröhlich A. Empowering Parents of Obese Children (EPOC): a randomized controlled trial on additional long-term weight effects of parent training. *Appetite*. 2016;103:148–156
131. Wilfley DE, Saelens BE, Stein RI, et al. Dose, content, and mediators of family-based treatment for childhood obesity: a multisite randomized clinical trial. *JAMA Pediatr*. 2017;171(12):1151–1159
132. Williams CL, Strobino BA, Brotanek J. Weight control among obese adolescents: a pilot study. *Int J Food Sci Nutr*. 2007;58(3):217–230
133. Yackobovitch-Gavan M, Nagelberg N, Demol S, Phillip M, Shalitin S. Influence of weight-loss diets with different macronutrient compositions on health-related quality of life in obese youth. *Appetite*. 2008;51(3):697–703
134. Ford AL, Hunt LP, Cooper A, Shield JP. What reduction in BMI SDS is required in obese adolescents to improve body composition and cardiometabolic health? *Arch Dis Child*. 2010;95(4):256–261
135. Kolsgaard MLP, Joner G, Brunborg C, Anderssen SA, Tonstad S, Andersen LF. Reduction in BMI z-score and improvement in cardiometabolic risk factors in obese children and adolescents. The Oslo Adiposity Intervention Study - a hospital/public health nurse combined treatment. *BMC Pediatr*. 2011;11(1):47
136. TODAY Study Group. Treatment effects on measures of body composition in the TODAY clinical trial. *Diabetes Care*. 2013;36(6):1742–1748
137. van der Aa MP, Elst MA, van de Garde EM, van Mil EG, Knibbe CA, van der Vorst MM. Long-term treatment with metformin in obese, insulin-resistant adolescents: results of a randomized double-blinded placebo-controlled trial. *Nutr Diabetes*. 2016;6(8):e228
138. Akcam M, Boyaci A, Pirgon O, Kaya S, Uysal S, Dundar BN. Therapeutic effect of metformin and vitamin E versus prescriptive diet in obese adolescents with fatty liver. *Int J Vitam Nutr Res*. 2011;81(6):398–406
139. Allen HF, Mazzoni C, Heptulla RA, et al. Randomized controlled trial evaluating response to metformin versus standard therapy in the treatment of adolescents with polycystic ovary syndrome. *J Pediatr Endocrinol Metab*. 2005;18(8):761–768
140. Atabek ME, Pirgon O. Use of metformin in obese adolescents with hyperinsulinemia: a 6-month, randomized, double-blind, placebo-controlled clinical trial. *J Pediatr Endocrinol Metab*. 2008;21(4):339–348
141. Burgert TS, Duran EJ, Goldberg-Gell R, et al. Short-term metabolic and cardiovascular effects of metformin in markedly obese adolescents with normal glucose tolerance. *Pediatr Diabetes*. 2008;9(6):567–576
142. Canas JA, Lochrie A, McGowan AG, Hossain J, Schettino C, Balagopal PB. Effects of mixed carotenoids on adipokines and abdominal adiposity in children: a pilot study. *J Clin Endocrinol Metab*. 2017;102(6):1983–1990
143. Casteels K, Fieuws S, van Helvoirt M, et al. Metformin therapy to reduce weight gain and visceral adiposity in children and adolescents with neurogenic or myogenic motor deficit. *Pediatr Diabetes*. 2010;11(1):61–69
144. Chanoine JP, Hampl S, Jensen C, Boldrin M, Hauptman J. Effect of

- orlistat on weight and body composition in obese adolescents: a randomized controlled trial. *JAMA*. 2005;293(23):2873–2883
145. Clarson CL, Mahmud FH, Baker JE, et al. Metformin in combination with structured lifestyle intervention improved body mass index in obese adolescents, but did not improve insulin resistance. *Endocrine*. 2009; 36(1):141–146
146. Evia-Viscarra M, Rodea-Montero E, Apolinar-Jiménez E, et al. The effects of metformin on inflammatory mediators in obese adolescents with insulin resistance: controlled randomized clinical trial. *J Pediatr Endocrinol Metab*. 2012;25(1-2):41–49
147. Fox CK, Kaizer AM, Rudser KD, et al. Meal replacements followed by topiramate for the treatment of adolescent severe obesity: a pilot randomized controlled trial. *Obesity (Silver Spring)*. 2016;24(12):2553–2561
148. Freemark M, Bursey D. The effects of metformin on body mass index and glucose tolerance in obese adolescents with fasting hyperinsulinemia and a family history of type 2 diabetes. *Pediatrics*. 2001;107(4):E55
149. Kelly AS, Metzger AM, Rudser KD, et al. Exenatide as a weight-loss therapy in extreme pediatric obesity: a randomized, controlled pilot study. *Obesity (Silver Spring)*. 2012;20(2): 364–370
150. Kelly AS, Rudser KD, Nathan BM, et al. The effect of glucagon-like peptide-1 receptor agonist therapy on body mass index in adolescents with severe obesity: a randomized, placebo-controlled, clinical trial. *JAMA Pediatr*. 2013;167(4):355–360
151. Kendall D, Vail A, Amin R, et al. Metformin in obese children and adolescents: the MOCA trial. *J Clin Endocrinol Metab*. 2013;98(1):322–329
152. Mauras N, DelGiorno C, Hossain J, et al. Metformin use in children with obesity and normal glucose tolerance—effects on cardiovascular markers and intrahepatic fat. *J Pediatr Endocrinol Metab*. 2012; 25(1-2):33–40
153. Molnár D, Török K, Erhardt E, Jeges S. Safety and efficacy of treatment with an ephedrine/caffeine mixture. The first double-blind placebo-controlled pilot study in adolescents. *Int J Obes Relat Metab Disord*. 2000;24(12): 1573–1578
154. Ozkan B, Bereket A, Turan S, Keskin S. Addition of orlistat to conventional treatment in adolescents with severe obesity. *Eur J Pediatr*. 2004;163(12): 738–741
155. Pastor-Villaescusa B, Cañete MD, Caballero-Villarraso J, et al. Metformin for obesity in prepubertal and pubertal children: a randomized controlled trial. *Pediatrics*. 2017;140(1):e20164285
156. Rynders C, Weltman A, Delgiorno C, et al. Lifestyle intervention improves fitness independent of metformin in obese adolescents. *Med Sci Sports Exerc*. 2012;44(5):786–792
157. Slattery M, Bredella MA, Stanley T, Torriani M, Misra M. Effects of recombinant human growth hormone (rhGH) administration on body composition and cardiovascular risk factors in obese adolescent girls. *Int J Pediatr Endocrinol*. 2014;2014(1):22
158. Srinivasan S, Ambler GR, Baur LA, et al. Randomized, controlled trial of metformin for obesity and insulin resistance in children and adolescents: improvement in body composition and fasting insulin. *J Clin Endocrinol Metab*. 2006;91(6): 2074–2080
159. Stagi S, Lapi E, Seminara S, et al. Policaptil gel tetard significantly reduces body mass index and hyperinsulinism and may decrease the risk of type 2 diabetes mellitus (T2DM) in obese children and adolescents with family history of obesity and T2DM. *Ital J Pediatr*. 2015;41:10
160. Wilson DM, Abrams SH, Aye T, et al; Glaser Pediatric Research Network Obesity Study Group. Metformin extended release treatment of adolescent obesity: a 48-week randomized, double-blind, placebo-controlled trial with 48-week follow-up. *Arch Pediatr Adolesc Med*. 2010;164(2):116–123
161. Yanovski JA, Krakoff J, Salaita CG, et al. Effects of metformin on body weight and body composition in obese insulin-resistant children: a randomized clinical trial. *Diabetes*. 2011;60(2):477–485
162. Bassols J, Martínez-Calcerrada JM, Osiniri I, et al. Effects of metformin administration on endocrine-metabolic parameters, visceral adiposity and cardiovascular risk factors in children with obesity and risk markers for metabolic syndrome: a pilot study. *PLoS One*. 2019;14(12):e0226303
163. Adam S, Westenhofer J, Rudolph B, Kraaijenhagen HK. Effects of a combined inpatient-outpatient treatment of obese children and adolescents. *Obes Facts*. 2009;2(5):286–293
164. Anderson YC, Cave TL, Cunningham VJ, et al. Effectiveness of current interventions in obese New Zealand children and adolescents. *N Z Med J*. 2015;128(1417):8–15
165. Braet C, Tanghe A, Bode PD, Franckx H, Winckel MV. Inpatient treatment of obese children: a multicomponent programme without stringent calorie restriction. *Eur J Pediatr*. 2003;162(6): 391–396
167. Braet C, Van Winckel M, Van Leeuwen K. Follow-up results of different treatment programs for obese children. *Acta Paediatr*. 1997;86(4):397–402
168. Bruyndonckx L, Hoymans VY, De Guchteneere A, et al. Diet, exercise, and endothelial function in obese adolescents. *Pediatrics*. 2015;135(3): e653–e661
169. Chamay-Weber C, Farpour-Lambert NJ, Saunders Gasser C, Martin XE, Gal C, Maggio AB. Obesity management in adolescents: comparison of a low-intensity face-to-face therapy provided by a trained paediatrician with an intensive multidisciplinary group therapy. *Obes Facts*. 2016;9(2):112–120
170. Chen JL, Kwan M, Mac A, Chin NC, Liu K. iStart smart: a primary-care based and community partnered childhood obesity management program for Chinese-American children: feasibility study. *J Immigr Minor Health*. 2013;15(6):1125–1128
171. Cheng JK, Wen X, Coletti KD, Cox JE, Taveras EM. 2-Year BMI changes of children referred for multidisciplinary weight management. *Int J Pediatr*. 2014;2014:152586



172. Cloutier MM, Wiley J, Huedo-Medina T, et al. Outcomes from a pediatric primary care weight management program: steps to growing up healthy. *J Pediatr*. 2015;167(2):372–7.e1
173. Danielsson P, Bohlin A, Bendito A, Svensson A, Klaesson S. Five-year outpatient programme that provided children with continuous behavioural obesity treatment enjoyed high success rate. *Acta Paediatr*. 2016; 105(10):1181–1190
174. Eliakim A, Friedland O, Kowen G, Wolach B, Nemet D. Parental obesity and higher pre-intervention BMI reduce the likelihood of a multidisciplinary childhood obesity program to succeed—a clinical observation. *J Pediatr Endocrinol Metab*. 2004;17(8):1055–1061
175. Eliakim A, Kaven G, Berger I, Friedland O, Wolach B, Nemet D. The effect of a combined intervention on body mass index and fitness in obese children and adolescents - a clinical experience. *Eur J Pediatr*. 2002;161(8):449–454
176. Endevelt R, Elkayam O, Cohen R, et al. An intensive family intervention clinic for reducing childhood obesity. *J Am Board Fam Med*. 2014;27(3):321–328
177. Gortmaker SL, Polacsek M, Letourneau L, et al. Evaluation of a primary care intervention on body mass index: the Maine Youth Overweight Collaborative. *Child Obes*. 2015;11(2):187–193
178. Hinchman J, Beno L, Mims A. Kaiser Permanente Georgia's Experience with Operation Zero: a group medical appointment to address pediatric overweight. *Perm J*. 2006;10(3):66–71
179. Lipana LS, Bindal D, Nettiksimmons J, Shaikh U. Telemedicine and face-to-face care for pediatric obesity. *Telemed J E Health*. 2013;19(10):806–808
180. Mårild S, Gronowitz E, Forsell C, Dahlgren J, Friberg P. A controlled study of lifestyle treatment in primary care for children with obesity. *Pediatr Obes*. 2013;8(3):207–217
181. Nemet D, Levi L, Pantanowitz M, Eliakim A. A combined nutritional-behavioral-physical activity intervention for the treatment of childhood obesity—a 7-year summary. *J Pediatr Endocrinol Metab*. 2014;27(5-6): 445–451
182. Nowicka P, Höglund P, Pietrobelli A, Lissau I, Flodmark CE. Family Weight School treatment: 1-year results in obese adolescents. *Int J Pediatr Obes*. 2008;3(3):141–147
183. Nuutinen O. Long-term effects of dietary counselling on nutrient intake and weight loss in obese children. *Eur J Clin Nutr*. 1991;45(6):287–297
184. Nuutinen O, Knip M. Weight loss, body composition and risk factors for cardiovascular disease in obese children: long-term effects of two treatment strategies. *J Am Coll Nutr*. 1992;11(6):707–714
185. Reinehr T, Kersting M, Alexy U, Andler W. Long-term follow-up of overweight children: after training, after a single consultation session, and without treatment. *J Pediatr Gastroenterol Nutr*. 2003;37(1):72–74
186. Reinehr T, Kleber M, Toschke AM. Lifestyle intervention in obese children is associated with a decrease of the metabolic syndrome prevalence. *Atherosclerosis*. 2009;207(1):174–180
187. Reybrouck T, Vinckx J, Van den Berghe G, Vanderschueren-Lodeweyckx M. Exercise therapy and hypocaloric diet in the treatment of obese children and adolescents. *Acta Paediatr Scand*. 1990;79(1):84–89
188. Schwartz RP, Hamre R, Dietz WH, et al. Office-based motivational interviewing to prevent childhood obesity: a feasibility study. *Arch Pediatr Adolesc Med*. 2007;161(5):495–501
189. Sousa P, Fonseca H, Gaspar P, Gaspar F. Controlled trial of an Internet-based intervention for overweight teens (NextStep): effectiveness analysis. *Eur J Pediatr*. 2015;174(9):1143–1157
190. Spieth LE, Harnish JD, Lenders CM, et al. A low-glycemic index diet in the treatment of pediatric obesity. *Arch Pediatr Adolesc Med*. 2000;154(9): 947–951
191. Tanas R, Marcolongo R, Pedretti S, Gilli G. A family-based education program for obesity: a three-year study. *BMC Pediatr*. 2007;7:33
192. Taveras EM, Perkins M, Anand S, et al. Clinical effectiveness of the Massachusetts childhood obesity research demonstration initiative among low-income children. *Obesity (Silver Spring)*. 2017;25(7):1159–1166
193. Tripicchio GL, Ammerman AS, Neshteruk C, et al. Technology components as adjuncts to family-based pediatric obesity treatment in low-income minority youth. *Child Obes*. 2017;13(6):433–442
194. Tucker SJ, Ytterberg KL, Lenocho LM, et al. Reducing pediatric overweight: nurse-delivered motivational interviewing in primary care. *J Pediatr Nurs*. 2013;28(6):536–547
195. Tyler DO, Horner SD. A primary care intervention to improve weight in obese children: a feasibility study. *J Am Assoc Nurse Pract*. 2016;28(2):98–106
196. Uysal Y, Wolters B, Knop C, Reinehr T. Components of the metabolic syndrome are negative predictors of weight loss in obese children with lifestyle intervention. *Clin Nutr*. 2014;33(4):620–625
197. Vanhelst J, Mikulovic J, Fardy P, et al. Effects of a multidisciplinary rehabilitation program on pediatric obesity: the CEMHaVi program. *Int J Rehabil Res*. 2011;34(2):110–114
198. Videira-Silva A, Fonseca H. The effect of a physical activity consultation on body mass index z-score of overweight adolescents: results from a pediatric outpatient obesity clinic. *Eur J Pediatr*. 2017;176(5):655–660
199. Wald ER, Moyer SC, Eickhoff J, Ewing LJ. Treating childhood obesity in primary care. *Clin Pediatr (Phila)*. 2011;50(11):1010–1017
200. Warschburger P, Fromme C, Petermann F, Wojtalla N, Oepen J. Conceptualisation and evaluation of a cognitive-behavioural training programme for children and adolescents with obesity. *Int J Obes Relat Metab Disord*. 2001;25(Suppl 1): S93–S95
201. Yoshinaga M, Sameshima K, Miyata K, Hashiguchi J, Imamura M. Prevention of mildly overweight children from development of more overweight condition. *Prev Med*. 2004;38(2): 172–174
202. Bailey-Davis L, Kling SMR, Wood GC, et al. Feasibility of enhancing well-child visits with family nutrition and physical activity risk assessment on

- body mass index. *Obes Sci Pract*. 2019;5(3):220–230
203. Coles N, Patel BP, Li P, et al. Breaking barriers: adjunctive use of the Ontario Telemedicine Network (OTN) to reach adolescents with obesity living in remote locations. *J Telemed Telecare*. 2020;26(5):271–277
204. Derwig M, Tiberg I, Björk J, Hallström I. Child-Centred Health Dialogue for primary prevention of obesity in Child Health Services - a feasibility study. *Scand J Public Health*. 2021;49(4):384–392
205. Hagman E, Bohlin A, Klaesson S, Ejderhamn J, Danielsson P. Promising results from an implemented treatment model for paediatric obesity. *Acta Paediatr*. 2020;109(8):1656–1664
206. Tucker JM, DeFrang R, Orth J, Wakefield S, Howard K. Evaluation of a primary care weight management program in children aged 2(-)5 years: changes in feeding practices, health behaviors, and body mass index. *Nutrients*. 2019;11(3):498
207. van der Aa MP, Hoving V, van de Garde EM, de Boer A, Knibbe CA, van der Vorst MM. The effect of eighteen-month metformin treatment in obese adolescents: comparison of results obtained in daily practice with results from a clinical trial. *J Obes*. 2016; 2016:7852648
208. Harden KA, Cowan PA, Velasquez-Miery P, Patton SB. Effects of lifestyle intervention and metformin on weight management and markers of metabolic syndrome in obese adolescents. *J Am Acad Nurse Pract*. 2007; 19(7):368–377
209. Juárez-López C, Klünder-Klünder M, Madrigal-Azcárate A, Flores-Huerta S. Omega-3 polyunsaturated fatty acids reduce insulin resistance and triglycerides in obese children and adolescents. *Pediatr Diabetes*. 2013; 14(5):377–383
210. Krzystek-Korpacka M, Patryn E, Kustrzeba-Wojcicka I, Chrzanowska J, Gamian A, Noczynska A. The effect of a one-year weight reduction program on serum uric acid in overweight/obese children and adolescents. *Clin Chem Lab Med*. 2011;49(5):915–921
211. Marques P, Limbert C, Oliveira L, Santos MI, Lopes L. Metformin effectiveness and safety in the management of overweight/obese nondiabetic children and adolescents: metabolic benefits of the continuous exposure to metformin at 12 and 24 months. *Int J Adolesc Med Health*. 2016;29(5):/j/ijamh.2017.29.issue-5/ijamh-2015-0110/ijamh-2015-0110.xml
212. Ryder JR, Kaizer A, Rudser KD, Gross A, Kelly AS, Fox CK. Effect of phentermine on weight reduction in a pediatric weight management clinic. *Int J Obes*. 2017;41(1):90–93
213. Stagi S, Ricci F, Bianconi M, et al. Retrospective evaluation of metformin and/or metformin plus a new polysaccharide complex in treating severe hyperinsulinism and insulin resistance in obese children and adolescents with metabolic syndrome. *Nutrients*. 2017;9(5):524
214. Lentferink YE, van der Aa MP, van Mill EGAH, Knibbe CAJ, van der Vorst MMJ. Long-term metformin treatment in adolescents with obesity and insulin resistance, results of an open label extension study. *Nutr Diabetes*. 2018;8(1):47
215. Göthberg G, Gronowitz E, Flodmark CE, et al. Laparoscopic Roux-en-Y gastric bypass in adolescents with morbid obesity—surgical aspects and clinical outcome. *Semin Pediatr Surg*. 2014;23(1):11–16
216. Inge TH, Courcoulas AP, Jenkins TM, et al; Teen-LABS Consortium. Weight loss and health status 3 years after bariatric surgery in adolescents. *N Engl J Med*. 2016;374(2):113–123
217. Inge TH, Laffel LM, Jenkins TM, et al; Teen-Longitudinal Assessment of Bariatric Surgery (Teen-LABS) and Treatment Options of Type 2 Diabetes in Adolescents and Youth (TODAY) Consortium. Comparison of surgical and medical therapy for type 2 diabetes in severely obese adolescents. *JAMA Pediatr*. 2018; 172(5):452–460
218. Manco M, Mosca A, De Peppo F, et al. The benefit of sleeve gastrectomy in obese adolescents on nonalcoholic steatohepatitis and hepatic fibrosis. *J Pediatr*. 2017;180:31–37.e2
219. O'Brien PE, Sawyer SM, Laurie C, et al. Laparoscopic adjustable gastric banding in severely obese adolescents: a randomized trial. *JAMA*. 2010;303(6):519–526
220. Olbers T, Beamish AJ, Gronowitz E, et al. Laparoscopic Roux-en-Y gastric bypass in adolescents with severe obesity (AMOS): a prospective, 5-year, Swedish nationwide study. *Lancet Diabetes Endocrinol*. 2017;5(3):174–183
221. Olbers T, Gronowitz E, Werling M, et al. Two-year outcome of laparoscopic Roux-en-Y gastric bypass in adolescents with severe obesity: results from a Swedish Nationwide Study (AMOS). *Int J Obes*. 2012; 36(11):1388–1395
222. Pedrosa FE, Gander J, Oh PS, Zitsman JL. Laparoscopic vertical sleeve gastrectomy significantly improves short term weight loss as compared to laparoscopic adjustable gastric band placement in morbidly obese adolescent patients. *J Pediatr Surg*. 2015;50(1):115–122
223. Ryder JR, Gross AC, Fox CK, et al. Factors associated with long-term weight-loss maintenance following bariatric surgery in adolescents with severe obesity. *Int J Obes*. 2018; 42(1):102–107
224. Henfridsson P, Laurenius A, Wallengren O, et al. Five-year changes in dietary intake and body composition in adolescents with severe obesity undergoing laparoscopic Roux-en-Y gastric bypass surgery. *Surg Obes Relat Dis*. 2019;15(1):51–58
225. Inge TH, Coley RY, Bazzano LA, et al; PCORnet Bariatric Study Collaborative. Comparative effectiveness of bariatric procedures among adolescents: the PCORnet bariatric study. *Surg Obes Relat Dis*. 2018;14(9):1374–1386
226. Barlow SE; Expert Committee. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics*. 2007;120(Suppl 4):S164–S192
227. Dietz WH, Solomon LS, Pronk N, et al. An integrated framework for the prevention and treatment of obesity and its related chronic diseases.

- Health Aff (Millwood)*. 2015;34(9):1456–1463
228. Pearl RL, Puhl RM. Weight bias internalization and health: a systematic review. *Obes Rev*. 2018; 19(8):1141–1163
  229. Weingarten SR, Henning JM, Badamgarav E, et al. Interventions used in disease management programmes for patients with chronic illness-which ones work? Meta-analysis of published reports. *BMJ*. 2002;325(7370):925
  230. Cole TJ, Faith MS, Pietrobelli A, Heo M. What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile? *Eur J Clin Nutr*. 2005;59(3):419–425
  231. Dietz WH. Time to adopt new measures of severe obesity in children and adolescents. *Pediatrics*. 2017;140(3):e20172148
  232. Freedman DS, Butte NF, Taveras EM, et al. BMI z-Scores are a poor indicator of adiposity among 2- to 19-year-olds with very high BMIs, NHANES 1999-2000 to 2013-2014. *Obesity (Silver Spring)*. 2017;25(4):739–746
  233. Skelton JA, Martin S, Irby MB. Satisfaction and attrition in paediatric weight management. *Clin Obes*. 2016;6(2):143–153
  234. Skelton JA, Beech BM. Attrition in paediatric weight management: a review of the literature and new directions. *Obes Rev*. 2011;12(5):e273–e281
  235. Wilfley DE, Staiano AE, Altman M, et al; Improving Access and Systems of Care for Evidence-Based Childhood Obesity Treatment Conference Workgroup. Improving access and systems of care for evidence-based childhood obesity treatment: conference key findings and next steps. *Obesity (Silver Spring)*. 2017;25(1):16–29
  236. Tolbert J. *The Coverage Provisions in the Affordable Care Act: An Update*. San Francisco, CA: Kaiser Family Foundation; 2015
  237. Children's Hospital Association. *2013 Survey Findings of Children's Hospitals Obesity Services*. Washington, DC: Children's Hospital Association; 2013