Interventions to treat obesity in Mexican children and adolescents: systematic review and meta-analysis.

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Special Article

Interventions to Treat Obesity in Mexican Children and Adolescents: Systematic Review and Meta-Analysis

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Context: *Prevalence of overweight and obesity has been rising in the past 3 decades among Mexican children and adolescents.* ***Objective:*** *To systematically review experimental studies evaluating interventions to treat obesity in Mexican children and adolescents (≤18 years old).* ***Data Sources:*** *For this study, 13 databases and 1 search engine were searched.* ***Data Analysis:*** *A total of 29 studies met the inclusion criteria. Overall, 2302 participants (age range, 8–16 years) from 11 states in Mexico were included. Most of the studies (n = 17 of 29) were provided in a clinical setting. A random-effect meta-analysis of 4 randomized controlled trials was conducted and a significant effect was found on body mass index reduction that favored the intervention group (−1.52; 95%CI, −2.15 to −0.89) for short-term (≤6 mo) interventions.* ***Conclusions:*** *A multicomponent, multidisciplinary, and individualized intervention that includes dietary modifications, physical activity practice, behavioral strategies, and active parental involvement might help treat childhood obesity in Mexico. However, long-term results need to be produced to identify effectiveness pointers that might help establish an integrated, long-lasting care model to treat obesity.*

INTRODUCTION

Mexico is an upper-middle-income Latin American country, and it has been experiencing the double burden of malnutrition in recent decades.[1] Specifically, childhood overweight and obesity rates have been increasing in the population younger than 19 years. According to the latest results from the National Health and Nutrition Survey 2018, it is estimated that in Mexico, 8.2% of infants (0–4 years old), 35.6% of children (5–11 years old), and almost 40% of the adolescents (12–19 years old) present overweight or obesity.[2] These increasing levels position Mexico among the countries with higher levels of overweight worldwide.[3] According to the Organization for Economic Cooperation and Development 's estimations, such rates will continue to increase if no effective strategies are implemented.[4] Currently, no national intervention

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Table 1 **PICOS framework**

Population	Children and adolescents from zero to 18 years old (mean age at the start of the study or evaluation) from any ethnicity or sex living in Mexico, with overweight or obesity, were included.
Interventions	Studies testing obesity treatment through lifestyle, environmental, behavioral, pharmacologic, or surgical interventions, delivered in any setting, were considered.
Comparator	Studies with or without a control group were considered.
Outcomes	Weight-related outcomes (eg, body mass index,, body mass index z-score)
Study design	Experimental studies

or guideline exists targeting obesity treatment among children and adolescents.

Excess body fat in children and adolescents can lead to a variety of clinical conditions and psychosocial disorders. Children with obesity might have significant reductions in quality of life and a greater risk of early discrimination, low self-esteem, and depression. Children and adolescents with overweight and obesity are likely to maintain their weight status into adulthood and are at higher risk of development of chronic diseases, contributing to increased morbidity or premature death.[5]

Lifestyle interventions can lead to improvements in weight and cardiometabolic outcomes in children or adolescents.[6] However, effectiveness can be smaller compared with pharmacologic or surgical interventions.[7] Still, most of the evidence shows short-term effects, with limited evidence about long-term efficacy. In addition, the safety of such pediatric obesity treatments remains unclear.[7]

Because of the severity of the consequences childhood obesity has on the child's health and well-being, it is essential to identify interventions that can treat obesity in the short and long term.[8] The "Childhood and Adolescent Obesity in Mexico: Evidence, Challenges, and Opportunities" (COMO) Project aims to synthesize and use data to comprehend the extent, nature, effects, and costs of childhood or adolescent obesity in Mexico.[9] This article is part of the COMO project. In this study, we aimed to systematically review experimental studies assessing lifestyle, environmental, behavioral, pharmacologic, or surgical interventions to treat obesity in Mexican children and adolescents (<18 years old).

METHODS

This systematic review has been registered with the International Prospective Register of Systematic Reviews (PROSPERO registration no. CRD42019154132).[10] Also, it has been reported according to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[11] The systematic review strategy was based on the Population, Intervention, Comparator, Outcomes, Study (PICOS) design framework (Table 1). For more details on the methods we used, see Appendix 1.

Electronic searches

Terms such as "overweight," "obesity," "child," "adolescent," "intervention," "program," "Mexico" in the search strategy. The databases searched included Medline, Embase, the Cochrane Library, Global Health Library, LILACS, CINAHL, CAB abstracts, ERIC, PsycINFO, ScienceDirect, Scopus, AGRICOLA, and SciELO Citation Index. Also, relevant material was searched in the search engine Google Scholar. When possible, searches were also conducted in Spanish to capture relevant references. No inclusion study design restrictions were applied. Full reports and conference abstracts were included if these met the inclusion criteria. Reference lists of included studies also were scrutinized for additional publications. Searches were performed in January 2020 and updated in January 2021.

Selection criteria

Reports from 1995 onward in English, Spanish, or Portuguese were considered in this review. Following the PICOS framework (Table 1), the inclusion criteria were as described in the following paragraphs.

Population Children and adolescents from zero to 18 years old (mean age at the start of the study or evaluation) from any ethnicity or sex living in Mexico were considered in this review. Studies including children and adolescents with overweight or obesity (defined as body mass index [BMI] above a healthy weight range; BMI z-score > 1; clinical diagnosis; or study population reported as having overweight or obesity) were included. Mexican children living in a different country were excluded from this review to conceptualize the obesity problem within the country sociodemographic characteristics and avoid confounding information inherent to migration phenomena. Studies in which children were analyzed under severe conditions (eg, HIV, cancer, fibrosis, Down syndrome), premature babies, and pregnant adolescents were excluded.

Studies Studies in which obesity treatment was tested through lifestyle, environmental, behavioral, pharmacologic, or surgical interventions were considered. Studies delivered in any setting (eg, home, school, clinic, community) or digital domains (eg, mobile-phone-network interventions) were considered.

Comparator Studies with or without a control group were considered.

Outcomes Effectiveness measurements included anthropometric changes (eg, weight, BMI, BMI z-score). Because of the type of interventions considered in this review, any lifestyle changes (eg, dietary, physical activity, behavioral outcomes) were also recorded.

Study design Experimental studies were considered in this review.

Data extraction

Titles and abstract screening and full-text review was performed by 2 reviewers (L.L.-C., M.G.-B.) and 100% checked by a third reviewer (M.A.-M.). Two reviewers (M.A.-M. and L.L.-C.) extracted data independently from included papers. In case of any disagreement, a third author was contacted (Y.Y.G.-G.). A data extraction form was created based on the Effective Public Health Practice Project Quality Assessment Tool[12] and the Template for Intervention Description and Replication.[13] Data on the main components of the studies were extracted and categorized according to the components included: nutritional (eg, diet prescriptions, nutritional advice); physical activity (PA; eg, PA practices, PA advice); behavioral or psychological (eg, psychological, family, or behavioral therapy); environmental (ie, changes in children's settings to promote a weight change); pharmacologic (eg, sibutramine); or bariatric surgery. Any theory or framework used in the design or delivery of the intervention was recorded.

Risk of bias

Following the Cochrane Handbook's recommendation for Systematic Reviews of Interventions for health promotion interventions,[14] the Effective Public Health Practice Project Quality Assessment Tool[12] tool was used. Evidence was rated as strong, moderate, or weak on the basis of their selection bias; study design; confounders; blinding; data collection methods; withdrawals and drop-outs; intervention integrity; and analysis. Also, funding sources and reported conflicts of interests were extracted and considered in this review. For more details, see Appendix 1.

Data synthesis and analysis

A narrative synthesis was conducted across all the included studies. From those randomized controlled trials (RCTs) in which the mean difference and its standard deviation of BMI were reported or could be calculated, a meta-analysis was conducted. Whenever provided, intention-to-treat data were used. WebplotDigitizer software was used to extract data when data were provided in graphs. The formulas from the Cochrane Guidelines were used to estimate the effect size.[15,16] Lifestyle interventions in obesity are quite heterogeneous; hence, we chose a random effect model for this analysis.[17,18] Because of the small sample sizes, the Hedges estimator[19] was used to fit the random-effect model. The analysis was done using R statistical software, using the library "*metafor*".

RESULTS

Through the searches, 7363 references were identified, from which 1432 were retrieved for full-text review. Overall, 886 references were identified by reporting obesity-related data in Mexican children and are included in the COMO database. From these, 29 studies (presented in 31 publications)[20–50] met the inclusion criteria (Figure 1). Most of the publications were full-text papers, except for 3 abstracts,[24,32,45] 1 doctoral thesis,[46] and 1 letter to the editor.[50] Ten studies were RCTs,[20,21,25,26,34,40–43,48] 3 were controlled clinical trials,[27,29,35] 3 were cohort analytic studies with >1 group (2 or 3 groups, before and after),[32,39,46] and 13 were cohort analytic studies with a single group (before and after).[22–24,28,33,36–38,44,45,47,49,50]

Overall, the 29 identified studies included 2302 participants (age range, 8–16 years) recruited from 11 states of 32 states in Mexico (Figure 2). Most of the studies were conducted in a clinical setting (n = 17); some (n = 7) in a school setting. One included both settings (ie, school and clinic).[40] In 1 study, participants were recruited in a school, but activities were delivered outside school hours.[41] Two studies were conducted in summer camps[39,46]; the setting was unclear in 1 of the studies[24] (Table 2).[20–50]

Overall, 20 of the 29 studies included a nutritional component, 19 included a PA component, 8 included a psychological or behavioral component, and 3 studies included pharmacologic treatment. The effects of 2 different bariatric surgeries among participants were reported in 1 study[32]; however, this was 1 of the included abstracts, and it was poorly reported. None of the included studies reported an environmental change to aid the weight-loss process. In 16 studies, parents or siblings were included. The duration of the 29 studies

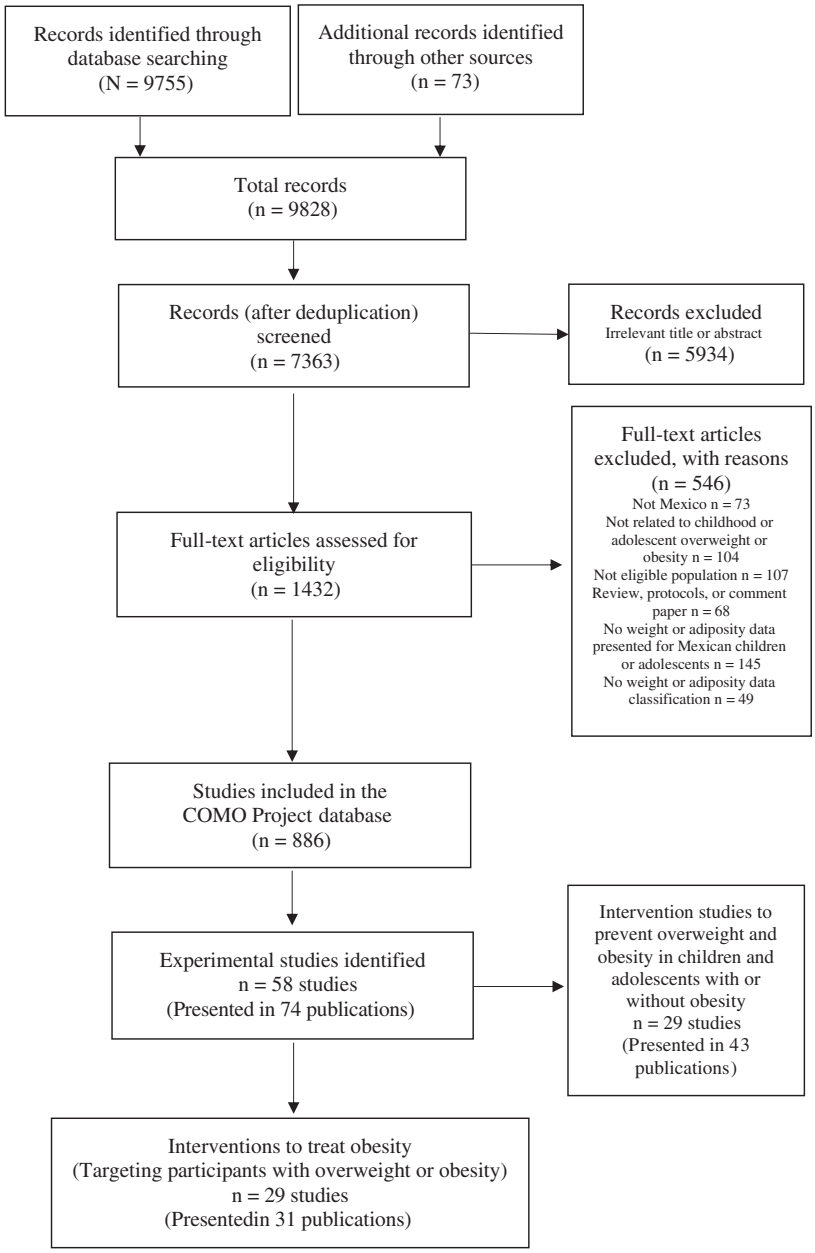

Figure 1 **PRISMA flowchart.** COMO, Childhood and Adolescent Obesity in Mexico: Evidence, Challenges, and Opportunities.

ranged from 1 week to 12 months. There was no long-term (>12 mo) study identified in this review. An approximate number of sessions was calculated from reported information in the publications, and this number varied from 4 to 106 sessions. See Table 2 or Table S1 in Appendix 2 in the Supporting Information online.

Significant reductions in anthropometric outcomes were reported in 10 of the 29 studies,[21–23,25,33,36,38,47–49] 9 reported no significant changes,[20,26,27,34,35,40,41,43,44] and the effect of the intervention was unclear in 5 studies.[24,32,37,39,45] In 2 studies,[28,50] significant changes were reported in some, but not all, of the anthropometric outcomes considered (eg, changes in skin folds, but not in BMI). Two studies[29,46] reported effectiveness only in those participants who finished the intervention. For more details on the outcomes see Table S2 in Appendix 2 in the Supporting Information online.

Of the 29 included studies, 10 were RCTs; however, only 4 were included in the meta-analysis.[20,21,40,48] One was excluded because it comprised a pharmacologic therapy (ie, sibutramine, banned since 2010 in Mexico).[25] Three provided nutritional supplementation (with some generic dietary advice, but not a lifestyle intervention).[26,34,43] One did not provide sufficient information to calculate the effect size.[41] The study of

Figure 2 **Map of the Mexican 11 states from which evidence was reported.**

Rosado et al[42] was excluded from the meta-analysis because in that study, the aim was to increase ready-to-eat cereals as a strategy to reduce excess body weight, and no individualized nutritional advice was provided to participants.

The population included in the 4 RCTs included in the meta-analysis was 237 participants (age range, 11–13 years old). The duration of these 4 RCTs varied from 3 months to 12 months. The intensity and frequency of sessions also varied, from 5 to 100 sessions. In the Díaz et al[21] study, children with obesity participated in the intervention frequently during the first 12 weeks, and then the intensity decreased to monthly visits. The Díaz et al[21] study was the only 1 presenting 6 and 12 months of data. Because the remaining studies included in the meta-analysis lasted 3.5 or 4 months, 2 analyses were done: 1 including data from Díaz et al [21] recorded at 6 months (Figure 3)[20,21,40,48] and another with data at 12 months (Figure 4).[20,21,40,48] Overall, there was a significant effect (−1.52; 95%CI, −2.15 to −0.89; I^2 = 66%) (Figure 3) on BMI in the short term (≤6 mo) favoring the intervention groups. The effect was diminished but remained significant when including the 12 months of data from Díaz et al[21] (−1.31; 95%CI, −1.73 to −0.89; I^2 = 50%) (Figure 4).

Overall, 6 of the 29 studies were considered of strong quality,[25,29,34,40,42,47] 5 of moderate quality,[20,35,36,38,44] and the rest (n = 18) were considered of low quality. In 11 studies,[20,21,25,26,34,40–43,48] participants were randomly assigned into different study groups; in 7 of these, the randomization methods were reported, and in 6,[21,25,34,40,42,47] blinding of participants and personnel was reported. In most of the included studies (n = 20),[20–23,25–29,33–36,38,40–42,47,48,50] individuals were somewhat likely to represent the target population. In 12 of the 29 studies, some relevant confounders were identified and controlled for.[21,25,26,29,34,35,40,42,44,46,49] In most of the included studies, the data collection tools were valid and reliable. Data collection for anthropometric measurements did not raise any quality uncertainties, because all the studies collected data according to international protocols. However, lifestyle outcome measurements were very heterogeneous across studies, and the validity of tools was not reported in most cases. Withdrawals and drop-outs reported in 17 of the studies. When analyzing data, intention-to-treat analysis was used in only 3 studies.[21,25,49] (Table 3).[20–50]

Thirteen of the 29 studies did not report any funding source, and 3 reported not receiving funding for the intervention.[22,33,41] For 1 study, authors reported receiving funding from the food industry,[42] and in another, authors reported receiving funding from a pharmaceutical company.[25] National funding was reported in 2 studies,[26,43] and for 1 study, authors reported receiving support from international organizations.[21] Six of the 29 studies reported[28,29,34,35,40,48] receiving funding from public institutions (eg, public hospitals, public universities), and 1[23] reported receiving funding from private institutions (eg, private universities, insurance companies). The authors' conflicts of interest were not reported in 17 studies. In those studies that reported it, no conflict of interest was declared.

DISCUSSION

In this systematic review and meta-analysis of evidence from studies of obesity in Mexican children and adolescents, we found a significant short-term (≤12 mo) effectiveness on BMI reduction. However, these results need to be cautiously interpreted in the light of the analysis' limitations. Only 4 RCTs,[20,21,40,48] with an overall

Table 2 **General characteristics of included studies**

Reference; study design	Setting characteristics: location, setting, year intervention was implemented	Participants' characteristics: total initial sample, female sex (%), mean (SD) age	Main intervention	Main characteristics of intervention: duration, follow-up period, intensity and frequency	Nutritional component	PA component	Psychological or behavioral component	Pharmacologic or surgery component	Other relevant component
Ceballos-Gurrola 2020[20] Randomized controlled trial	NR (Nuevo Leon) Public secondary school in a municipality in the urban area. 2014	62 46.7% Mean (SD) age: 13.3 (1.01) y	The CENLO (not an abbreviation) health program considered 3 simultaneously: nutritional orientation, PA practice, and phototherapy (ie, light therapy or heliotherapy post-PA)	3.5 mo NR 14 nutritional sessions (60 min/wk) + 56 PA sessions (60 min × 4 times/wk) + 28 phototherapy sessions (40 min × 2 times/wk) Delivered by: NR	✓	✓	NR	NR	Phototherapy was implemented in 1 of the interventions groups.
Diáz 2010[21] Randomized controlled trial	Hermosillo (Sonora) Public primary care unit within a secondary care hospital 2006–2007	43 51.1% 11.6 (2.1) y	Behavioral modification intervention based on a program, culturally appropriate topics focused mainly on the health belief model and a simple food guide	12 mo NR 12 sessions (2 h group sessions/12 wk) + 21 sessions with a nutritionist (weekly during the first 12 consecutive weeks, months after that) + 12 sessions with physician (10–15 min monthly consultations) Delivered by: trained general practitioners, a pediatrician, and a nutritionist	✓	✓	✓	NR	Parents received 6 education sessions and were encouraged to lose weight if they were overweight.
Elizondo-Montemayor[22a] Cohort (1 group before and after)	Monterrey (Nuevo Leon) 8 Public schools of low SES 2010–2011	96 45.8% 9.1 (1.4) y	Dietetic and lifestyle intervention, including individualized diets and PA, advice Information was given to parents about healthy food and eating.	1 school year NR 13 session (30 min each) Delivered by: nutritionist	✓	✓	NR	NR	Parents were involved in the intervention.
Elizondo-Montemayor 2014 b[23a] Cohort (one group before and after)	Monterrey (Nuevo Leon) 8 Public schools of low SES NR	125 45.5% NR	Dietetic and lifestyle intervention, including individualized diets Information given to parents about healthy food and eating	1 school year NR 13 sessions (45 min each) Delivered by: nutritionist	✓	NR	NR	NR	Parents were involved in the intervention.
Escalante-Izeta 2013 (abstract)[24] Cohort (1 group before and after)	Mexico City (Mexico City) No data on setting NR	10 NR NR	Lifestyle intervention based on the Spanish program "Kids in Motion," which aims to produce changes in the child and their family, lifestyle, eating habits, and emotional factors contributing to weight gain	3 mo NR 11 sessions (no additional detail provided) Delivered by: NR	✓	✓	✓	NR	NR

(continued)

Table 2 **Continued**

Reference; study design	Setting characteristics: location, setting, year intervention was implemented	Participants' characteristics: total initial sample, female sex (%), mean (SD) age	Main intervention	Main characteristics of intervention: duration, follow-up period, intensity and frequency	Nutritional component	PA component	Psychological or behavioral component	Pharmacologic or surgery component	Other relevant component
Garcia-Morales 2006[25] Randomized controlled trial	Mexico City (Mexico City) Outpatients attending the Endocrinology Department of a public children's hospital 2001–2003	51 56.5% 14.9 (1.2) y	Pharmacologic intervention (ie, sibutramine) plus lifestyle changes intervention Participants received individually tailored diet and exercise advice.	6 mo NR 18 sessions (no additional detail provided) Delivered by: practitioners, pediatric nutritionist, and registered nutritionist (for anthropometry)	✓	✓	NR	✓	NR
Garibay-Nieto 2017[26] Randomized controlled trial	Mexico City (Mexico City) Pediatric obesity clinic at a public hospital 2012–2014	83 NR 12.6 (2.7) y	Patients received a lifestyle intervention program and were randomly assigned to receive either metformin (1 g/d) and conjugated linoleic acid (3 g/d) or a placebo (1 g/d). Lifestyle intervention included a structured PA session, followed by a psychoeducational group session and educational material about healthy lifestyles.	4 mo NR 4 sessions (each included 1 h PA + psychoeducational group session + medical consultation) Delivered by: nutritionists, psychologists, pediatricians, pediatric endocrinologists, and a physical trainer	✓	✓	✓	✓	Parents were involved in the intervention.
González-Heredia 2014[27] Controlled trial	Ciudad Obregon (Sonora) Family medicine unit of a public hospital NR	60 51.6% 9.2 (2) y	Lifestyle intervention focused on eating habits modification through individualized diets.	6 mo NR Delivered by: unclear	✓	NR	NR	NR	The intervention included personalized diet for the parents and children.
Hall-López 2017[28] Cohort (1 group before and after)	Mexicali (Baja California) Public elementary school NR	26 42.3% 9.4 (0.3) y	PA practice intervention based on the CATCH model (US program), including moderate to vigorous exercise	10 mo NR; 80 sessions (50 min × 2 times/wk) Delivered by: unclear	NR	✓	NR	NR	Pedagogical elements of teaching support for the teacher to instruct PA with moderate to vigorous intensity for ≥50% of class time.
Huang 2010[29–31] Controlled trial	Mexico City (Mexico City) Public children's hospital NR	97 41.2% 11.9 (1.4) y	Lifestyle intervention included dietary advice, PA practices, behavioral counselling, and active involvement of the family.	6 mo NR 24 sessions + 4 parents intensive lifestyle support sessions + 6 telephone sessions (15 min monthly) Delivered by: nutritionist, physician, clinical psychologist	✓	✓	✓	NR	Family (parents and siblings) was involved in the intervention.

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Table 2 **Continued**

Reference; study design	Setting characteristics: location, setting, year intervention was implemented	Participants' characteristics: total initial sample, female sex (%), mean (SD) age	Main intervention	Main characteristics of intervention: duration, follow-up period, intensity and frequency	Nutritional component	PA component	Psychological or behavioral component	Pharmacologic or surgery component	Other relevant component
Jimenez 2017 (abstract)[32] Cohort analytic (2 groups before and after)	Guadalajara (Jalisco) No details on setting NR	27 63% 15.7 (NR) y	Surgery intervention. Two different bariatric surgeries: in 1 cohort, the gastric sleeve was performed, and in the other, gastric bypass.	NR 24 mo NR Delivered by: unclear	NR	NR	NR	✓	NR
Laguna-Alcaraz 2017[33] Cohort (1 group before and after)	Morelia (Michoacan) Public clinic 2013–2014	13 46.1% 11.5 (1.6) y	Lifestyle intervention included the "PREVENIMSS program" (lifestyle change comprehensive program used in the public health system), nutritional support, and PA performance.	6 mo NR; 10 sessions (with nutritionist) + 24 educational sessions (1 h each) + 72 PA sessions (1 h each) Delivered by: nutritionist, undergraduate physician	✓	✓	NR	NR	NR
López-Alarcon 2019[34] Randomized controlled trial	Mexico City (Mexico City) Clinical nutrition research unit of a public hospital 2012–2015	245 52.6% 13.6 (1.8) y	Supplementation intervention. Participants were randomly assigned to receive 800 mg EPA + 400 mg DHA or a placebo.	1-mo NR Delivered by: nutritionist did anthropometry; however, the role was unclear	✓	NR	NR	NR	NR
López-Alarcon 2020[35] Controlled trial	Mexico City (Mexico City) Clinical nutrition research unit of a public hospital 2018	63 35.5% 11.4 (0.3) y	Mindfulness intervention with guided sessions, with interactive activities to teach standard mindfulness skills. A short homework exercise was assigned to help children apply mindfulness skills to daily life.	2 mo 2 mo 8 sessions (2 h each) Delivered by: 2 certified mindfulness consultants	?	NR	✓	NR	Sessions were delivered for parents in parallel with the sessions provided to the children.
Luna-Ruiz 2007[36] Cohort (1 group before and after)	Leon (Guanajuato) Public family medicine unit 2003–2004	28 46% 9.8 (1.6) y	Educational intervention that included children's' mothers. It used a participatory technique following a diabetes mellitus educational program. Also, outdoor PA for mothers and children	6 mo NR; 2 sessions for parents (1.5 h each) + 6 sessions for children (monthly, NR) + 24 PA session for mothers and children (2 h each). Delivered by: nutritionist, physical activity monitor, and "obesity educator"	✓	✓	NR	NR	Parents were involved in the intervention.

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Table 2 **Continued**

Reference; study design	Setting characteristics: location, setting, year intervention was implemented	Participants' characteristics: total initial sample, female sex (%), mean (SD) age	Main intervention	Main characteristics of intervention: duration, follow-up period, intensity and frequency	Nutritional component	PA component	Psychological or behavioral component	Pharmacologic or surgery component	Other relevant component
Martin-Mosqueda 2012[37] Cohort (1 group before and after)	Guadalajara (Jalisco) Outpatient nutrition consultation at a medical center NR	7 42.9% 11.5 (0.9) y	"Light mind and weight" was a lifestyle intervention for children and parents. Participants were taught how to put together their menus with no restrictions. They were thought to achieve the right nutritional balance. PA practice sessions were delivered. Cognitive behavioral therapy was conducted in group sessions for children's parents.	3 mo NR 1 nutritional session, 48 PA sessions (30–45 min each) + 12 psychological sessions (90 min each) Delivered by: NR	✓	✓	✓	NR	Parents were involved in the intervention.
Moran 2017[38] Cohort (1 group before and after)	Mexico City (Mexico City) Pediatric public hospital NR	46 65.2% 11.8 (2.6) y	Educational intervention including both children and parents in small groups (5 children with their parents or guardians) provided material about the importance of adequate nutrition.	4 mo NR 8 group sessions (1 h each) Delivered by: dietitian and medical doctor	✓	✓	NR	NR	Parents were involved in the intervention.
Pompa-Guajardo 2018[39] Cohort analytic (3 groups before and after)	Unclear (Nuevo Leon) Summer camp. No additional details provided NR	102 38% 10.2 (1.5) NR	Lifestyle intervention delivered at a 5-day summer camp. Activities included group sessions where participants were encouraged to express their feelings about eating behavior and express their thoughts and emotions.	6 mo or 1 y (depending on the allocated intervention group) Group 2 included 12 mo follow-up Group 1: 5 daily sessions during summer camp + 6 group sessions (1/mo after the summer camp) Group 2: 5 daily sessions during summer camp + 12 group sessions (90 min session, 1 every 15 d after the summer camp) + 12 monthly meetings with parents Delivered by: nutritionists, psychologists, pediatricians, and sports doctors	?	?	?	NR	In group 2, parents were involved in the intervention.
Rodríguez-Morán 2014[40]	Durango City (Durango)	115 47.8% 13.2 (0.9) y		4 mo NR	✓	✓	✓	NR	Parents were invited to participate in

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Table 2 **Continued**

Reference; study design	Setting characteristics: location, setting, year intervention was implemented	Participants' characteristics: total initial sample, female sex (%), mean (SD) age	Main intervention	Main characteristics of intervention: duration, follow-up period, intensity and frequency	Nutritional component	PA component	Psychological or behavioral component	Pharmacologic or surgery component	Other relevant component
Randomized controlled trial	Low SES secondary schools, located near a public clinic where the study took place NR		Cognitive behavioral therapy plus indications for a low-calorie diet and PA practice	20 nutrition sessions (1 h weekly) + 80 PA sessions (from Monday to Friday) NR Delivered by: medical doctors, psychologists, nutritionists, and physical education and sport graduates					the exercise group sessions.
Romero-Pérez 2020[41] Randomized controlled trial	NR (Sonora) Primary schools (unclear if public or private) NR	105 57.1% 10 (0.8) y	PA practice group sessions intervention	5 mo NR 40 sessions (50 min each × 2 times a week) Delivered by: NR	NR	✓	NR	NR	NR
Rosado 2008[42] Randomized controlled trial	Queretaro City (Queretaro) 6 Elementary schools (unclear if public or private) 2002–2003	262 51.1% 9.1 (1.5) y	Intervention looking at the increase in ready-to-eat cereal (from Kellogg's) intake	3 mo NR 12 sessions (1 weekly) NR Delivered by: nutritionist.	✓	NR	NR	NR	Mothers were involved in the intervention.
Rosas-Nexticapa 2017[43] Randomized controlled trial	Xalapa (Veracruz) 5 Public elementary schools NR	121 53.7% NR	Supplementation intervention. Participants were randomly assigned to (1) 2 gummies 60 mg of DHA and EPA; (2) 3 gummies (90 mg DHA and EPA); (3) 10 g of salmon (211 mg DHA); or (4) 15 g of salmon (316 mg DHA)	3 mo NR 60 doses (Monday to Friday × 3 mo) Delivered by: NR	×	NR	NR	NR	Supplements of DHA
Sáenz-Soto 2004[44] Cohort (1 group before and after)	Monterrey (Nuevo Leon) Pediatric clinic of a third-level hospital NR	25 52% 12 (1) y	Educational intervention targeting adolescents and mothers to modify the level of PA and the consumption of foods rich in fat. PA practice sessions were delivered for both mothers and adolescents.	9 wk 4 wk 4 educational sessions (45–60 min each) + 8 PA sessions (45–60 min each) Delivered by: pediatrician checked, but unclear if delivered	✓	✓	NR	NR	Mothers were involved in the intervention.

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Table 2 **Continued**

Reference; study design	Setting characteristics: location, setting, year intervention was implemented	Participants' characteristics: total initial sample, female sex (%), mean (SD) age	Main intervention	Main characteristics of intervention: duration, follow-up period, intensity and frequency	Nutritional component	PA component	Psychological or behavioral component	Pharmacologic or surgery component	Other relevant component
Santiago-Lagunes 2018 (abstract)[45] Cohort (1 group before and after)	Mexico City (Mexico City) Obesity and Adolescents Clinic of the National Institute of Pediatrics (public service) NR	27 NR NR	Individualized lifestyle intervention	8 mo NR 1 consultation (basal consultation, NR) + 8 consultations (weekly up to 8, duration NR) + 6 consultations (monthly consultation up to 6 times to complete 8 mo) Duration: NR Delivered by: multidisciplinary health team (no additional detail provided)	?	?	NR	NR	NR
de Sanchez 2004[46] Cohort analytic (3 groups before and after)	Monterrey (Nuevo Leon) Department of Endocrinology in a public hospital, but children recruited from schools 2002–2005	100 56% 8.8 (1.8) y	Multidisciplinary intervention for weight loss treatment, which consisted of a week-long summer camp and a monthly follow-up for6 mo (no additional information provided)	1 wk 6 mo 2 sessions + 6 sessions (monthly follow-up) Delivered by: endocrinologist, pediatrician, dietitian, nurse, sports physician, and psychologist	?	?	NR	NR	NR
Velázquez-López 2009[47] Cohort (1 group before and after)	Mexico City (Mexico City) Public family medicine unit NR	40 45% 10.3 (3) y	All patients and their families received personalized nutritional advice once a month.	4 mo NR 4 sessions (1 monthly, duration: NR) Delivered by: nutrition graduates	✓	✓	NR	NR	Family (parents and siblings) was involved in the intervention.
Velázquez-López 2014[48] Randomized controlled trial	Mexico City (Mexico City) Public family medicine unit NR	49 53% 11.3 (2.8) y	Nutritional intervention comparing Mediterranean-style vs a standard diet style.	4 mo NR 5 sessions (consultation every 3 wk) Duration: NR Delivered by: nutritionists	✓	✓	NR	NR	Family (parents and siblings) was involved in the intervention.
Violante-Ortíz 2005[49] Cohort (1 group before and after)	NR, but authors affiliations are within the Mexican context Obesity clinic (unclear if private or public) NR	105 67.1% 15.8 (1.5) y	Pharmacologic intervention (ie, sibutramine 10 mg/d) with behavioral modification intervention, and PA and dietetic advice.	6 mo NR Doses daily Delivered by: nutritionist. No additional health professional reported	✓	✓	✓	✓	NR
Virgen-Ortiz 2007 (letter to the editor)[50] Cohort (1 group before and after)	Colima City (Colima) Private school NR	169 NR NR	PA practice and a diet modification intervention	4 mo NR NR Delivered by: NR	✓	✓	NR	NR	NR

Abbreviations: DHQ, docosahexaenoic acid; EPA, eicosapentaenoic acid; NR, not reported; PA, physical activity; SES, socioeconomic status; CATCH, Coordinated Approach to Child Health, PREVENIMSS program, Spanish abbreviation for "Prevention program from the Mexican Institute of Social Security"; ✓, component included; ?, unclear if the component was included; ×, component not included.
*Unclear from the publications if the population data of Elizondo-Montemayor et al[22] and Elizondo-Montemayor et al[23] overlapped. For this reason, these publications are presented separately.

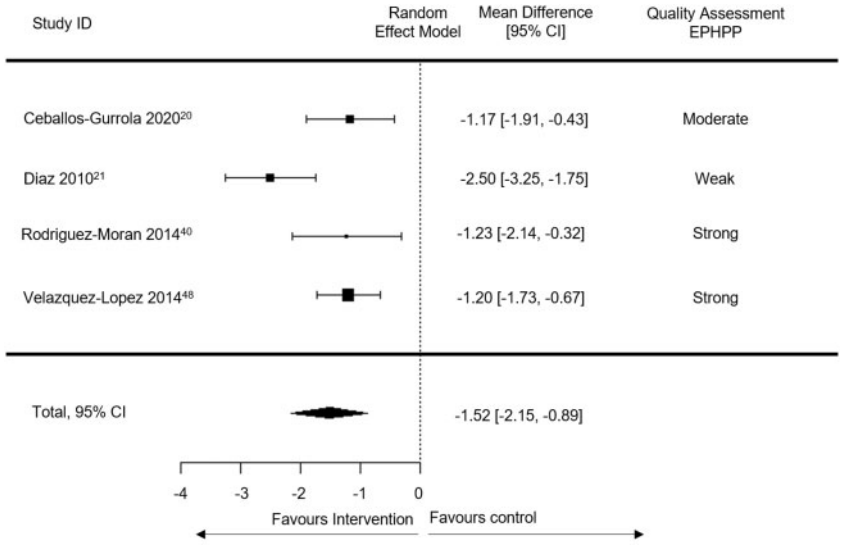

Figure 3 **Meta-analysis with 6 months' data (I^2 = 66%).** Weight of each study: Ceballos-Gurrola et al,[20] 12.7%; Diáz et al,[21] 27.5%; Rodríguez-Morán et al,[40] 26.9%; Velázquez-López et al,[48] 32.8%. Total number of participants in the intervention groups: 116; total number of participants in the control groups: 121. EPHPP, Effective Public Health Practice Project CI, Confidence Interval.

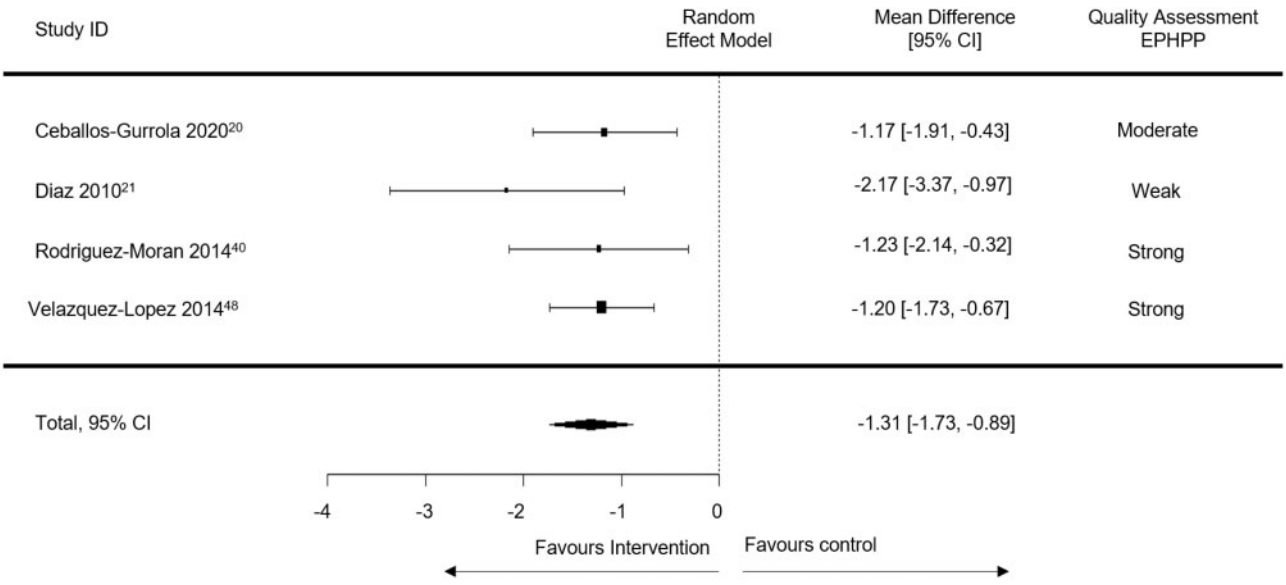

Figure 4 **Meta-analysis with 12 months' data (I^2 = 50%).** Weight of each study: Ceballos-Gurrola et al,[20] 19.2%; Diáz et al,[21] 21.6%; Rodríguez-Morán et al,[40] 35.6%; Velázquez-López et al,[48] 23.5%. Total number of participants in the intervention groups: 116; total number of participants in the control groups: 121. EPHPP, Effective Public Health Practice Project, CI, Confidence Interval.

sample of 237 participants (age range, 11–13 years old), were suitable to be included in a meta-analysis, and only 2 of these were of strong quality. Moreover, these 4 RCTs were delivered in different settings. Also, from the 29 studies included in this review, evidence regarding weight-related outcomes improvement was heterogeneous and inconclusive. Most of the evidence was of low quality, which increased the risk of bias. Across all the studies, several interventions with different durations and intensities were found. Still, no long-term interventions (≥12 mo) were identified in this systematic review.

Overall, the purposes of the interventions in the 29 studies identified mainly were to reduce energy intake, increase energy expenditure, and decrease sedentary behavior. Some interventions (n = 8) also included a psychological or behavioral component, and 3 included pharmacologic treatment. One abstract reported the comparison of 2 types of bariatric surgery among adolescents. There is still no gold standard childhood

Table 3. **Quality assessment of included interventions**[a]

Reference	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and drop-outs	Overall rating	Funding	COI
Ceballos-Gurrola 2020[20]	Moderate	Strong	Weak	Moderate	Strong	Moderate	Moderate	NR	NR
Díaz 2010[21]	Weak	Strong	Strong	Strong	Strong	Weak	Weak	Funded by an international agency	Nothing to declare
Elizondo-Montemayor 2013[22]	Moderate	Moderate	Weak	Moderate	Strong	Weak	Weak	No funding received	Nothing to declare
Elizondo-Montemayor 2014[23]	Weak	Moderate	Weak	Moderate	Strong	Strong	Weak	Funded by a private university	Nothing to declare
Escalante-Izeta 2013 (abstract)[24]	Weak	Moderate	Weak	Moderate	Weak	Weak	Weak	NR	NR
García-Morales 2006[25]	Moderate	Strong	Strong	Strong	Strong	Moderate	Strong	Abbott Laboratories	NR
Garibay-Nieto 2017[26]	Weak	Strong	Strong	Moderate	Strong	Weak	Weak	Science Mexican Council	NR
González-Heredia 2014[27]	Moderate	Strong	Weak	Moderate	Strong	Weak	Weak	NR	Nothing to declare
Hall-López 2017[28]	Moderate	Moderate	Weak	Moderate	Strong	Weak	Weak	Funded by a public university	Nothing to declare
Huang 2010[29–31]	Moderate	Strong	Strong	Moderate	Strong	Strong	Strong	Funded by a public pediatric hospital	Nothing to declare
Jimenez 2017 (abstract)[32]	Weak	Moderate	Weak	Moderate	Weak	Weak	Weak	NR	NR
Laguna-Alcaraz 2017[33]	Moderate	Moderate	Weak	Moderate	Strong	Weak	Weak	No funding received	Nothing to declare
López-Alarcon 2019[34]	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Funded by public health institute and National Council of Education and Science Mexican Council	Nothing to declare
López-Alarcon 2020[35]	Moderate	Strong	Strong	Weak	Strong	Strong	Moderate	Funded by public health institute	Nothing to declare
Luna-Ruiz 2007[36]	Moderate	Moderate	Weak	Moderate	Strong	Strong	Moderate	NR	NR
Martin-Mosqueda 2012[37]	Weak	Moderate	Weak	Moderate	Strong	Weak	Weak	NR	NR
Moran 2017[38]	Moderate	Moderate	Weak	Moderate	Strong	Strong	Moderate	NR	NR
Pompa-Guajardo 2018[39]	Weak	Moderate	Weak	Moderate	Strong	Moderate	Weak	NR	NR
Rodríguez-Morán 2014[40]	Moderate	Strong	Strong	Moderate	Strong	Moderate	Strong	Partially funded by public health institute	Nothing to declare
Romero-Pérez 2020[41]	Moderate	Strong	Weak	Moderate	Strong	Weak	Weak	No funding received	Nothing to declare
Rosado 2008[42]	Strong	Strong	Strong	Moderate	Strong	Moderate	Strong	Funded by industry (Kellogg's)	Nothing to declare
Rosas-Nexticapa 2017[43]	Weak	Strong	Weak	Moderate	Strong	Weak	Weak	Funded by the National Council of Education and Science Mexican Council	NR
Sáenz-Soto 2004[44]	Weak	Moderate	Strong	Moderate	Strong	Moderate	Moderate	NR	NR
Santiago-Lagunes 2018 (Abstract)[45]	Weak	Moderate	Weak	Moderate	Strong	Weak	Weak	NR	NR
de Sanchez 2004[46]	Weak	Moderate	Weak	Moderate	Strong	Strong	Weak	NR	NR
Velázquez-López 2009[47]	Moderate	Moderate	Weak	Moderate	Strong	Weak	Weak	Unclear if funded by public health institute	Nothing to declare

(continued)

Table 3. **Continued**

Reference	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and drop-outs	Overall rating	Funding	COI
Velázquez-López 2014[48]	Moderate	Strong	Strong	Strong	Strong	Strong	Strong	Funded by public health institute	Nothing to declare
Violante-Ortíz 2005[49]	Weak	Moderate	Strong	Moderate	Strong	Weak	Weak	NR	NR
Virgen-Ortíz 2007 (letter to the editor)[50]	Weak	Moderate	Weak	Moderate	Strong	Weak	Weak	NR	NR

Abbreviations: COI, conflict of interest; NR, not reported.
[a]Quality assessed using the Effective Public Health Practice Project Quality Assessment Tool[12] for quantitative studies.

obesity treatment. However, some effectiveness has been shown in multicomponent interventions.[51]

In 12 studies, parents were included in the activities, and in 3, siblings were included as well. The involvement of parents has been described as a critical factor for the effectiveness of childhood obesity treatments.[52] Family-based obesity therapy provides interventions for both children and their parents, but children benefit more compared with their parents.[53]

We found that most interventions to treat obesity in Mexican children and adolescents were delivered in a clinical setting (n = 17 of 29). Also, from the included studies, no environmental changes were identified. Childhood obesity treatment ideally should be provided within an integrated care system, including primary care practice, a tertiary care center, and support at home, school, and in community settings.[51] The conception of a support network for young people while attempting to lose weight and maintain a healthy weight needs to target different settings and include several stakeholders. Likewise, environmental changes need to be made to facilitate behavioral change.[54]

It is noteworthy that Mexico has led the implementation of different nationwide strategies to tackle obesity among the general population. For instance, Mexico recently introduced a 1 peso/L excise tax on sugar-sweetened beverages.[55,56] More recently, a front-of-pack labelling system has been implemented.[57] Still, effective and targeted strategies are needed urgently to tackle this problem among children and adolescents. Some institutional documents about generic obesity prevention and diagnostic procedures can be found.[58–60] However, such documents are not targeted to populations <18 years old, do not contemplate a comprehensive treatment of obesity, and are mainly limited to primary health care.

From the 4 RCTs included in the meta-analysis, the studies of Rodríguez-Morán et al[40] and Diáz et al[21] showed the most beneficial effect across studies. However, the Rodríguez-Morán et al[40] study was considered to have a strong quality, whereas the study of Diáz et al[21] was considered to be of low quality. The intervention delivered by Rodríguez-Morán et al[40] included an individualized low-calorie diet, individualized PA advice, group exercise sessions (including parents), and individualized cognitive behavioral therapy as adjuvant treatment. This intervention was delivered in a public clinic by a multidisciplinary team (including doctors, psychologists, nutritionists, and graduates in physical education and sport). Although it was a short-term intervention (4 mo), the frequency was greater than in other included studies. Participants received 20 nutrition sessions (1 h/wk), plus 80 after-school PA sessions, plus individualized

cognitive behavioral therapy sessions (when necessary). This intervention's effect size was significant, favoring the intervention group, and might indicate the importance of an individualized, frequent, and multidisciplinary effort, considering close relatives for treating childhood obesity in a Mexican context. Nevertheless, better-quality research needs to be done in Mexico to determine the optimal length, intensity, and long-term effectiveness of obesity treatment interventions among children and adolescents.

A multicomponent and individualized study that comprises dietary modifications, PA practice, behavioral strategies, and active parental involvement has been suggested in other countries.[6,7,51] Long-term results are needed to measure and identify effectiveness pointers, and might help create an integrated long-lasting health care model that aids in preventing and treating obesity. Such a health care model should make available the integration of follow-up visits to monitor and maintain behavioral change as needed, facilitating the provision of the required intensity and frequency of treatment sufficient to achieve meaningful outcomes.[61,62]

While conducting this systematic review, we found some challenges, including for instance, the poor description of methods across the included papers. The lack of high-quality RCTs also is noticeable. Ten of the 29 studies were RCTs, but only 4 could be included in a meta-analysis. The sample sizes of the included RCTs were relatively small. Few studies with small sizes could introduce into the model bias or variability because of sampling. Some other limitations of this systematic review include the heterogeneity of included studies in terms of intervention design, sample size and characteristics, intervention approach, primary measures used to assess intervention effects, length of follow-up, analytical approaches, and overall quality. Such variability made it challenging for cross-comparisons. Also, the retrieved evidence came from 11 of 32 states in Mexico, so the results might not reflect a nationwide picture.

This work's strengths include, to our knowledge, being the first systematic review conducted about intervention to treat obesity in Mexican children and adolescents. This is relevant considering that most of the published systematic reviews include only English publications, excluding valuable evidence from non–English-speaking low- or middle-income countries such as Mexico. The exhaustive search for evidence was done across 13 databases and 1 search engine, in 2 languages (whenever possible), which helped us capture relevant publications. The included studies' particular characteristics were extracted, and the quality of evidence was appraised, which was considered in the synthesis.

No cost-effectiveness studies regarding Mexican interventions to prevent or tackle childhood obesity were identified in the COMO project. However, some economic models have suggested that the costs of childhood obesity in Mexico from 2006 to 2050 (considering only 2 comorbidities: diabetes and hypertension) will be much higher than the health care system can stand, jeopardizing the health and well-being of the population.[63,64] Early intervention is essential, because less weight change is needed at younger ages to achieve a healthy weight than the amount of weight loss necessary at older ages.[65] Moreover, it has been acknowledged that the ability to estimate a national impact systematically and cost-effectiveness of implementation of childhood obesity interventions enables comparison within and across sector-specific interventions to inform primary prevention investment.[66]

CONCLUSION

Efforts to identify vulnerable populations and implementation barriers among different populations are needed in Mexico. Long-term nationwide interventions and comprehensive recommendations that can guide health professionals and other stakeholders in the obesity treatment at individual and community levels are essential to change the upward trends in obesity prevalence. Such efforts need to be comprehensive, multidisciplinary, and target several risk factors in the long term. This review is part of a broader project aiming to synthesize and use data to comprehend the extent, nature, effects, and costs of childhood or adolescent obesity in Mexico (ie, the COMO Project).[9] Because of the increasing levels of obesity in Mexico, every action measuring or attempting to tackle obesity in Mexico should be acknowledged. Any effort should be considered an experiment, where effects must be documented and evaluated to benefit every other initiative or strategy. Such efforts need to enhance their methodological quality, including different settings, stakeholders, and target different health risk behaviors. Interventions should be designed using a comprehensive approach within the national sociopolitical, cultural, and economic contexts.

Supporting Information

The following Supporting Information is available through the online version of this article at the publisher's website.

Appendices 1 and 2 (which contain Table S1 and Table S2) are supplied as supporting information.

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Appendix 1.

Detailed Methods Section

A sensitive search was developed to include index terms, free-text words, abbreviations, and synonyms to combine the key concepts to this review. Terms such as "overweight", "obesity", "child", "adolescent", "intervention", "program", "Mexico" were included in the strategy with different term variation/synonyms and Boolean connectors to capture relevant publications. The databases searched included: MEDLINE, EMBASE, the Cochrane Library, Global Health Library, LILACS, CINAHL, CAB abstracts, ERIC, PsycINFO, ScienceDirect, Scopus, AGRICOLA, and SciELO Citation Index. Also, the search engine Google Scholars was used to retrieving relevant evidence. When possible, searches were also done in Spanish to capture relevant references. No inclusion study design restrictions were applied. Full reports and conference abstracts were included only if these met the inclusion criteria. Also, reference lists were scrutinised for additional publications and experts in the field contacted for additional relevant reports.

Selection criteria:

Reports from 1995 onwards were included in this project to focus on information conducted under current epidemiological and environmental circumstances of child and adolescence overweight and obesity in Mexico. All searches were restricted to English, Spanish or Portuguese language publications. By including publication in these three languages, we included reports from the most widespread languages spoken in the Americas (including possible comparisons among American countries that include Mexico).

Following the PICOS framework (**Table 1** in the main manuscript), our inclusion/exclusion criteria were:

Population: Children and adolescents from zero to 18 years old (mean age at the start of the study or evaluation) from any ethnicity or gender living in Mexico were considered in this review. Studies including children and adolescents with overweight or obesity (defined as body mass index [BMI] above a healthy weight range, BMI z-score > 1, clinical diagnosis, or study population reported as having overweight or obesity) were included. Mexican children living in a different country were excluded from this review to conceptualise the obesity problem within the country sociodemographic characteristics and avoid cofounding information inherent to the migration phenomena. Studies that analyse children's severe conditions or adverse conditions, in which weight might be influenced either by the condition or the treatment, were excluded (e.g. HIV, cancer, fibrosis, Down syndrome). Studies on premature babies and pregnant adolescents were also excluded.

Interventions: Studies testing obesity treatment through lifestyle interventions, environmental interventions, behavioural interventions, pharmacological interventions, or surgical interventions were considered. Studies delivered in any setting (e.g., home-based, school-based, clinic-based, community-based) or digital domains (e.g., mobile phone networks interventions) were considered.

Comparator: Any or none.

Outcomes: Effectiveness measurements included anthropometric changes (e.g., weight, BMI, BMI z-score). Due to the interventions' nature, any lifestyles changes (e.g., dietary, physical activity, behavioural outcomes) were also considered.

Study Design: Any experimental study design was considered in this review.

Data extraction

Titles and abstracts were screened by two reviewers (LL, MGB) and 100% checked by a third reviewer (MA-M). Relevant titles and abstracts were full text reviewed by two reviewers (LL, MGB). Two reviewers (MA-M and LLC) extracted data independently from included papers. In case of any disagreement, a third author was contacted (YG).

A data extraction form was based on the Effective Public Health Practice Project Quality Assessment Tool [EPHPP][S1] for quantitative studies with additional data extraction items specifically related to the design and

implementation. To facilitate a complete understanding of interventions, items from the template for intervention description and replication (TIDieR)[S2] checklist and guide were included in the extraction. Data on the main components of the interventions were extracted and categorised according to the components included: Nutritional (i.e. interventions that included diet prescriptions or nutritional advice), Physical Activity [PA] (i.e. if interventions included PA practise or PA advice), behavioural or psychological (i.e. if the interventions considered psychological, family or behavioural therapy, as well as counselling or management strategies), pharmacological (i.e. sibutramine, or any other treatment to reduce weight), surgery (i.e. bariatric surgery) and environmental (i.e. interventions that included changes in children's environments to promote a weight change). Any other component was also recorded. Additionally, we documented if any theory or framework was used to design or deliver the intervention.

Risk of Bias

Following the Cochrane Handbook's recommendation for Systematic Reviews of Interventions for health promotion interventions,[S3] the EPHPP[S1] tool was used. This tool produces an overall methodological rating of strong, moderate, or weak evidence in support of interventions; it can be applied to different design and setting interventions and consists of 8 categories: selection bias; study design; confounders; blinding; data collection methods; withdrawals and drop-outs; intervention integrity; and analysis. The scores were summed according to the quality assessment tool's guidelines for each category, producing a global rating.[S1] Also, funding sources and reported conflicts of interests was extracted and considered in this review.

Data synthesis

A narrative synthesis was conducted across all the included. A meta-analysis of randomised controlled trials [RCTs], providing data from baseline to post-intervention and including a control group, was conducted. The included RCTs in the meta-analysis were those in which the Mean Difference [MD] and its Standard Deviation [SD] of Body Mass Index [BMI] were reported or could be calculated from the available data. Whenever provided, intention-to-treat data were used. WebplotDigitizer software was used when data was provided in graphs. Formulas from the Cochrane Guidelines [S4] were used to derive necessary statistics in the meta-analysis and impute a change from baseline SD using a correlation coefficient. [S5] It has been acknowledged previously that lifestyle interventions in obesity are quite heterogeneous; hence a random effect model was chosen to do this analysis.[S6-S7] The random-effect model was used to assume varying effect sizes between studies because of different study design and study population. In cases where more than one intervention group was being studied, we included data only of the interventions group that included more components. Due to the small sample sizes, the Hedges estimator[S8] was used to fit the random-effect model. The analysis was done using R statistical software by using the library "*metafor*". Results are presented in a forest-plot.

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Appendix 2.

Results

Our searches identified 7363 references, from which 1432 were retrieved for full-text review. Overall, 886 references were identified by reporting obesity-related data in Mexican children and are included in the COMO database. From these, 58 interventions (presented in 74 publications) were identified. Twenty-nine interventions (presented in 31 publications)[S1-S31] analysed interventions met our inclusion criteria and are presented in this paper (Figure 1).

Most of the publications were full-text papers, except for three abstracts[S5,S13,S26], one a doctoral thesis[S27] and one letter to the editor.50 Ten studies were RCTs;[S1,S2,S6,S7,S15,S20,S22-S24,S29] three were controlled clinical trials,[S8,S10,S16] three were cohorts analytic studies with more than one group (two or three groups, before and after),[S13,S20,S27]and 13 were cohort analytic studies with a single group (before and after).[S3-S5,S9,S14,S17,S18,S25,S26,S28,S30,S31]

Overall, the 29 interventions identified included 2302 participants (ages ranging from 8 to 16 years) that were recruited from 11 states (out of 32 states) in Mexico (**Figure 2**). In one of the studies, the location was unclear.[S30] All the interventions included both males and females. Most of the interventions were delivered in a clinical setting (17/29); some (7/29) in a school setting, [S1-S4,S9,S22,S24,S31] one included school and clinic setting;[S21] one recruited participants in a school but was delivered outside school hours.[S22] Two were delivered in summer camps,[S20,S21] and for one[S5] of the abstracts, the setting was unclear (see details in **Table 2** in the main manuscript).

Regarding the components included, 20/29 included a nutritional component, from which 7/20 included a nutritional education intervention, and 13/20 included individualised dietary plans. 19/29 included a PA component, were 7/19 included only PA advise and 12/19 included sessions of PA practise (four of which included parents in the sessions). 8/29 included a psychological or behavioural component. 3/29 studies included pharmacological treatment. Of these, two[S6,S30] (one RCT and one group cohort study) included 10 mg/day of sibutramine for six months, and one[S7] randomised participants to receive either metformin (1 g/day) or conjugated linoleic acid (3 g/day) or a placebo (1 g/day). One abstract[S13] reported effects of two different bariatric surgeries among participants; however, this abstract was poorly reported. None of the included studies reported an environmental change to aid the weight-loss process. In 13/29 of the interventions, parents were included in the interventions. In 3/29 of the interventions, families (parents and siblings of the participants) were included.[S10,S28,S29] **Supplementary Table 1**

Some studies included alternative therapies to lifestyle interventions. One intervention [S1] included "phototherapy" besides PA sessions in one of the two intervention groups. In two studies, participants were randomised to receive dietary supplementation. In one,[S15] participants were randomised to either 800 mg/day DHA + EPA polyunsaturated fatty acids or a placebo. In the second,[S24] participants were randomised to receive DHA (docosahexaenoic acid) in two different doses or fresh salmon in two different amounts. An overview of the component is presented **in Table 2** in the main manuscript. More details about the interventions are provided in **Supplementary Table 1** below.

The duration of the 29 included interventions ranged from 1 week to 12 months. There was no long-term (>12 months) intervention identified in this review. Five/29 studies[S13,S16,S20,S25,S27] reported following up participants after finalising the intervention. An approximate number of sessions was calculated with reported information in publications, and this number varied from 4 to 106 sessions. (see details in **Table 2** in the main manuscript**)**

All the included studies reported anthropometric outcomes, 17 studies included biochemical parameters changes as an outcome, and nine included other clinical outcomes (e.g. blood pressure or heart rate). Eleven reported dietary changes in outcomes and seven reported PA outcomes. An overview of the reported outcomes and tools used to measure such outcomes can be seen in **Supplementary Table 2,** below.

Regarding anthropometric outcomes, 10/29 reported significant reductions, 9/29 reported no significant changes, and in 5/29 the effect of the intervention was unclear. 2/29 interventions[S9,S31] reported significant changes in some, but not all, of the anthropometric outcomes considered (e.g. changes in skin folds, but not in BMI). Two studies[S10,S27] reported effectiveness only in those participants that finished the intervention. One RCT[S23] (funded

by Kellogg's Mexico) studied increasing "ready to eat cereals" intake as a healthy option for reducing weight and blood lipids. In this study, participants were randomised to different doses of ready to eat cereal vs the control group (no cereals). The authors reported that after 12 weeks of intervention, there was a significant increase in body weight in the two of the intervention's groups and the control group. In this study, only the group with one dose of ready to eat cereals plus nutrition education had no increment in body weight (but no reduction was reported).

Out of 10/29 RCTs, only four were included in the meta-analysis.[S1, S2,S21,S29] One/10 was excluded since consisted of a pharmacological therapy (i.e. sibutramine, banned since 2010 in Mexico).[S6] Three/10 more provided nutritional supplementation (with some dietary advice, but not a lifestyle intervention).[S7,S15,S24] One/10 did not provide sufficient information to calculate the effect size.[S22] Rosado 2008[S23] was excluded from the meta-analysis, since this paper aimed to increase ready to eat cereals, as a strategy to reduce excess body weight, and no individualised nutritional advice was provided to participants.

From the four RCTs included,[S1,S2,S21,S29] two were conducted in a clinic, [S2,S29] one in a school [S1] and one recruited participants from a school, but delivered the intervention in a public clinic.[S21] However, it was unclear from the publication if activities were also undertaken in the school.

The population included in the four RCTs included in the meta-analysis was 237 participants (age range 11 to 13 years old). The duration of these interventions varied from 3 months until 3.5 to 12 months. The intensity and frequency of sessions also varied from 5 to 100. Dias 2010 intervene in children with obesity in an intense format during the first 12 weeks, and then, the intensity was decreased, and children were seen monthly. Diaz 2010 was the only study presenting data at 6- months and 12- months. Since the rest of the included studies included in the meta-analysis lasted 3.5 or 4 months, we ran two analyses: one including data from Diaz 2010 recorded at six months **(Figure 3)**, and one another with data at 12 months **(Figure 4)**.

There is a significant effect (-1.52, 95% CI -2.15, 0.89) on BMI on a short-term (≤6 months) favouring the intervention groups. Such effect is diminished when including the 12 months data of Diaz 2010 (-1.31, 95% CI -1.73, -0.89), but stays significant favouring the intervention groups.

Supplemental Table 1. Details on the interventions included in this Systematic Review.

STUDY ID	Nutritional component	PA component	Behavioural or psychological component	Environmental changes	Another relevant component	Material Provided	Control group activities
Ceballos-Gurrola 2020[S1]	Educational sessions for parents and adolescents based on the Family Nutrition Guide by FAO 2006, including healthy eating sessions.	PA practise sessions based on cooperative, modified, and split-court and games essential sports, based on three fundamentals: playful-situational orientation, physical abilities, and skills.	NR	NR	Phototherapy (i.e. adolescents were exposed a considerable distance to an LED panel for a specific time) post exercise. Parents were involved in the intervention	NR	The control group only underwent the measurements.
Diaz 2010[S2]	Educational sessions and diet prescription included a simple food guide using different colours (red, yellow, and green) to designate different food groups. Participants were given a personalised diet of 1,200 to 1,800 kcal/day.	PA and sedentary weekly goals. Such goals were revised periodically.	The intervention focused mainly on children's perceptions of susceptibility, severity, benefits, and barriers.	NR	Parents received six education sessions and were encouraged to lose weight if they were overweight.	Food guide adapted to include various traditional foods eaten in México.	Participants in the control group and their parents attended monthly consultations of 10 to 15 mins with a primary care physician. BMI was monitored, PA advise was given and encouraged to eat a healthy diet
Elizondo-Montemayor 2013[S3]	Balanced macronutrient dietary planning and provision of structured daily meals for the following three weeks.	PA plan encouraging the practice of a 60 min day and motivation to decrease screen time to less than 2 hrs day.	NR	NR	Parents were involved in the intervention.	NR	NA
Elizondo-Montemayor 2014b[S4]	Balanced macronutrient dietary planning and provision of structured daily meals.	NR	NR	NR	Parents were involved.	NR	NA

Escalante-Izeta 2013 [S5] (Abstract)	Nutrition educational sessions, including topics such as food false advertising.	Educational sessions that included PA (no further detail provided).	Educational sessions that included body image, communication, conflict resolution, assertiveness, self-esteem, and relaxation.	NR	NR	NR	NA
Garcia-Morales 2006 [S6]	Participants received an individualised diet (30 kcal/kg of the current body weight) with the following macronutrient distribution: 50% carbohydrates, 30% lipids, and 20% proteins. All participants received a list of recommended food portions and possible combinations.	Participants were advised to perform at least 30 mins of aerobic PA a day.	NR	NR	Pharmacological intervention (i.e. Sibutramine)	NR	Both groups had diet and exercise advice individually tailored for each participant.
Garibay-Nieto 2017 [S7]	Educational sessions about balanced and healthy nutrition. An individualised diet with the following macronutrient distribution: 55% carbohydrates, 20% proteins, 25% lipids (7% saturated fat, 300 mg/d cholesterol, 1% trans-fat), and 3 g of salt per day.	An educational session on the benefits of exercise and PA advise (of at last five days a week and for a minimum of 60 mins).	Sessions on emotion-related eating behaviour and family support.	NR	Pharmacological intervention participants were received either metformin (1 g/d), conjugated linoleic acid, containing 50:50 isomers c9,t11 and t10,c12 (3 g/d).	NR	Same lifestyle intervention as intervention group + placebo (1 g/d).
Gonzalez-Heredia 2014 [S8]	Participants received a personalised diet according to their weight and age no further detail provided.	NR	NR	NR	The intervention group included a personalised diet for the parents.	NR	Unclear if the control group received or not intervention. Per reported information, the main difference is that the intervention group also

							included parents but not in the control group.
Hall-Lopez 2017 [S9]	NR	PA practice sessions were divided into 5 min of warm-up, 40 mins of aerobic component, and 5 min of cool down with stretching and movements that reduced heart rate progressively.	NR	NR	Pedagogical support for the teacher instructs PA, including a moderate to vigorous intensity for at least 50% of class time.	An activity file containing concise information and instructions to be implemented in class was used as didactic support for teachers.	NR
Huang 2010 [S10-S12]	Nutritional intervention that included a personalised low-calorie diet. Nutrition counselling was based on healthy food selections, emphasising to reduce dietary fat and sugar-based carbonated drink intake, together with an increase in vegetables and fruits with rich fibre.	PA practise performing brisk walking for 30 min daily during the first two weeks. After that, the duration of activity was progressively increased to 1 h by the third week. Participants were also encouraged to undertake moderate-intensity PA (cycling, jogging, and swimming) at least five times per week in addition to daily walking.	Behavioural counselling (in consultation with a clinical psychologist)	NR	The parents of the adolescents participated in four intensive lifestyle support sessions and received individual telephone session.	NR	NR
Jimenez 2017 [S13] (Abstract)	NR	NR	NR	NR	Surgery	NR	NR
Laguna-Alcaraz 2017 [S14]	Participants were advised to decrease caloric diet to reach a caloric intake	PA was performed at the clinic guided by an undergraduate general practitioner. The workouts for PA	NR	NR	Parents involved in the sessions.	All participants were provided with the PREVENIMSS guide for teenagers. The guide includes health	NR

	between 21 and 25 kcal/kg/day. Unclear if they received or not a personalised diet.	sessions were designed for the whole family, in which the interaction of parents with children was favoured.				promotion, nutrition, prevention and control of diseases and sexual and reproductive health.	
Lopez-Alarcon 2019 [S15]	Children were prescribed a hypocaloric diet consisting in 700 kcal restriction from regular daily intake.	NR	NR	NR	Daily doses of 800 mg EPA + 400 mg DHA for 3 months.	NR	Placebo (1 g sunflower oil).
Lopez-Alarcon 2020 [S16]	Unclear	NR	Mindfulness activities during sessions included practice meditation, learn different types of breathing, improve body awareness using body scan and organ senses scanner techniques, understand the transient character of emotions, acquire abilities to observe and release thoughts, use the semaphore technique to detect those anxiety signals that provoke impulsive reactions, and practice conscious eating. At the end of each session, a short homework exercise was assigned to help children to apply	NR	At least one parent or caregiver of each child was asked to attend the 2-h mindfulness sessions, delivered in parallel with the sessions provided to the children, but in a different room, to learn mindfulness attitudes and reinforce the information given to children.	NR	Children assigned to the conventional nutrition intervention written dietary recommendations including a hypocaloric diet (700 kcal restriction). Children and at least one parent or caregiver attended half-hour sessions, once a week, to revise and solve questions about diets.

			mindfulness skills to daily life				
Luna-Ruiz 2007 [S17]	Participants have prescribed a personalised diet (calories assigned depending on the age), with a macronutrient distribution as follows:10-15% protein, 20-25% of lipids, and 55-60% of carbohydrates. The nutritionist provided practical food-making sessions for mothers or caregivers of children.	PA practise sessions were carried out outdoors, including the mothers with the children. Educational material and PA advice were also provided.	NR	NR	Parents were involved and received the intervention.	Educational material was provided (no further detail).	NA
Martin-Mosqueda 2012 [S18]	Children and parents were taught to create their menus in a restrictive way but in a nutritionally balanced way.	PA practice sessions had a recreative and non-competitive aim. Sessions were undertaken in a friendly environment.	Cognitive Behavioural Therapy was delivered in group sessions, including parents and children. This therapy looked to facilitate the change of lifestyle from the joint work between participants, parents, and team-work. Participants and their parents were provided with strategies for problem-solving	NR	Parents included in the intervention.	NR	NA

			and relapse prevention.				
Moran 2017 [S19]	Educational sessions included the importance of adequate food intake by lowering the amount of refined sugary food, reducing the number of carbohydrates and fat consumed every day, and increasing fibre intake. The principal strategy was dietary modifications focusing on change eating habits.	Educational session about the importance and health benefits of PA. Participants received PA advice based on the USA PA pyramid for children.	NR	NR	NR	NR	NA
Pompa-Guajardo 2018 [S20]	Unclear	Unclear	Unclear	NR	Group sessions. Parents were included.	NR	Control group did not receive any type of treatment.
Rodriguez-Moran 2014 [S21]	Personalised low-calorie diet (30 kcal/kg of ideal body weight) with a macronutrient distribution follows 21% fat (less than 10% saturated fat), 25% protein, and 54% carbohydrates.	PA practise in group sessions delivered in a clinical setting at afterschool hours (parents were invited to participate) and PA advice (at least half an hour/day five days/week),	Cognitive Behavioural Therapy and further psychological support if necessary.	PA was performed in the clinic.	Furthermore, the parents or guardians of both groups' participants were invited to participate in the exercise sessions in groups.	NR	A low-calorie diet and PA advise. Only if necessary psychological support for management was provided.
Romero-Perez 2020 [S22]	NR	PA practise sessions with an initial 5-min warm-up, a 40-min core session in which specific exercises and pre-sport games were	NR	NR	NR	NR	No intervention, usual activities.

		performed to work on developing conditional and coordinative capacities, and a final 5 min of relaxation and stretching. Children exercised their conditional and coordinative capacities (strength, resistance, coordination, and speed). Sessions were performed at afterschool school hours.					
Rosado 2008[S23]	Group 1 consumed one serving of 33 ± 7 g of RTEC at breakfast. Group 2 consumed two servings of 33 ± 7 g of RTEC, one at breakfast and another serving at dinner. Group 3 consumed one serving of 33 ± 7 grams of RTEC, and also, both children and mothers received a nutrition education guide that contained.	NR	NR	NR	Mothers involved.	Both children and mothers received a nutrition education guide that contained recommendations for healthy eating.	Children in the control group (group 4) received no RTEC.
Rosas-Nexticapa 2017 [S24]	No. Supplemented daily over three months, and otherwise, no changes in the diet were established during the study.	NR	NR	NR	Supplementation of 70 or 105mg of DHA and 10 or 15g of salmon/day	NR	Some of the children received salmon in two different amounts.

Saenz-Soto 2004[S25]	Educational sessions on the eating pattern and its relationship with health.	PA practise sessions, including adolescents and mothers, consisted of warm-up movements for conditioning muscles, tendons and joints; strength and endurance exercises that gradually increased; and cooling movements for 20 mins. Also, educational sessions on the PA, sedentary lifestyle and its relationship with health were delivered.	NR	NR	Mothers and adolescents were involved in the intervention.	NR	NA
Santiago-Lagunes 2018 [S26] (Abstract)	Unclear	Unclear	NR	NR	NR	NR	NA
Solis-de-Sanchez 2004 [S27]	Unclear	Unclear	NR	NR	NR	NR	Children did not participate in the summer camp or multidisciplinary programme.
Velazquez-Lopez 2009 [S28]	Personalised diet (adjusted for child's age and gender) with a macronutrient distribution follows: 15 to 20% protein; 30% fats (10% saturated fat and 20% monounsaturated and polyunsaturated fat), and 50-55%c carbohydrates.	PA advice based on the PA pyramid and participants was suggested to carry out at least 2-3 days a week. General recommendations were given to reduce sedentary lifestyles.	NR	NR	Families included	NR	Twenty-four children and adolescents received the Mediterranean-style diet (MSD), and 25 received the standard diet.

Velazquez-Lopez 2014[S29]	The Mediterranean-style diet group received a personalised diet with a macronutrient distribution: 60% carbohydrates (50% complex and no more than 10% refined and processed sugars), 25% lipids, and 15% proteins. Consumption of foods rich in essential fatty acids (e.g. olives oil), omega 3 fatty acids (e.g. salmon); omega 9 fatty acids (e.g. olive oil); antioxidants (e.g. such as beta carotenes), and flavonoids (e.g. grapes); and e) fibre.	Both groups received general recommendations about PA.	NR	NR	Families included	NR	The standard diet group received a personalised diet with a macronutrient distribution: 55-60% of carbohydrates (45-50% complex and no more than 10% refined and processed sugars), 25-30% lipids, and 15% proteins. Participants were encouraged to consume homemade diets, avoiding fried or sugary food and fresh fruit and vegetables. At the same time, any dairy products and products of animal origin should be low in fat.
Violante-Ortiz 2005[S30]	Participants received a personalised diet (30 kcal/kg of current body weight) with a macronutrient distribution: 50% carbohydrates, 30% lipids, and 20% proteins. Participants received a list of recommended food portions and possible combinations.	At least 30 mins of aerobic PA per day was recommended.	Behavioural modification programme (no further detail provided)	NR	Pharmacological (Sibutramine)	NR	NR

Virgen-Ortiz 2007[S31] (letter to the editor)	Participants followed a "Traffic Light Diet" (No further specification provided).	Participants followed a PA practise intervention that consisted of walking and recreational activities.	NR	NR	NR	NR	NR

NR=Not Reported, NA= Not Applicable, PA= Physical Activity, RTEC= Ready to Eat Cereals.

Supplemental Table 2. Overall results

STUDY ID	Anthropometric	Diet	PA	Biochemical	Clinical	Other
Ceballos-Gurrola 2020[S1]	Non-significant reductions in BMI between groups after the intervention. However, there was a significant difference in the tricipital fold among groups, significantly reducing the group with phototherapy.	NR	NR	Significant reductions of triglycerides and glucose were reported in the intervention group without phototherapy at the end of the intervention.	Non-significant differences in blood pressure among groups after the intervention	Any intervention, with or without phototherapy, corresponded with better social self-concept for the control group.
Diaz 2010[S2]	Significant differences in body weight and BMI between groups. Intention-to-treat analysis showed significant differences between the groups in body weight and BMI at 12 months. Lifestyle group participants had a slight non-significant increase in body weight. In contrast, the control group participants had a more significant mean body weight increase, and the difference between the groups was significant.	NR	NR	No significant between-group changes in fasting glucose, triglyceride, HDL, LDL, or total cholesterol levels at 6 or 12 months.	Significant differences between-group systolic and diastolic blood pressures only at six months in favour of the lifestyle intervention, but not at 12 months.	NR
Elizondo-Montemayor 2013[S3]	By the end of the intervention, there was a significant decrease in BMI. Also, the prevalence of normal weight children reached 8%, whereas children with obesity fell to 60%. There was a significant decrease in the BMI percentile at the end of the intervention. A significant reduction in the prevalence	Significant decrease in energy intake s at the end of the intervention. Diet analysis showed that most children maintained the recommended dietary composition in each of the visits.	Children increased their PA by approximately 15 min a day ($p= 0.02$) and two days a week ($p< 0.01$). Although children-maintained screen time every day, there was a reduction of 48 min day ($p< 0.01$).	The prevalence of Metabolic Syndrome was significantly reduced from 44% at baseline to 16% at the end of the intervention ($p<0.01$), which is a noteworthy decrease. There was also a striking reduction in hypertriglyceridemia prevalence from 64% to 35%, of HDL 40 from	Levels of hypertension decreased from 19% to 0%.	NR

	of children with WC >90th percentile decreased from 72% to 57% (p= 0.01). The % body fat also significantly decrease (p<0.01).			60% to 41%. The only child with hyperglycaemia achieved normal glucose levels. Also, there was a significant decrease in the prevalence of the number of risk factors for Metabolic Syndrome (p< 0.01).		
Elizondo-Montemayor 2014b[S4]	BMI percentile, Waist circumference (>90 percentile) and body-fat percentage decreased significantly (p<0.01).	There was a significant decrease in calories consumption of the total energy intake/day. Children maintained the recommended dietary composition of the total energy. There was a significant increase in servings/day of fruits and water consumption (p=0.00). There was a decrease in processed meats, oils, sugar-sweetened beverages, saturated fat, desserts and refined-grain bakery products, whole fat milk, sweets, fast food meals, and fried food.	NR	NR	NR	NR
Escalante-Izeta 2013 [S5] (Abstract)	Discrete changes (10%) in the abdominal circumference of children and their mothers. (Unclear if such changes were significant).	Changes in daily habits such as increased consumption of vegetables, skim milk and slowly absorbed carbohydrates—decreased consumption of foods and beverage high in sugar.	NR	NR	NR	Authors report (unclear how it was measured) that participants learned to work by goals, being the easiest: try new vegetables for a week, and the most difficult: to do 30 minutes of PA every day. The interviews highlighted that the intervention was successful in children's self-esteem and improved

						parents' communication skills.
Garcia-Morales 2006 [S6]	In the sibutramine group, 47.8% had a reduction in the initial BMI; in contrast, in the placebo group, 4.3 % achieved BMI reduction ($p<0.005$).	There were no significant differences in dietary intake between or within the groups from baseline to 6 months.	There were no significant differences in PA either between or within the groups from baseline to 6 months.	A significant reduction in LDL in both groups was reported. There were significant changes ($p<0.05$) in the rest of the variables in either one or both of the groups (glucose, uric acid, creatinine, albumin, chloride, total cholesterol, AST, alkaline phosphatase, and the increase in the ST segment of the electrocardiogram). However, these changes were not considered clinically relevant by the authors.	All intergroup comparisons among blood pressure and heartbeat were non-significant ($p> 0.05$).	Quality of life measured using the 36-Item Short-Form Health Survey (SF-36) questionnaire shows improvements in both groups. However, there were no significant differences between the groups.
Garibay-Nieto 2017 [S7]	The intervention showed a positive effect on weight, height, BMI, and waist circumference in the intervention group. Non-significant differences were observed in these parameters between treatment groups.	Results not reported.	The intervention showed a positive effect on PA score in all the groups. Non-significant differences were observed in these parameters between treatment groups.	There was a positive effect on surrogated indexes of insulin resistance in all of the groups. Non-significant differences were observed in these parameters between treatment groups.	NR	Skeletal muscle biopsies Total RNA was isolated from biopsies samples showed upregulated expression of the insulin receptor substrate in the CLA group.
Gonzalez-Heredia 2014 [S8]	BMI was reduced in both groups. However, the differences among groups were not significant. 18.3% of the participants managed to reach a normal weight status after the intervention.	NR	NR	NR	NR	NR

Hall-Lopez 2017 [S9]	There was a significant body fat reduction (p=0.022) at the end of the intervention.	NR	A significant increase in VO2max ($p \leq 0.001$) was registered at the end of the intervention. Changes in aerobic capacity when participating in the programme were registered as well.	NR	NR	NR
Huang 2010 [S10-S12]	Of the total 61 adolescents who completed the programme, 46 attained a decrease in standard deviation score-body mass index (SDS-BMI), while 15 maintained o increased their SDS-BMI.	NR	NR	After six months of intervention, the obese adolescents who decreased SDS-BMI showed significant reductions in insulin and HOMA levels to baseline levels. In adolescents with obesity and stable or increased SDS-BMI, no significant difference was recorded in glucose, insulin, and HOMA except that triglyceride levels increased concerning the baseline values. Compared to the changes in a subgroup with stable SDS-BMI after the intervention, the levels of BMI, BMI percentile, SDS-BMI and triglycerides decreased significantly in a subgroup with the decrease of SDS-BMI.	NR	NR
Jimenez 2017 [S13] (Abstract)	The average excess weight loss was 80% after 12 months of follow-up. No further information provided. (No further information provided).	NR	NR	Glycosylated haemoglobin levels in those with insulin resistance and diabetes remained on average 5.3% at two years of follow-up.	NR	No decrease in the educational performance of each patient nor any psychological alterations. (no further information provided)
Laguna-Alcaraz 2017 [S14]	A significant reduction in BMI ($p = 0.01$) and waist circumference ($p = 0.04$) was observed in the mothers,	There was a significant decrease in caloric intake in both parents and adolescents at the end of	NR	A significant decrease was found in parents BMI, waist circumference, glucose, triglycerides, and	A significant decrease in diastolic blood pressure was observed in parents ($p = 0.013$).	NR

	and a tendency to decrease in BMI was observed in adolescents and their fathers.	the intervention. According to the survey, nutrition domains were improved significantly after the intervention (p=0.000).		total cholesterol and a significant increase in HDL in both parents and adolescents. At baseline, Metabolic Syndrome was diagnosed in 53.57% of the participants (7 parents and eight teenagers). This reduced to 39.28% (4 parents and 7 teenagers) after the intervention (p<0.05).		
Lopez-Alarcon 2019 [S15]	No significant changes in anthropometric parameters were reported. Body Weight changed similarly in both groups at the end of intervention.	No outcomes presented (although measured, participants were asked not to change their diets)	NR	Metabolic markers as insulin, and HOMA changed similarly in both groups at the end of intervention. When djusting for baseline values, changes in weight, insulin, and HOMA was not related with supplementation,	NR	NR
Lopez-Alarcon 2020 [S16]	Significant reductions in BMI, body fat was reported in the intervention group compared to the control group. However, body weight did not change during the 8-week intervention period or at the end of the 16 weeks. However, significant increases in height were observed at both times (p<0.001).	NR	NR	No significant changes in the insulin concentrations were reported.	NR	Anxiety symptoms and perceived stress were measured with the "Spence self-report questionnaire, " a validated tool in Spanish. At the end of the intervention, changes in anxiety scores were significantly lower in the intervention group than the control group (p<0.001). The proportion of children with altered subscales decreased in the MND-CNI group and increased in the control group (p<0.05).

Luna-Ruiz 2007 [S17]	The average BMI gradually decreased from the first to the sixth month ($p < 0.0001$). Adiposity variables also decreased at the end of the study.	Results showed an increase in the consumption and balance of carbohydrates and proteins, whereas the lipids decreased. A significant decrease in energy consumption ($p = 0.0001$) between the beginning and the end of the study.	NR	A non-significant reduction of children with insulin resistance (from 20 to 14 $p=0.06$); hypercholesterolemia, 4 to 1 ($p=0.08$); and hypertriglyceridemia, 10 to 5 ($p=0.06$), between the baseline and the final evaluation was reported.	There was a significant reduction.	NR
Martin-Mosqueda 2012 [S18]	After the intervention, significant weight reduction, decrease in fat and circumference of the waist. Not reported if these changes were significant.	No results reported.	NR	NR	NR	Eating behaviour and habits general health and psychosocial functioning measured using O'Donnell and Warren (2007). Significant differences were presented in the subscales of overeating, rationality, and health habits.
Moran 2017 [S19]	Significant differences in BMI were observed at the end of the intervention.	No results reported.	NR	At the end of the intervention, four children (8.8%) showed normal glucose levels, one had (2.2%) normalisation of cholesterol levels, 6 (13.0%) had reduced serum concentrations of LDL, 5 (10.8%) had increased HDL concentrations, and one was diagnosed with diabetes. At baseline, only five children (10.86%) had hypertriglyceridemia, and at the end of the intervention, 17 children (36.95%) had increased triglyceride levels ($p<0.05$).	NR	NR

Pompa-Guajardo 2018 [S20]	Small but significant BMI change only in one of the interventions group. However, results are reported to be significant depending on adherence and frequency of treatment.	NR	NR	NR	NR	Anxiety Scale manifested in children was used, and no significant changes were observed in anxiety and depression, but a slight decrease in the mean of these variables was observed.
Rodriguez-Moran 2014 [S21]	Non-significant differences between the BMI of the groups was reported. However, the adolescents who received the intervention had a more significant and sustained decrease in body weight and BMI and total fat percentage compared to the control group.	NR	NR	NR	NR	NR
Romero-Perez 2020 [S22]	Non-significant differences were reported between groups and within groups regarding changes in weight, height or BMI Z-Score-	NR	NR	NR	NR	Anxiety was measured with the Manifest Anxiety Scale in Children-Revised, which has a Spanish validation. The students' median score in the psychological aspects at the start and 20 weeks was very similar, and non-significant differences were observed between groups in anxiety level ($p=0.683$) or depressive thoughts ($p=0.885$).
Rosado 2008[S23]	After 12 weeks of intervention, there was a significant increase in body weight in the two RTEC groups. In the control group, only the group with RTEC and nutrition education had no increase in body weight.	NR	Changes in PA-reported practice were not significantly different between basal and final evaluations nor among experimental groups.	Only children that had RTEC and nutrition education showed a significant reduction in triglycerides ($p<0.05$), an increase in HDL ($p<0.01$) and a slight reduction in VLDL ($p<0.05$). Changes	NR	NR

	Bodyweight change in the RTEC and nutrition education group adjusted for gender, school and baseline body weight was also significantly different from the control ($p < 0.001$) and the other two treatment groups ($p<0.01$). BMI reduced significantly only in the group of children that received RTEC and nutrition education ($p < 0.01$).			in the other groups were not significant.		
Rosas-Nexticapa 2017 [S24]	No significant change on weight or adiposity outcomes.	NR	NR	A significant increase ($p< 0.05$) was observed in glucose before and after supplementation. Cholesterol, LDL, VLDL, TG and AI significantly decreased ($p<0.05$) before and after supplementation in all supplemented doses. Also, a significant increase in serum HDL was found after supplementation with the four doses ($p<0.00001$)	NR	NR
Saenz-Soto 2004[S25]	Only two out of 18 participants managed to reach an average weight. No statistical analysis presented.	Self-report on food consumption for one week showed a decrease in foods rich in fat consumption.	Self-reports on the PA carried out during the week reported an increase in activities classified as active and a slight decrease in those classified as sedentary or low intensity.	NR	NR	Social support was measured with the Rosenberg Self-Esteem Scale self-esteem with the Sallis Scale of Social Support for Diet and Exercise. Perception of social support did not improve by the end of the intervention.
Santiago-Lagunes 2018 [S26] (Abstract)	A reduction is reported. However, no statistical analysis is presented.	Good maintenance of healthy eating was reported. However, no statistical analysis is presented.	NR	NR	NR	NR

Solis-de-Sanchez 2004 [S27]	Children with obesity who completed the intervention had a significant decrease in weight and BMI compared to those who did not complete the intervention (which were reported to increase their weight) ($p < 0.05$).	NR	NR	NR	Leptin concentrations were higher in obese children than in non-obese children at baseline and six months. Results suggested that leptin levels in obese children were correlated with their BMI.	NR
Velazquez-Lopez 2009 [S28]	A significant reduction was obtained in body weight ($p=0.001$), BMI ($p = 0.002$), waist circumference ($p=0.001$), hip circumference ($p=0.002$), the waist / hip ratio ($p=0.002$), the average arm circumference ($p=0.021$) and the subscapular fold ($p=0.048$) after the intervention.	NR	At the end of the intervention, 55% of the participants performed some type of exercise, which consisted mainly of swimming, cycling, soccer, walking, or dancing. However, no statistical analysis is presented.	There was a reduction in total cholesterol values ($p=0.026$) and LDL ($p=0.001$) and an increase in HDL ($p=0.013$).	There was a non-significant reduction in their blood pressure at the end of the intervention.	NR
Velazquez-Lopez 2014[S29]	The intervention group significantly decrease BMI, fat mass, lean mass ($p< 0.05$).	The intervention group exhibited a significant increase in dietary fibre consumption, proteins, omega nine fatty acids, zinc, selenium, vitamin E, and flavonoids. Furthermore, fewer saturated fatty acids ($p < 0.05$) were reported; No significant changes were identified in the diet's components in the standard diet group.	NR	The intervention group significantly decreased glucose levels, total cholesterol, triglycerides and LDL levels ($p<0.05$). Furthermore, a significant increase in HDL was also reported in the intervention group ($p<0.05$).	NR	The frequency of components of Metabolic Syndrome significantly decreased in the intervention group ($p<0.05$). About Metabolic Syndrome, the intervention group showed a decrease of 45% in Metabolic Syndrome, which was a significant difference after 16- week of intervention ($p<0.05$).
Violante-Ortiz 2005[S30]	According to intent-to-treat analysis and last observation carried forward analysis, average patient weight and BMI reduced significantly ($p<.001$), as well as waist measurement($p<0.005$).	NR	No result reported	NR	No significant changes in blood pressure were reported.	Adverse events (e.g. changes in blood pressure, constipation, dry mouth, anorexia, headache, tachycardia, restlessness) in at least 18 participants were reported.

Virgen-Ortiz 2007[S31] (letter to the editor)	At the end of the intervention, a non-significant decrease in BMI and% of body fatwas achieved. However, a significant decreasing trend in all body folds was reported.	A decrease in the consumption of fats and an increase in carbohydrates consumption without changes in the consumption of fruits and vegetables was reported. Completers are more easily able to identify the benefits of good eating habits and different aspects of the health risks of obesity.	NR	The levels of triglycerides and glucose remained unchanged at the end of the intervention.	NR	NR

NR=Not reported; BMI=Body Mass Index; LDL= Low-density lipoprotein; VLDL= Very low-density lipoprotein HDL= High-density lipoprotein; TG= triglycerides; PA=Physical Activity; HOMA-IR = Homeostatic Model Assessment of Insulin Resistanc

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5, Table 1
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4, Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Appendix 1
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6, Appendix 1

PRISMA 2009 Checklist

Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6, Appendix 1
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7, Appendix 1

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Table 3
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7, Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table 2 Appendix 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Appendix 2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	9
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Table 3
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Fig 3,4
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	10
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14

PRISMA 2009 Checklist

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097