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Primary prevention of overweight and obesity in adolescents: An overview of systematic reviews

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Summary

The aim of this overview of systematic reviews was to summarize evidence from up-to-date reviews of the effectiveness of interventions aimed at preventing overweight and obesity in adolescents aged 10 to 19 years. We searched nine databases for systematic reviews published between January 2008 and November 2019. We used A Measurement Tool to Assess Systematic Reviews (AMSTAR) 2 to assess the quality of reviews, excluding those of critically low quality, and the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) tool to grade the certainty of included evidence. We included 13 reviews. Three reviews focused on dietary behaviour, six on physical activity, and four on both types of behaviours. Individual-oriented and school-based interventions dominated. Results across reviews showed little or no effect on body mass index, or physical activity levels of adolescents, whereas results from a couple of reviews suggest possibly beneficial effects of public health interventions on dietary behaviours (i.e., consumption of sugar-sweetened beverages). The certainty of evidence was low to very low for all outcomes. Overall, the evidence base for the effect of primary interventions to prevent overweight and obesity in adolescents is weak. In particular, there is a lack of reviews assessing the impact of environmental interventions targeting adolescents, and reviews addressing social inequality are virtually absent from this body of literature.

KEYWORDS

adolescents, obesity, overview of reviews, overweight, prevention

Abbreviations: AMSTAR, A Measurement Tool to Assess Systematic Reviews; BMI, body mass index; BMI z-score, body mass index adjusted for age and gender; CI, confidence interval; CRCT, cluster randomized controlled trial; F/V, fruit and vegetables; GRADE, Grading of Recommendations Assessment, Development and Evaluation; ITS, interrupted time series; LMIC, low- and middle-income countries; M, median; MD, mean difference; MVPA, moderate to vigorous physical activity; NRCT, nonrandomized controlled trial; PA, physical activity; PICO, Population Intervention Comparator Outcome; PROGRESS, Place of residence, Race/ethnicity/culture/language, Occupation, Gender/sex, Religion, Education, Socio-economic status, Social capital; QE, quasi experimental; RCT, randomized controlled trial; ROB, risk of bias; SB, sedentary behaviour; SES, socio-economic status; SMD, standardized mean difference; SSB, sugar-sweetened beverages.

1 | INTRODUCTION

High and increasing prevalence of overweight and obesity in adolescents is a major global public health problem.[1] Adolescents affected by obesity are at higher risk of poor health in adolescence and in later life than adolescents with a normal weight.[2,3]

Adolescence is a time of physical, cognitive, and social development. It is also a period of increasing autonomy, and as such, a period during which health behaviours may be more susceptible to change. Preventive interventions applied in this 'window of opportunity' may be more effective in promoting change to a healthy behaviour and thus in improving health throughout life.[4,5]

The prevalence of overweight and obesity varies across countries, regions, and socio-economic groups. Data from OECD countries suggest a prevalence of self-reported overweight and obesity among 15 year olds that ranges from 10% to 31%.[4] Other survey data suggest generally higher obesity prevalence among boys than girls, younger than older adolescents, and in socially disadvantaged groups.[4,6] Existing approaches for obesity prevention have not been effective at reaching these adolescents, and it is important to adopt universal public health approaches, including structural policy measures, with targeted interventions when necessary.[7–9]

There is general agreement among researchers and stakeholders that actions at all levels, and through a joint effort of governments, institutions, and other private and nongovernmental organizations, are needed for effective prevention.[10,11] Most strategies addressing obesity in young people to date have, however, focused on the school setting through behavioural interventions targeting the individual or as setting-based interventions enabling the healthy choice as the easiest choice and less often on the community or the wider environment.[12,13]

A number of systematic reviews and overviews of reviews (e.g., previus studies[14–18]) of obesity prevention interventions have been conducted. These have mainly targeted younger children, adults, or mixed age groups, and few have assessed the certainty of the included evidence.[14] Previously published overviews of reviews have often been limited to a specific setting (e.g., the community[15]) or to a specific behaviour (e.g., sedentary behaviours [SBs]).[16]

The aim of this overview was to summarize recent evidence from systematic reviews, published after 2008, of the effects of interventions aimed at preventing overweight and obesity in adolescents aged 10 to 19 years. In this overview of reviews, which is part of the Confronting Obesity: Co-Creating Policy with Adolescents (CO-CREATE) project,[17] we will provide up-to-date evidence on the effects of primary interventions targeting adolescents, using robust methods to summarize and grade the certainty of the evidence.

2 | METHODS

This methods section contains a summary of the methods used; for a detailed description of our methods and selection criteria, we refer to our published protocol PROSPERO 2018 CRD42018115333. We used the Participants, Interventions, Comparison, and Outcomes (PICO) framework to develop the inclusion and exclusion criteria for our overview of reviews.[18,19] See Table 1 for the details. We considered a review to be systematic if it had a methods section with predefined selection criteria, a quality assessment, and an adequate search. We had planned to include reviews of high to moderate quality only, as assessed with the A Measurement Tool to Assess Systematic Reviews (AMSTAR) 2 tool,[20] but because we only found one high quality review, we decided to include also low-quality reviews, excluding only those of critically low quality.

TABLE 1 Inclusion criteria according to the PICO framework

Population	Adolescents, that is, individuals between 10 and 19 years old
Interventions	Any primary intervention aimed at preventing overweight and obesity in adolescents, delivered alone, or in combination with one or more other intervention(s)
Comparisons	Any comparison, for example, no intervention/standard practice/enhanced practice, or other intervention(s)/strategies used for prevention of overweight and obesity
Outcomes	Primary outcomes: • BMI/BMI z-score • Physical activity level • Dietary behaviour (e.g., consumption of fruit/vegetables and sugar-sweetened beverages) Secondary outcomes: • Other weight-related outcomes (e.g., body weight, body fat percentage, BMI percentile) • Sedentary behaviour (time physically inactive, e.g., in front of the TV) • Transport (e.g., to and from school or to other activities) • Health outcomes (e.g., diabetes, hypertension, mental health) • Quality of life • Satisfaction • Equity outcomes • Attitudes, intention to change, change in consumer behaviour • Harm/unintended effects • Cost data

2.1 | Inclusion and exclusion criteria

We included reviews published 2008 or later, evaluating the effectiveness of interventions aimed at preventing overweight and obesity in adolescents aged 10 to 19 years.[21] Reviews including younger children were also considered if the results for adolescents were reported separately or if a majority (>50%) of participants were adolescents according to the reported age at baseline.

Interventions of interest included, but were not limited to, the three categories described in the Global Accelerated Action for the Health of Adolescents (AA-HA!) report[10]: (i) structural and environmental interventions, for example, nutrient profiles/labelling, reducing affordability and the impact of marketing of unhealthy food and beverages, urban planning policies, and adequate school and public facilities for physical activity (PA). (ii) Organizational and community interventions, for example, nutrition literacy programs, improved access to healthy foods, public awareness programs on PA, and regular, structured sports activities; and (iii) interpersonal and individual interventions, for example, guidance on healthy behaviours, and behaviour change communication. We also considered reviews evaluating the effects of involving adolescents in the development and planning of programs and policy change to promote a healthy lifestyle.

We excluded reviews of younger children, adults, and reviews concerned with interventions to treat obesity, as these were not within scope of our overview. We also excluded reviews that did not report a quality assessment of included studies.

Primary outcomes were body mass index (BMI)/BMI z-score, PA level, and dietary behaviour (e.g., consumption of fruit and vegetables and sugar-sweetened beverages [SSBs]). Secondary outcomes included other weight-related outcomes (e.g., body weight, body fat percentage, and BMI percentiles), SB, active transport, health outcomes (e.g., diabetes and mental health), quality of life, satisfaction, equity outcomes (assessed using for example the PROGRESS framework[22]), attitudes, change in consumer behaviour, adverse effects, and costs.

2.2 | Search methods

We searched nine databases from January 2008 up to November 2019, using standard Cochrane methods[19]: PROSPERO, Epistemonikos, Cochrane Library of Systematic Reviews of Interventions, MEDLINE, EMBASE, PsychInfo, ERIC, HTA database, and Web of Science. We searched reference lists and contacted experts in the field. The search had no language restrictions, but due to our strict timelines, we included only papers in English. The MEDLINE search strategy is provided in Table S1.

2.3 | Selection of systematic reviews and data extraction

Two authors (GMF and AH) independently assessed the eligibility of titles and abstracts for inclusion using the EPPI reviewer software[23] and assessed full texts for inclusion. Data extraction was performed by one author and checked by a second author using a standardized and piloted data extraction form.[24] We resolved any disagreements through discussion. We listed possible relevant reviews read in full text, but subsequently excluded, in a table along with the reasons for exclusion (see Table S2).

2.4 | Assessment of methodological quality of included reviews

GMF and AH independently assessed the methodological quality of each review that met our initial inclusion criteria using the AMSTAR 2 instrument.[20] We rated the overall confidence in the results of reviews according to the instruments' four levels: high, moderate, low, or critically low quality. We excluded reviews judged to be of 'critically low' quality, that is, reviews with major methodological limitations. We resolved any disagreements through discussion, but we did not experience substantial differences in classification between authors.

2.5 | Data synthesis

We reported the results narratively in text and tables, together with comments on the certainty of the evidence. We organized the data by intervention target (i.e., dietary behaviour, PA, or a combination of both) and second by type of reported main outcomes (BMI/BMI z-score, dietary behaviour, and PA).

2.6 | Grading of the certainty of evidence

GMF and AH assessed the certainty of the included evidence using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) tool[25] if this was not reported by the authors of the original reviews. We assessed the certainty of evidence according to five items (inconsistency, imprecision, indirectness, quality, and publication bias) for the primary outcomes (BMI/BMI z-score, dietary behaviour, and PA behaviour) according to the tool's four levels: high, moderate, low, and very low. We resolved any disagreements through discussion.

3 | RESULTS

3.1 | Results of the search

The electronic searches yielded 7474 records after removing duplicates and searching other sources. After screening titles and abstracts, we excluded 7386 irrelevant studies. We retrieved and scrutinized 106 reviews, of which we excluded 93 for reasons including results not being separately reported for adolescents, inclusion of studies of adolescents who were exclusively obese, or ineligible review methods (see Table S2). We judged 13 reviews as eligible for inclusion in this overview of reviews.[26–38] See Figure 1 for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) study flow chart.[29] In total, 108 primary studies were included in the 13 reviews, 76 were included in only 1 review, 24 studies were included in 2–3 reviews, and 4 primary studies published between 2006 and 2014 were included in 4–6 reviews. In one review,[37] all of the four included primary studies overlapped with studies included in another review,[29] but these reviews reported on different outcomes (see Table S4 for the details).

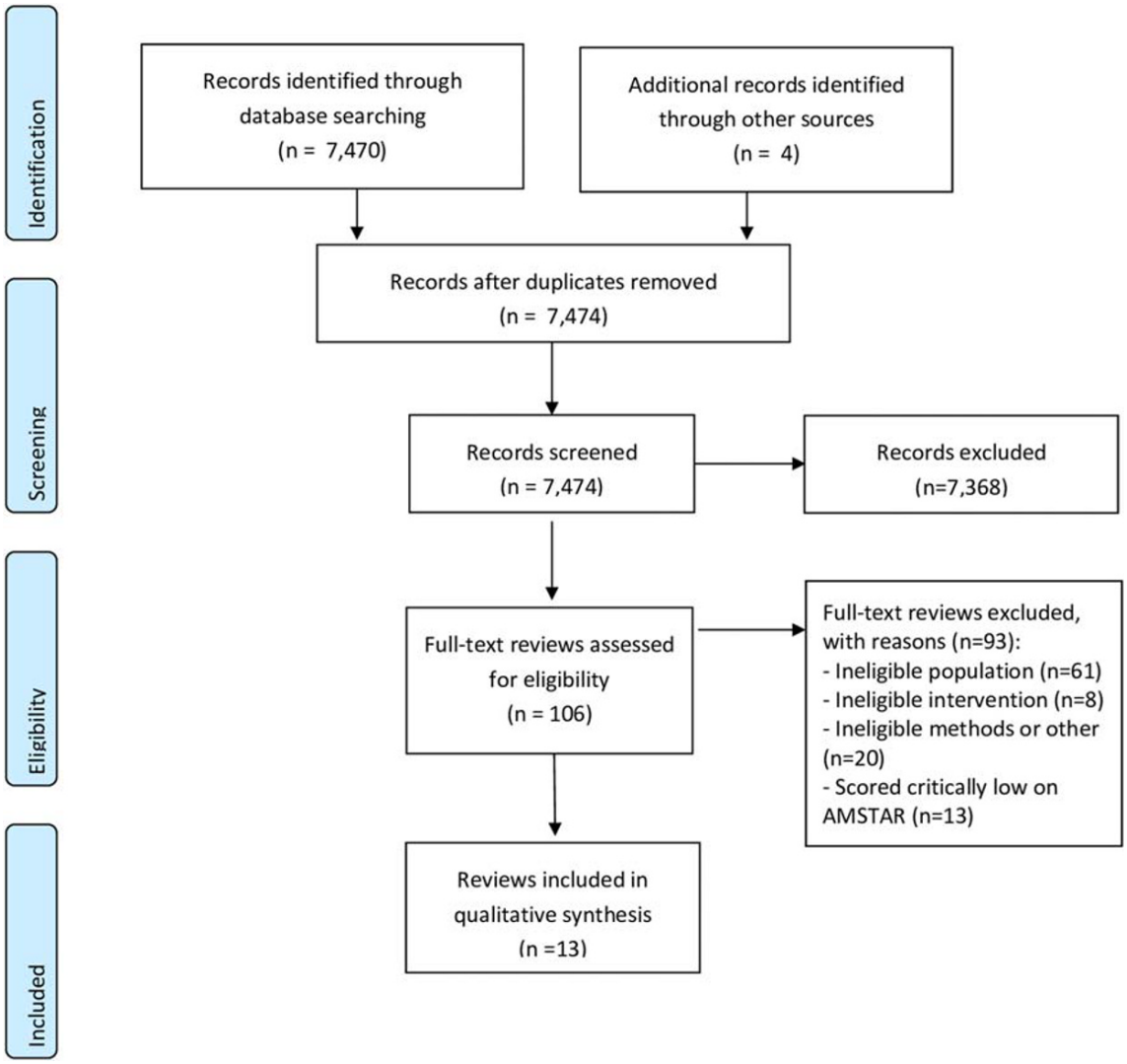

FIGURE 1 PRISMA flow diagram

3.2 | Characteristics of included reviews

Table 2 provides a summary of included reviews. See Table S3 for more details of individual reviews.

The 13 included systematic reviews were published between 2014 and 2019. Six of the reviews included randomized studies (randomized controlled trials [RCTs]) only,[26,27,30,34,36] whereas the remaining seven reviews included either nonrandomized controlled studies (nonrandomized controlled trials [NRCTs]) only[37] or both types of study design.[28,29,31–33,35,38] Almost 50% of studies in included reviews had been conducted in the United States and around 20% in Europe and Oceania, respectively. Few studies were from low- and middle-income countries (LMICs; see Figure 2).

3.2.1 | Type of interventions

For additional details, see Tables 2 and S3.

Three of the thirteen reviews included interventions aimed at promoting healthy dietary behaviours,[32,34,35] six reviews included interventions to promote PA,[26,28,30,33,36,38] and four reviews included both healthy eating behaviour and PA interventions, either alone or in combination.[27,29,31,37] Although a majority of the interventions were targeted at the individual level, some school-based studies also included environmental components aimed at facilitating healthy choices. The median follow-up time across reviews and studies included in the reviews was 8 months (range < 12 weeks to 3 years). Median follow-up was less than 6 months in four reviews, less than 12 months in three reviews, and more than 12 months in two reviews. Median follow-up could not be estimated in four reviews.

3.2.2 | Description of interventions in included reviews

Two of the three reviews summarizing the effects of interventions to promote healthy dietary behaviours reported interventions aimed at reducing intake of SSBs, mainly in school settings.[34,35] The majority had an individual/educational focus like health

TABLE 2 Summary of the characteristics of the included systematic reviews (n = 13)

		Azevedo 2016[a]	Borde 2016	Brown 2019	Carlin 2016	Hoare 2015	Hynenen 2015	Kornet van der Aa 2017	Nørnberg 2016	Pearson 2015	Vargas Garcia 2017	Vezina-im 2016	Voskuil 2016	Wolfenden 2014	TOTAL
General review information															
Study design	RCTs only	14	13	29	2	3	10	8	1	26	5	13	10		95
	Non-RCTs	1			1	4		1	1	8		11		4	13
Origin of included studies	Europe	6	4	7		1	3	1		8	2	3	1		24
	North-America	5	3	12	1	2	3	4	2	22	2	16	7		55
	Asia				1	2	2	1		1		2	2		7
	Oceania	3	5	6	1	2	1	3		3	1	2		4	16
	South America	1	1	3			1					1			5
	Africa			1											1
Population characteristics															
Study population	Adolescent only		•			•	•	•		•					5
	Adolesc. And children	•		•	•				•		•			•	6
	Majority adolescents											•	•		2
Gender	Females	•	•	•	•	•	•	•	•	•	•	•	•	•	13
	Males	•	•	•	•	•	•	•	•		•	•		•	11
Definition of adolescents	10–19 years (WHO)		•			•								•	3
	11–18 years								•						1
	12–18 years	•						•		•	•	•			5
	13–18 years			•	•										2
	15–18 years						•								1
	No defintion												•		1
Baseline weight status of sample participants	"Healthy"						•		•						2
	Mixed weight	•	•									•	•		4
	No weight criteria				•			•		•	•				4
	Excl. OW/obese and/or eating disorders					•	•							•	3

(Continues)

TABLE 2 (Continued)

		Azevedo 2016[a]	Borde 2016	Brown 2019	Carlin 2016	Hoare 2015	Hynenen 2015	Kornet van der Aa 2017	Nørnberg 2016	Pearson 2015	Vargas Garcia 2017	Vezina-im 2016	Voskuil 2016	Wolfenden 2014	TOTAL
Intervention characteristics															
Target of intervention	Dietary behaviour			•		•		•	•		•	•		•	7
	Physical activity	•	•	•	•	•	•	•		•			•	•	11
Setting	School	10	13	24	3	3	10	6	2	30	4	24	7	1	93
	Community	1		3		4		1		3			3	3	8
	Home	1		2						1	1				3
	Health care	3						2							3
Duration of intervention (median)	<6 months	•			•		•		•						
	<12 months		•								•		•		
	>12 months													•	
Equity	PROGRESS framewrk.			•							•				2
	Focus disadv. Groups							•							1
Involvement of adolescents	Int. development														0
	Int. implementation							•							1
Outcomes															
Primary outcomes	BMI/BMI z-score	•		•		•		•					•	•	6
	Physical activity level		•		•		•	•		•			•		6
	Dietary behaviour							•	•		•	•			4
Secondary outcomes	Other weight related							•					•	•	3
	Sedentary behaviour							•							1
	Health outcomes, QoL					•									1
	Unintended effects			•											1

TABLE 2 (Continued)

		Azevedo 2016[a]	Borde 2016	Brown 2019	Carlin 2016	Hoare 2015	Hynenen 2015	Kornet van der Aa 2017	Nørnberg 2016	Pearson 2015	Vargas Garcia 2017	Vezina-im 2016	Voskuil 2016	Wolfenden 2014	TOTAL
Risk of bias, grading of certainty of evidence (by review authors)															
Quality assessment tool	Cochrane RoB tool	•			•		•			•	•			•	6
	EPHPP							•	•			•			3
	EPOC/ PRISMA/ CASP		•										•		2
Tools used to assess certainty	GRADE			•		•									2
Quality assessment with AMSTAR 2 (by authors of the overview of reviews)															
AMSTAR 2 ratings	High quality			•											1
	Moderate quality		•				•		•	•				•	5
	Low quality	•			•	•		•			•	•	•		7

Abbreviations: BMI, body mass index; CASP, Critical Appraisal Skills Programme; EPHPP, Effective Public Health Practice Project; EPOC, Effective Practice and Organization of Care Group; GRADE, Grading of Recommendations, Assessment, Development and Evaluations; non-RCT, nonrandomized controlled trial; OW, overweight; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROGRESS, place of residence, Race/ethnicity/culture/language, occupation, gender/sex, religion, education, socio-economic status, and social capital; QoL, quality of life; RCT, randomized controlled trial; RoB, risk of bias; WHO, World Health Organization.

[a]Includes five obesity treatment studies.

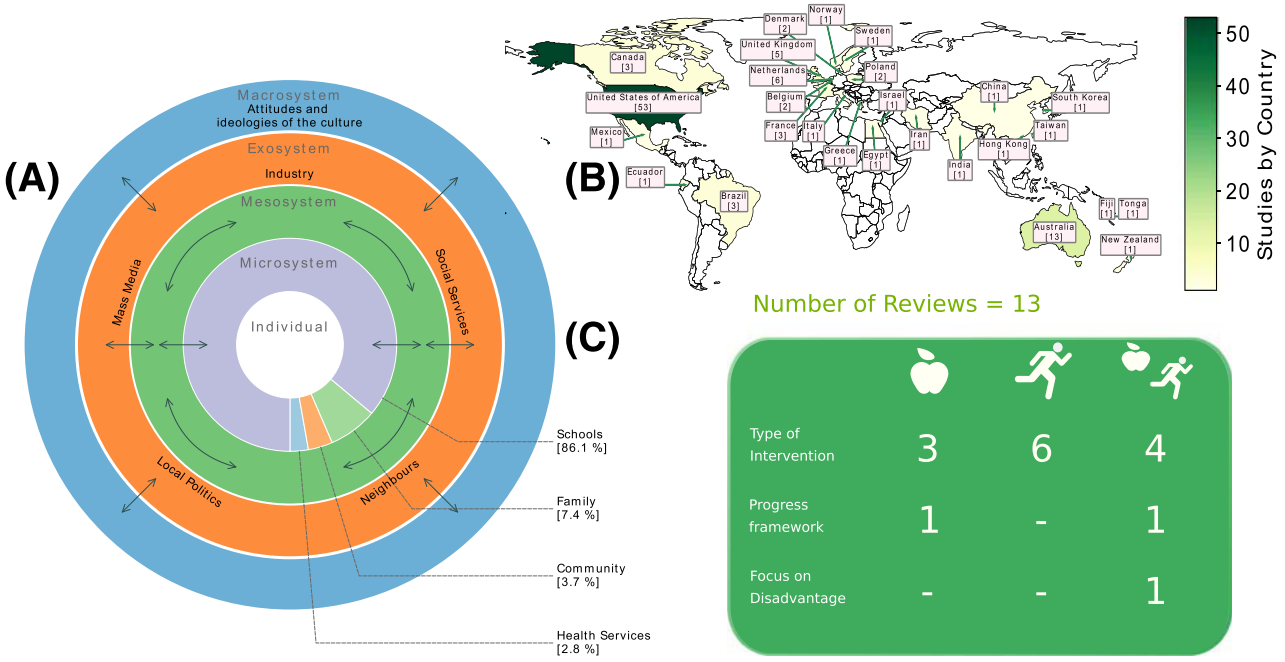

FIGURE 2 Distribution of studies in included reviews by country, setting, type of intervention, and equity: (A) distribution of single studies by social setting (based on the socio-ecological model in Bronfenbrenner (1979). The Ecology of Human Development: Experiments by Nature and Design. Cambridge, Massachusetts: Harvard University Press); (B) distribution of single studies per country (see also appendix S6); (C) distribution of targeted behaviours (dietary behaviour, physical activity, or combined) and equity covered by the included systematic reviews

education but also legislative/environmental interventions on school policies or provision of free water were included. The third review summarized choice-architecture interventions (i.e., free delivery of fruit and vegetables to schools) to promote vegetable consumption.[32]

The six reviews summarizing the effects of interventions to promote PA,[26,28,30,33,36] or interventions to reduce SBs,[38] were mostly school based, even if some were set in the community. The main focus of a majority of the interventions was to provide adolescents with increased opportunities for structured regular sports or exercise activities (additional and/or enhanced PE lessons included), and to a lesser extent, behaviour change education and counselling. Environmental interventions were mentioned only in a couple of reviews (e.g., changes to the school environment, e.g., upgrade of existing school outdoor areas; new play spots; improvement of safety for active transport,[26] changings the school cafeteria, and 'improving' the school environment[33]). A couple of the reviews particularly focused on increasing PA among adolescents girls.[33,36]

The four review summarizing effects of interventions targeting both PA interventions and healthy eating behaviours reported a majority of school-based interventions with an educational focus[27,29,31,37] but also with a few examples of environmental intervention like increasing availability of healthy foods and water fountains at schools or improving outdoor areas and students traffic patrols educated in safe cycling. There were also examples of interventions outside schools. Two of the reviews focused on community interventions, which often included multicomponent interventions and community capacity building.[29,37]

3.2.3 | Intervention settings

See Figure 2 for details. A majority of interventions in the included reviews was set in schools, whereas a couple of reviews also included a few studies of healthcare, home-, and community-based interventions.

3.2.4 | Mode of intervention delivery

In a majority of the included reviews, the mode of delivery was not reflected upon. The mode of intervention delivery when reported was typically a mix of face-to-face group and/or individual educational sessions, different types of electronic delivery (tailored or untailored), printed educational materials, and posters. Other modes of delivery were phone calls, direct delivery of fruit and vegetables to schools, or delivery of low-calorie drinks to adolescents' homes.

In three reviews, a combination of teachers (other school staff) and researchers delivered the intervention.[28,37,38] One of the reviews reported that peer education was included in all the studies as one of several intervention delivery strategies, but it was unclear whether adolescents were involved in policy development or interventions design.

3.2.5 | Theory used in included reviews

Six reviews reported that all or a majority of included studies had used various theories in developing their interventions.[27,30,32,33,35,36] In

these reviews, social cognitive theory was the one most frequently used. Two reviews stated that the included studies had used behaviour change techniques.[28,34] In two reviews, a majority of included studies were not based on theory.[26,31] Three reviews provided no information on the use of theory.[29,37,38]

3.2.6 | Study participants

Five reviews targeted adolescents only,[26,29–33] whereas eight reviews included both children and adolescents.[27,28,32,34–38] The definition of an adolescent in terms of age varied across reviews (see Table 2), and the WHO definition (10–19 years)[21] was only used in three reviews.[26,29,37] Total number of adolescent participants in included reviews ranged from 272 to around 20 000 (median: 8177).

Some reviews included studies that targeted adolescents that were generally 'healthy', of 'mixed', or 'normal' weight,[27,30,32] whereas in other reviews, weight status was not part of the selection criteria.[26,28,31,33–36] Four reviews included a couple of very small studies that exclusively included adolescents participants affected by overweight or obesity[26,35,36,38] but as we judged that these studies would not have an overturning effect on the results these reviews were included. Other reviews explicitly stated that they excluded such studies and studies including adolescents with eating disorders.[29,37,39]

One review[31] included participants from socio-economically disadvantaged backgrounds only. Two reviews attempted to address inequity in included studies using the PROGRESS framework.[27,34] Two reviews included studies targeting girls only.[33,36]

3.2.7 | Outcomes

Primary outcomes reported in the included reviews were BMI/BMI z-score (six reviews), PA level (six reviews), and healthy dietary behaviours (four reviews). The secondary outcomes reported in included reviews were other weight-related outcomes (three reviews), harm/adverse effects (one review), and the remaining outcomes (SBs, quality of life, mental health, and attitudes) were only reported in single reviews. All dietary outcomes were based on self-report. Some reviews included studies in which PA had been objectively (accelerometer or pedometer) assessed,[26,28,36] and in some reviews, a majority of included studies based their results on self-reported behaviours.[30,33] In some reviews, information on outcome measurement was missing.[31,38]

For more details on each review and characteristics of the original studies included, see Table S3.

3.3 | Quality of included studies and certainty of the evidence (assessed by authors of original reviews)

The included reviews used a variety of tools to assess the quality of included studies, of which the Cochrane Collaboration's Risk of Bias (ROB) tool[40] was most commonly used.[27,28,30,33,34,37,38] The study quality was overall low in 10 reviews and overall moderate in three reviews.[26,31,36]

Only two of the reviews reported having graded the certainty of the included evidence.[27,29]

3.4 | Quality of included reviews according to AMSTAR 2 (assessed by authors of overview of reviews)

One review[27] was of high quality according to AMSTAR 2, whereas all the others were of low (seven reviews) to moderate quality (five reviews). Thirteen reviews that were of critically low quality were excluded,[41–53] with the main reasons being lack of information provided in the reviews, particularly regarding quality assessment of the included studies. The main reasons for judging seven reviews to be of low quality according to the AMSTAR 2 was that risk of bias of individual studies was not accounted for when interpreting the results of the review and in some cases that review authors did not report separate summaries for RCTs and NRCTS when including both study designs.

4 | EFFECTIVENESS OF INTERVENTIONS

Six reviews reported meta-analyses,[26,27,33,34,37,38] seven reviews reported narrative results,[28–32,35,36] and two of these reviews did not report any effect sizes.[28,35] For more information, see Table S5 GRADE summary of findings tables.

4.1 | Reviews of interventions to promote healthy dietary behaviour

Of the four reviews summarizing the effects of interventions aimed at promoting healthy dietary behaviour in adolescents, one review evaluated the effects of multicomponent interventions to promote healthy dietary behaviour on the BMI of adolescents.[27] Two reviews summarized the effects of a variety of public health interventions on the consumption of SSB.[35,36] One review evaluated the effects of 'food choice architecture' interventions on vegetable intake.[32]

4.1.1 | Body mass index

Brown et al.[27] reported little or no effect of dietary interventions on the BMI of adolescents (mean difference, MD: −0.13 kg/m^2 [−0.50, 0.23]; two RCTs; n = 294; low-certainty evidence).

4.1.2 | Dietary behaviour

Vargas-Garcia et al.[34] reported a small significant effect of a variety of public health interventions on SSB consumption of adolescents

(*N* = 3,583; five RCTs) at median 8 months follow-up (MD: −66 ml/day (−130, −2); *p* = .04; I^2 = 62.8%, *p* = .03; very low certainty of evidence).

Vezina-Im et al.[35] also reported reduced SSB consumption in adolescents of a variety of public health interventions in 16/24 included studies (*N* = 19,971; 14 RCTs and 11 NRCTs; low-certainty evidence).

Nørnberg et al.[32] reported little or no effect of free delivery of fruit and vegetables in schools on adolescents' vegetable intake at 21 weeks and 12 months follow-up, respectively (*N* = 4,967, one CRCT, one QE; very low certainty of evidence). The effect on vegetable intake when the intervention was combined with nutrition education (+0.42 servings, *p* < .05; *N* = 1277; one CRCT) was significant.

4.2 | Reviews of interventions to promote PA (and reduce SB)

Of the six reviews summarizing the effects of interventions aimed at promoting PA, or at reducing SB, three reviews reported intervention effects on BMI/BMI z-score.[27,36,38] Five reviews reported effects on the PA level of adolescents,[26,28,30,33,36] and one of these reviews also reported on adverse effects and equity outcomes.[27]

4.2.1 | BMI/BMI z-score

Azevedo et al.[38] reported little or no effect of interventions to reduce SB, alone or in combination with PA, on the BMI/BMI z-score of adolescent girls at median 6 months follow-up (SMD: −0.037 [−0.094, 0.020]; *N* = 8,177; 15 studies; I^2 = 37%; very low certainty of evidence).

Brown et al.[27] reported a small effect of PA interventions on BMI (MD, 95% CI) of adolescents (−1.53 kg/m^2, [−2.67, −0.39]; four RCTs; *n* = 720; very low-certainty evidence), and little or no effect on BMI z-score (−0.2 [−0.3, −0.1]; 1 RCT; *n* = 100; low-certainty evidence).

Voskuil et al.[35] also reported little or no effect of PA interventions on the BMI of adolescents at median 10 months follow-up (1/9 studies showed a significant effect; *N* = 13 083; nine studies; low certainty of evidence).

4.2.2 | Physical activity

PA level was objectively measured only (accelerometer or pedometers) in three reviews,[26,28,36] and was based on self-report in a majority of included studies in the remaining reviews.[30,33] The mean effect size (SMD) for PA level ranged from 0.02 (no effect) to 0.35 (small effect) across reviews. In one review that reported effect sizes for change in PA level across included studies, Cohen's *d* ranged from 0.132 to 0.669.

Borde et al.[26] reported little or no effect of school-based (mostly multicomponent) interventions on the PA level of adolescents at median 9 months (Hedge's g: 0.02 [−0.13, 0.18]; *N* = 2,323; seven RCTs; low-certainty evidence).

Hynynen et al.[30] reported a small to moderate effect of PA interventions on the PA level of older adolescents (15–19 years) in 7 out of 10 studies at median 12 weeks (*N* = 5926; 10 RCTs; Cohen's *d* ranged from 0.132–0.669; very low certainty of evidence). The results for SB were mixed with only two of four studies showing an effect (*N* = 2452; four RCTs; very low certainty of evidence).[30]

Pearson et al.[33] reported a small effect of interventions to promote PA (educational, environmental, and multicomponent interventions) on the PA level of girls (*N* = 10 806; 34 studies; Hedge's g = 0.350, 95% CI [0.12, 0.58]; *p* < .001; I^2 = 98%).[33] The heterogeneity however was extremely high, and the certainty of this evidence is very low.

Voskuil et al.[36] reported mixed effects of PA interventions on objectively measured PA level of adolescent girls at median 10 months (*N* = unclear; two RCTs; very low certainty of evidence) and also mixed effects on percent body fat (four of six studies reported Cohen's *d* ranging from 0.12–0.42).

Carlin et al.[28] reported a beneficial effect of school-based interventions to promote walking on number of steps (*N* = 272; two RCTs and one QE; no effect size; very low certainty of evidence).

4.2.3 | Adverse effects and equity

Brown et al.[27] reported that PA interventions did not appear to result in adverse effects (seven RCTs) nor did combined dietary and PA interventions (three RCTs). Further, no intervention appeared to results in increased health inequities (two RCTs).

4.3 | Interventions to promote healthy dietary behaviours and PA

Four reviews summarized the effects of interventions aimed at promoting healthy dietary behaviours and PA.[27,29,31,37] Three of the reviews reported effects of multicomponent interventions on BMI/BMI z-score,[27,31,37] one review reported effects on PA and dietary behaviours,[31] and one review reported outcomes related to mental health and wellbeing.[29]

4.3.1 | BMI/BMI z-score

Brown et al.[27] reported little or no effect of interventions targeting both dietary behaviour and PA on the BMI of adolescents (MD: −0.02 kg/m^2 [−0.10, 0.05]; eight RCTs; *n* = 16 583; low-certainty evidence) or on the adjusted BMI z-score (MD: 0.01 kg/m^2, [−0.05, 0.07]; six RCTs; *n* = 16,543; low-certainty evidence).

Kornet van der Aa et al.[31] reported little or no effect of multicomponent interventions to promote healthy dietary behaviour and PA on the BMI of adolescents from disadvantaged backgrounds, at median 7 months follow-up (*N* = 2,065 estimated; nine RCTs; no single effect size; low certainty of evidence).

Wolfenden et al.[37] reported little or no effect of a population based whole of community intervention on the BMI z-score of adolescents at 3 years follow-up (MD: −0.02 [−0.08, 0.03]; *N* = 46 schools; three NRCTs; I^2 = 70%; very low certainty of evidence).

4.3.2 | Dietary behaviour and PA

Kornet van der Aa et al.[31] reported little or no effect of multicomponent interventions on the PA level of adolescents from disadvantaged backgrounds (*N* = not provided; five RCTs; no single effect size; low certainty of evidence) but slightly improved dietary behaviour in four of five RCTs at median 7 months follow-up.

4.3.3 | Secondary outcomes

Hoare et al.[29] reported a moderate decrease in anxiety symptoms after a 9-week whole of community intervention (Cohen's *d* = −0.56; *p* < .05; one study), but no difference in depressive symptoms at up to 3 years follow-up (Cohen's *d* = −0.32; *p* = .11; one study). The review further reported mixed effects on quality of life (*N* = 8,326; four studies), and no effect on self-esteem or self-efficacy at 6 and 12 months follow-up (*N* = 1,611; two studies). These results however were uncertain because they were all based on very low-certainty evidence.

Kornet van der Aa et al.[31] reported mixed effects for secondary weight-related outcomes: percentage body fat (desired effect in 2/6 studies); waist circumference (desired effect in 1/3 studies); and screen time (desired effect in 1/2 studies). Wolfenden et al.[37] reported mixed effects for a number of weight-related outcomes: percentage body fat (desired effect in 2/4 studies) and body weight (desired effect in 1/4 studies). Both reviews reported no effect on the proportion of adolescents with overweight or obesity.

5 | DISCUSSION

5.1 | Summary of main results

This overview of reviews included 13 systematic reviews of interventions aimed at preventing overweight and obesity in adolescents. Only one review was of high quality according to the AMSTAR 2 instrument, and the others were of moderate to low quality. The certainty of evidence was low to very low for all primary outcomes, across included reviews. The main reasons for downgrading were indirectness (e.g., other than intended populations included), imprecision (e.g., few participants, wide CIs that spans both desired and undesired effects), and high risk of bias and inconsistency (high I^2).

Whereas the evidence from these reviews mostly suggests little or no effect of interventions on BMI or PA level, results from a couple of reviews[34,35] suggest possibly beneficial effects on the consumption of SSBs and that, for example, school policies, legislative and environmental interventions, and nutrition education and counselling, may hold some promise. However, the low to very low certainty of included evidence prevents us from drawing any firm conclusions regarding the effectiveness of any of the evaluated interventions, which all require further study.

For reviews with meta-analyses, the heterogeneity was substantial. This was not surprising due to the wide variation in type of populations, interventions, comparators, outcome measures used, and duration of follow-up across reviews. The high heterogeneity and the fact that some reviews did not report any effect sizes hampered any attempt to compare results across interventions and reviews.

5.2 | Completeness and applicability of included evidence

There was a dominance of school-based interventions targeting individual behavioural change in included reviews, even though some studies also included environmental components aimed at facilitating healthy choices. Few if any interventions were directed towards the wider community, for example, creating more green spaces, improving cycle networks, using nutrient labelling/profiles, or reducing the affordability of unhealthy food and drinks. This is surprising because it is generally agreed that policy approaches to obesity prevention are required due to its potential to reach the whole population, reduce inequities, and enable systemic changes, with potential benefits in terms of duration of effects.[1] Meaningful involvement of young people in the development of interventions designed for them may potentially lead to improved uptake and adherence[54]; however, none of the reviews reported on involvement of adolescents in developing the intervention programs or policies. In one of the reviews, peer education was included as one of the intervention strategies in a majority of studies, albeit both in studies which reported effective and ineffective interventions.[31]

Interventions could not be categorized according to the WHO obesity prevention framework as initially planned.[10] The main reason for this was that the review authors did not categorize them in line with such a framework but also because the included interventions often had structural and environmental elements, even if the main focus tended to be on individual behaviour change, which is in accordance with what has been reported in the wider literature.[12,13]

Only a minority of included original studies were conducted in settings other than schools, for example, less than 2% were conducted in primary care, despite the potentially important role that primary care providers may play in obesity prevention.[55]

Almost 50% of all studies in included reviews were conducted in the United States, where the obesity prevalence is among the highest in the world.[56] It is unclear whether the effect of preventive interventions delivered to adolescent populations with very high obesity prevalence, would have the same effect when delivered to adolescent populations with much lower obesity prevalence, like, for example in Norway. However, while saying this, one of the aims with this overview of reviews was to identify interventions effective across settings that potentially could reduce the existing inequity in obesity

prevalence between countries and regions and socio-economic groups and therefore including studies from all countries is crucial.

Few included original studies (8.4%) were conducted in LMICs, even though many LMICs are experiencing a rapid growth in obesity prevalence.[57] As almost 9 out of 10 adolescents globally live in LMICs,[58] preventive intervention applied in these settings may reach a large number of adolescents and potentially have a great impact on the global burden of obesity.

There was limited evidence of differential effects of interventions based on socio-economic status (SES). Only one of the included reviews focused on adolescents from families with low SES by including studies of populations from disadvantaged backgrounds.[31] Two reviews that attempted to evaluate possible differential effects of preventive interventions across different population groups[27,34] stated that few studies reported the information needed to assess this. This is despite from the fact that population groups with lower SES have the highest and fastest increasing obesity prevalence in Europe.[59]

No review reported on satisfaction with school-based interventions, even though this is an important factor for intervention uptake and adherence. Only one of the reviews reported on adverse effects,[27] and none of the reviews reported costs or cost effectiveness.

Use of specific theories was only reported in approximately 30% of included reviews. Many of the reviews reported general use of theory in the included studies but provided little information on which theories had been used or how or when they had been used; which is consistent with previous research.[59] Interventions based on evidence and on behaviour change theory are considered to have an increased likelihood to result in desired effects.[60]

5.3 | Potential biases in the overview process

A research librarian developed the search strategy and ran a comprehensive search in nine databases. We searched the reference lists of included reviews and contacted experts in the field. We performed duplicate screening, eligibility assessment, data extraction, and grading of the evidence to minimize bias. We included only English publications and reviews published after 2008, which may have introduced bias. There is always a possibility that we may have missed including relevant eligible reviews, but this is not seen as very likely. There is furthermore a challenge with overviews of systematic reviews in the sense that some primary studies could occur in several systematic reviews and thereby be given extra weight in the conclusions. However, we found that 79 of the 108 single studies were included in only one of the reviews, which to some extent reduces the risk that findings from single studies get an unfair advantage and extra weight in the summaries (see Table S4 for more details).

5.4 | Limitations with the included evidence

At present, there is relatively little evidence from obesity prevention interventions specifically targeting adolescents, whereas younger children, adults, or mixed populations are the subjects of many reviews (for examples, see Table S2). Many excluded but relevant reviews combined results for younger children and adolescents and did not report results for adolescents separately (e.g., reviews on taxes/subsidies,[61,62] nutrition labelling,[63] portion size and presentation, and [64] environmental interventions and policies to reduce SSB consumption[65] to increase PA, e.g., active travel interventions, park and playground renovations, or play streets.[66–68] This is unfortunate as interventions targeting younger children are most likely different from those targeting adolescents[69] and also the results of the same intervention may differ between age groups. Adolescents are in a unique position in life, moving from childhood to adulthood, and interventions may require tailoring to the needs of this age group to be effective.

Another limitation with current available evidence is the poor reporting and/or poor quality of reviews and the studies they included. With the exception of the Cochrane review by Brown,[27] the interventions were typically poorly described in terms of the intervention elements included, mode of delivery, and intensity and duration of intervention and follow-up. It was often difficult to identify a 'core intervention' and typically it was not possible to determine the weight of the included intervention components (intensity and frequency) or disentangle the effect of single elements. In addition, few reviews had graded the certainty of the included evidence (i.e., provided information regarding to what degree the evidence can be trusted), which is an important step in the review process because it allows policy and decision makers to make well-informed decisions.[70,71]

Variation in the definitions used of what constituted an adolescent and poor characterization of adolescent samples might have affected the results. For example, in some reviews, children who according to WHO's definition would be considered young adolescents (10–13 years) were pooled together with results of younger children, and in some reviews, weight status was not a selection criteria, which resulted in the inclusion of studies of adolescents samples that were exclusively overweight or obese, that is, not appropriate targets for primary prevention interventions.

In included reviews, both dietary behaviour and PA were in many studies based solely on self-report, which is known to be susceptible to bias, that is to overreport or underreport depending on the desired change.[72] It was also often unclear whether the height and weight of participants (used for BMI calculations) were based on self-report, which carries similar risks of bias.

The measures of dietary behaviour and PA varied greatly across studies and reviews, which may explain some of the observed heterogeneity.

Reviews of interventions to reduce sugar intake were limited to those aimed at reducing SSB consumption. Although this source of sugars in adolescents with moderate to high sugar consumption may constitute as much as 33–54% of their total sugar intake, there are also other important sources of sugar.[73] Measuring the total sugar intake may provide a more reliable measure, as a decreased SSB intake may be compensated for by increased intake of other high-sugar products.

The one included review of food choice architecture interventions included mostly observational studies and few eligible studies targeting adolescents.[32] A recent Cochrane Review reported beneficial effects of product size and shape on food selection and purchases in children and adults but provided no separate results for adolescents.[64] Potentially effective policy measures with adolescents were thus not included; this again points at the need for age-specific reporting of outcome measures.

5.5 | Implications for research

Researchers should aim to address research gaps by conducting evaluations of population-based environmental interventions, for example, urban planning policies, nutrient labelling, or fiscal measures and obesity prevention interventions in settings other than schools (e.g., the wider community and primary care) to identify policy change and strategies that are effective in preventing overweight and obesity in adolescents at a population level. Future studies should report outcomes by age group, as interventions or policies targeting adolescents might not be the same as those that targets younger children or adults.[74] They should preferable include 'mixed weight' samples, that is, samples that are representative for the normal adolescent population.

The fact that around 50% of included reviews scored low on AMSTAR, and a number of relevant but excluded reviews scored critically low, suggest a need to improve conduct and reporting of systematic reviews. Future reviews should aim to follow the PRISMA reporting standards.[75]

Researchers should try to come to a consensus on the best way to assess the outcomes of interest in this field of research (e.g., dietary behaviour and PA) and agree on definitions. It would be helpful to describe whether current guideline recommendations for obesity prevention are met (i.e., targets for dietary behaviour, PA, and media consumption).[76]

Future studies should also aim, if possible, to report effects of interventions by SES and determine differential effects of interventions on disadvantaged groups, as suggested by WHO.[6]

Further, the evidence base may suffer from the requirement of systematic reviews to primarily consider randomized controlled trials because they count as the highest quality evidence. This may have the effect of ignoring evidence from other sources, including 'natural' experiments of, for example, wider population measures such as restrictions on the promotional marketing of 'junk' food to adolescents or the creation of neighbourhood cycling routes. Future studies should consider using robust study designs, for example, interrupted time series analysis of a natural experiment to evaluate such interventions, if RCTs are not feasible.[77]

6 | CONCLUSION

The evidence-base for the effectiveness of interventions to prevent overweight and obesity in adolescents is weak. In addition, the body of evidence is incomplete because the vast majority of included interventions targeted the individual and was set in schools, and structural and environmental interventions applied in the wider society were lacking. Community- and population-level interventions might stand a better chance of having a significant impact on the dietary and PA behaviours and health of the adolescent population. There is a need for high-quality evaluations of the effectiveness of such policy-based interventions.

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CONFLICT OF INTEREST

Gerd Flodgren declares no conflict of interest. Arnfinn Helleve declares no conflict of interest. Tim Lobstein declares no conflict of interest. Harry Rutter declares no conflict of interest. Knut-Inge Klepp declares no conflict of interest.

AUTHOR CONTRIBUTIONS

GMF: Screened references identified by the search, assessed studies for inclusion, extracted data, assessed the quality of included reviews, graded the certainty of evidence, produced figures and tables, and drafted the review. AH: Screened references identified by the search, assessed studies for inclusion, extracted data, assessed the quality of included reviews, graded the certainty of evidence, produced figures and tables, and read and commented on review drafts. KK: Read and commented on review drafts. TL: Read and commented on review drafts.

HR: Read and commented on review drafts. All authors contributed to the conception and development of the overall study. All authors read and approved the final review version.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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