



Synopsis

Towards optimal public health interventions for preventing obesity in children: a synopsis of a novel evidence synthesis

Julian PT Higgins^{1,2*}, Francesca Spiga¹, Annabel L Davies¹, Jennifer C Palmer¹, Sarah Dawson^{1,2}, Deborah M Caldwell¹, Lucy Condon², Fiona B Gillison³, Eve Tomlinson¹, Theresa HM Moore^{1,2}, Katie Breheny¹, James Nobles⁴, Sharea Ijaz^{1,2}, Jelena Savović^{1,2}, Rona M Campbell¹ and Carolyn D Summerbell^{5,6}

¹Population Health Sciences, Bristol Medical School, University of Bristol, Bristol, UK

²NIHR Applied Research Collaboration West (ARC West) at University Hospitals Bristol and Weston NHS Foundation Trust, Bristol, UK

³Department for Health, Centre for Motivation and Health Behaviour Change, University of Bath, Bath, UK

⁴School of Health, Leeds Beckett University, Leeds, UK

⁵Department of Sport and Exercise Sciences, Durham University, Durham, UK

⁶Fuse – Centre for Translational Research in Public Health, Newcastle upon Tyne, UK

*Corresponding author julian.higgins@bristol.ac.uk

Published February 2026

DOI: 10.3310/AKHD0407

Abstract

Background: Childhood obesity is a major public health concern worldwide, yet the best way to prevent it remains unknown.

Objective(s): To determine what types of intervention strategy are most effective at preventing the development of obesity in children aged 5–18 years, as measured by change in body mass index, and to determine whether interventions work differentially in children with different characteristics associated with inequities.

Design: Systematic reviews and statistical evidence syntheses.

Eligibility criteria: Randomised controlled trials of dietary and/or activity interventions that aimed to prevent overweight or obesity in children and young people aged 5–18 years and reported outcomes at least 12 weeks after baseline. Non-randomised evidence was identified through an overview of systematic reviews. Sources of inequity of interest were those defined by the PROGRESS (place of residence, race/ethnicity/culture/language, occupation, gender/sex, religion, education, socioeconomic status, social capital) acronym: place, race/ethnicity, occupation (of parents), gender/sex, religion, education (of parents), socioeconomic status and social capital.

Data sources: Updating of an existing Cochrane Review, searching bibliographic databases up to February 2023, including MEDLINE, EMBASE, PsycInfo® (American Psychological Association, Washington, DC, USA) and Cochrane Central Register of Controlled Trials on the Cochrane Library, international trial registers and grey literature databases, and examining reference lists. Results subgrouped by inequity factors were sought directly from trialists.

Review methods: Cochrane Reviews followed standard Cochrane procedures. The main statistical synthesis was informed by a novel analytic framework developed iteratively through discussions with children and young people, schoolteachers and public health professionals. Methodology was developed to analyse the data using multilevel meta-regression. To examine the impact of inequity factors, we performed a two-stage meta-analysis of interactions, based on subgroup-level aggregate data collected directly from the trialists. We collected available information on intervention costs.

Results: We included 172 trials in ages 5–11 and 74 in ages 12–18. In the main synthesis, of 204 trials from both reviews, we found interventions were effective on average (mean difference in standardised body mass index -0.037 , 95% credible interval -0.053 to -0.022 , which would correspond to a reduction in a proportion of 2.3% with obesity to a proportion of approximately 2.1%). Larger effects were associated with physical activity rather than dietary

interventions, after 12 months of follow-up and in the older age group. The overview of non-randomised evidence included 24 systematic reviews, yielding mixed results. The investigation of inequity did not identify substantial differences in effectiveness according to place of residence, race/ethnicity/culture/language, occupation, gender/sex, religion, education, socioeconomic status, social capital characteristics, and there was very limited information about costs.

Limitations: We were able to examine only the interventions that had been evaluated in studies identified for inclusion in the systematic reviews, which does not cover all possible intervention approaches.

Conclusions: Interventions to prevent obesity in children aged 5–18 have a small beneficial effect on body mass index on average but with considerable variation. A novel re-analysis of existing randomised trials failed to identify general intervention characteristics driving this variation. No evidence was identified to suggest that interventions increase (or decrease) health inequities.

Future work: Future studies of the effects of interventions to prevent childhood obesity should routinely collect baseline characteristics around potential inequities.

Funding: This synopsis presents independent research funded by the National Institute for Health and Care Research (NIHR) Public Health Research programme as award number NIHR131572.

A plain language summary of this synopsis is available on the NIHR Journals Library Website <https://doi.org/10.3310/AKHD0407>.

Introduction

Parts of this synopsis have been reproduced from Spiga *et al.*¹ This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY NC 4.0) licence, which permits others to distribute, remix, adapt and build upon this work, for non commercial use, provided the original work is properly cited. See: <https://creativecommons.org/licenses/by-nc/4.0/>. The text below includes minor additions and formatting changes to the original text.

Background and aims

Childhood obesity is a major public health concern worldwide, posing significant challenges to individuals, families and healthcare systems.² The World Health Organization estimates that the prevalence of obesity in people aged 5–19 increased from 2% in 1990 to 8% in 2022, amounting to 160 million young people worldwide.³ Despite the proliferation of intervention programmes to prevent development of obesity, their effectiveness remains a subject of ongoing investigation and debate. While some interventions have demonstrated promising effects, others have yielded equivocal or inconsistent results.⁴ Obesity is inequitably distributed in the population.⁵ However, there is a risk that interventions may increase inequities (sometimes referred to as ‘intervention-generated inequities’).^{6,7}

The UK Government aims to halve childhood obesity and significantly reduce the gap in obesity between children from the most and least deprived areas by 2030.^{8,9} Local authorities have been encouraged to develop and implement interventions aimed at maintaining a healthy weight. These interventions are complex, since they are

often comprised of many parts, and they intervene in systems that themselves are complex such as schools, communities and online environments.¹⁰ As such, the interventions should be viewed as packages, and their effects may depend strongly on the context in which they are introduced.¹¹

Here we summarise an NIHR-funded project to examine the effectiveness of interventions to prevent childhood obesity using a novel, sophisticated synthesis of the robust evidence in this area, offering the potential to unearth intervention features of both upstream and downstream interventions that are more likely to be effective in public health practice. The large body of existing randomised trials of interventions to prevent childhood obesity provides an invaluable resource whose potential has not been fully exploited. The careful application of modern evidence synthesis methods to this evidence base has the potential to derive important new messages about what types of intervention work best, for whom and in what circumstances. We also investigate differential effects of intervention according to aspects of inequity by collecting subgroup data from a substantial subset of the existing randomised trials; and we examine the evidence available on economic issues.

A key systematic review available at the start of our project was the Cochrane Review *Interventions for preventing obesity in children*.⁴ It was found that physical activity interventions and combined diet and physical activity interventions have a small effect on average, but with notable variability of effects across studies. It is this variability, which must have some cause (including the possibility of differential biases) that made us believe there is valuable unexplored information in the data.

The overall aims of the project were to:

1. update the evidence base through systematic reviews of randomised trials and robust non-randomised studies of interventions aimed at preventing obesity in children of school age (5–18)
2. synthesise the evidence, using modern, fit-for-purpose, evidence synthesis methods, informed by a novel analytic framework developed through engagement with stakeholders, to determine what types of public health intervention strategy are most promising
3. explore the extent to which individual characteristics associated with inequity impact on intervention effectiveness, using individual participant data from a large subset of trials
4. collate evidence on the costs of childhood obesity preventative interventions and estimate the potential costs of intervention approaches emerging as effective.

We addressed these through six specific objectives (*Figure 1*), which we use to structure the rest of this Introduction. A protocol for the full project was posted on the NIHR website (<https://fundingawards.nihr.ac.uk/award/NIHR131572>; accessed 12 June 2025) in June 2021 (reproduced in *Report Supplementary Material 1*), and updated in April 2023 with details of the plan for addressing equity through collection and analysis of subgrouped data (reproduced in *Report Supplementary Material 2*). The project was supported by an international Advisory Board which included methodologies, experts on obesity and intervention research and two school attenders. Journal articles (published, in review or in preparation) arising from the project are listed in *Box 1*. Other outputs, including conference papers and seminars, podcasts, and contributions to policy documents, are listed in *Publications*.

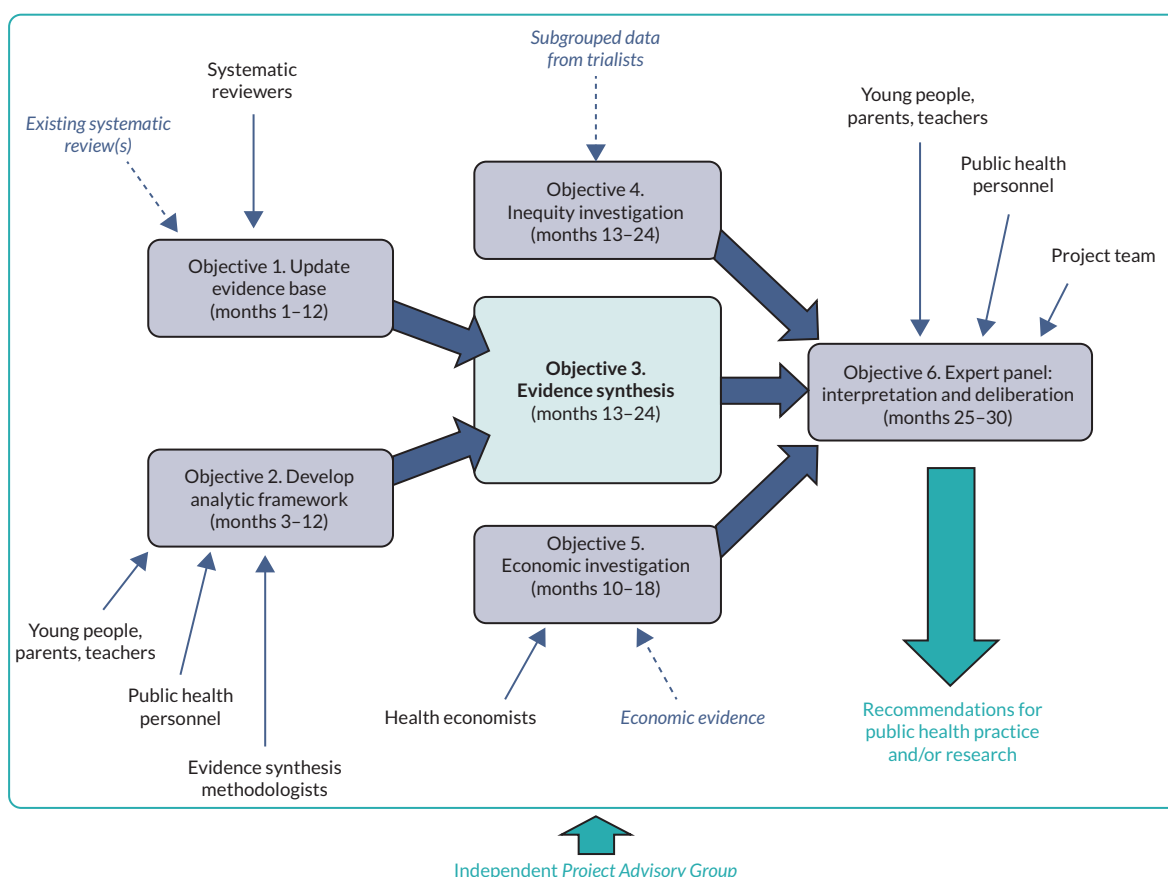


FIGURE 1 Diagram of research pathway.

BOX 1 Journal articles arising from the research summarised in this synopsis

- A. Moore THM, Tomlinson E, Spiga F, Higgins JPT, Gao Y, Caldwell DM, *et al.* Interventions to prevent obesity in children aged 5 to 11 years old [protocol]. *Cochrane Database Syst Rev* 2022;5:CD015328. <https://doi.org/10.1002/14651858.CD015328>. (Objective 1)
- B. Moore THM, Tomlinson E, Spiga F, Higgins JPT, Gao Y, Caldwell DM, *et al.* Interventions to prevent obesity in children aged 12 to 18 years old [protocol]. *Cochrane Database Syst Rev* 2022;CD015330. <https://doi.org/10.1002/14651858.CD015330>. (Objective 1)
- C. Spiga F, Davies A, Tomlinson E, Moore THM, Dawson S, Breheny K, *et al.* Interventions to prevent obesity in children aged 5 to 11 years old. *Cochrane Database Syst Rev* 2024:CD015328. <https://doi.org/10.1002/14651858.CD015328.pub2>. (Objective 1)
- D. Spiga F, Tomlinson E, Davies A, Moore THM, Dawson S, Breheny K, *et al.* Interventions to prevent obesity in children aged 12 to 18 years old. *Cochrane Database Syst Rev* 2024:CD015330. <https://doi.org/10.1002/14651858.CD015330.pub2>. (Objective 1)
- E. Spiga F, Picton H, Savović J, Moore THM, Caldwell DM, Summerbell CD, Higgins JPT. Population- and community-based interventions for preventing childhood obesity: an overview of systematic reviews of non-randomised studies of intervention. [Submitted] (Objective 1)
- F. Spiga F, Davies AL, Palmer JC, Tomlinson E, Coleman M, Sheldrick E, *et al.* Investigating differential effects of interventions to prevent obesity in children and young people: a novel analytic framework [published online ahead of print 29 October 2025]. *Public Health Res* 2025. <https://doi.org/10.3310/QLPD8523> (Objective 2)
- G. Davies AL, Higgins JPT. A complex meta-regression model to identify effective features of interventions from multi-arm, multi-follow-up trials. *Stat Med* 2024;43:5217–33. <https://doi.org/10.1002/sim.10237>. Preprint: *arXiv* 2024 (January 3); *arXiv*:2401.01806; <https://doi.org/10.48550/arXiv.2401.01806>. (Objective 3)
- H. Davies AL, Ades AE, Higgins JPT. Mapping between aggregate level BMI data on different measurement scales in a meta-analysis of childhood obesity prevention interventions. *Res Synth Methods* 2024;15:1072–93; <https://doi.org/10.1002/jrsm.1758>. Preprint: *arXiv* 2024 (February 28); *arXiv*:2402.18298. <https://doi.org/10.48550/arXiv.2402.18298>. (Objective 3)
- I. Davies AL, Spiga F, Caldwell DM, Savović J, Palmer JC, Tomlinson E, *et al.* Factors associated with effectiveness of interventions to prevent obesity in children: a synthesis of evidence from 204 randomized trials. *BMJ Public Health* 2025;3:e001707. <https://doi.org/10.1136/bmjph-2024-001707>. Preprint: *medRxiv* 2024 (June 20): 06.19.24309160; <https://doi.org/10.1101/2024.06.19.24309160>. (Objective 3)
- J. Palmer JC, Davies AL, Spiga F, Heitmann BL, Jago R, Summerbell CD, Higgins JPT. Do the effects of interventions aimed at the prevention of childhood obesity reduce inequities? A re-analysis of randomized trial data from two Cochrane reviews. *eClinicalMedicine* 2025;81:103130. <https://doi.org/10.1016/j.eclinm.2025.103130>. Preprint: *medRxiv* 2024 (June 10): 06.10.24308372. <https://doi.org/10.1101/2024.06.10.24308372>. (Objective 4)
- K. Breheny K, Spiga F, Summerbell CD, Higgins JPT. An evaluation of economic evidence included in published randomised controlled trials of interventions to prevent obesity in children [published online ahead of print 19 November 2025]. *Public Health Res* 2025. <https://doi.org/10.3310/GJJH1321> (Objective 5)
- L. Higgins JPT, Spiga F, Davies AL, Palmer J, Dawson S, Caldwell DM, *et al.* Towards optimal public health interventions for preventing obesity in children: a synopsis of a novel evidence synthesis. [this paper] (Objective 6)

Objective 1: Update the evidence base

We produced two Cochrane Reviews of randomised trials of interventions to prevent obesity in children, one in the age group 5–11 years, approximately corresponding

to primary school in the UK, and one in the age group 12–18 years, approximately corresponding to secondary school in the UK.^{12,13} These were updates of an existing Cochrane Review that covered the full age spectrum from birth to 18 years, which had fully incorporated trials from a search undertaken in 2015. Two other new Cochrane Reviews derived from this earlier review, in age groups 0–2 and 2–5, respectively, were not part of this project.

Protocols for the reviews were published in the *Cochrane Database of Systematic Reviews*.^{14,15} Review methods followed the procedures described in the *Cochrane Handbook for Systematic Reviews of Interventions*.¹⁶ We included only randomised trials, which could randomise either individuals or clusters providing there were at least three clusters per intervention arm. Eligible participants were children from the general population in the corresponding age groups. Trials including participants with overweight or obesity alongside other children were eligible, though we excluded trials restricted to people with overweight or obesity and trials addressing treatment of obesity. Interventions had to have a stated main aim to change at least one factor from diet and activity (i.e. physical activity, sedentary behaviour, sleep, play or structured exercise) to help prevent obesity in children. Interventions could be implemented in any setting. We included comparisons against a control group (e.g. no intervention or wait list) or an alternative eligible intervention. The search for eligible trials built on the existing Cochrane Review and included searches of multiple bibliographic databases up to February 2023, including MEDLINE, EMBASE, PsycInfo® (American Psychological Association, Washington, DC, USA) and Cochrane Central Register of Controlled Trials on the Cochrane Library. We also searched international trial registers and grey literature databases, and examined reference lists of included studies.

We included 172 trials in the age 5–11 review and 74 trials in the 12–18 review. We focussed on meta-analyses for three main comparisons: interventions focussed on diet versus control, interventions focussed on activity versus control and interventions addressing both diet and activity versus control. There was relatively little evidence for head-to-head comparisons of interventions. For the younger age group, we found that a range of school-based physical activity interventions, alone or in combination with dietary interventions, may on average have a modest beneficial effect on obesity in childhood at short- and medium-term, but not at long-term follow-up, and that dietary interventions alone may result in little to no difference. For the older age group, we found low-certainty evidence that physical activity interventions may have a small beneficial effect on body mass index (BMI) at medium- and long-term follow-up, and that diet

plus physical activity interventions may result in little to no difference.

We also undertook an overview of systematic reviews of non-randomised studies of interventions to prevent obesity in children. We sought reviews of non-randomised, comparative studies (non-randomised experimental studies, interrupted time series, controlled before-and-after studies and other natural experiments) evaluating the effectiveness of community- or population-level, obesity prevention interventions and reporting childhood BMI as an outcome. We included 28 systematic reviews, which included 136 controlled, non-randomised studies of interventions aiming to prevent obesity in people aged 5–18 years and reporting at least one BMI outcome (i.e. comparable to the randomised trials). Forty-eight of these evaluated policy interventions, 11 educational interventions and 77 multicomponent interventions with both policy and educational aspects. Evidence from the non-randomised studies is mixed, although multi-component, multisetting interventions seem most likely to be effective at preventing childhood obesity. However, the strength of this evidence was weak, with potential for associations to be due to confounding and other biases.

Objective 2: Develop a novel analytic framework

We developed an 'analytic framework' to drive our main synthesis of the results of the randomised trials included

in the Cochrane Reviews.¹ The analytic framework would yield a strategy for coding the interventions so that we could learn about intervention features associated with the greatest effectiveness. We established the following informal criteria for the coding scheme so as to maximise our prospect of obtaining informative results: (1) each item in the coding scheme should be applicable to every intervention examined in the studies; (2) each item should ideally be a dichotomous variable that approximately divides the studies into halves (since this would maximise precision in the estimation of the regression coefficients); (3) the coding scheme should include as many intervention features that potentially impact on effectiveness as possible; (4) the number of items should be kept to a minimum. There is clearly a tension between the last two criteria. To try and meet (3), we consulted widely with stakeholders. To try and meet (4), we bore in mind that rules of thumb generally advocate at least 10 data points per predictor in regression analyses, suggesting that at most 25 items should be included.

Our stakeholder consultation involved children and young people, parents, teachers and public health professionals. We held workshops with each of these and worked closely with our Advisory Board. The resulting coding scheme is summarised in [Table 1](#), with a short explanation of each item provided in [Box 2](#).

TABLE 1 Coding scheme for the interventions

Item	Question (possible answers)
1. Setting	Is the intervention delivered in a school (in full or in part)? (Yes/No)
	Is the intervention delivered in the home (in full or in part)? (Yes/No)
	Is the intervention delivered in the community or other non-school and non-home setting (in full or in part)? (Yes/No)
	Does the intervention include a home activity? (Yes/No)
2. Mode of delivery to the child	How is the intervention delivered? (Exclusively or mainly individually/Both individually and as a group/Exclusively or mainly as a group)
	Is the intervention delivered electronically? (Yes exclusively/Yes significantly/Yes as a minor component/No)
3. Realm targeted	Does the intervention aim to change diet? (Yes exclusively or substantially/Yes minimally/No)
	Does the intervention aim to change activity levels? (Yes exclusively or substantially/Yes minimally/No)
4. Multifactoriness and dimensionality	Does the intervention use multiple strategies (three or more)? (Yes/No)
	Is the intervention applied in a single phase? (Yes/No)
	Is the intervention applied for a continued period? (Yes/No)

continued

Item	Question (possible answers)
5. Peak intensity and duration	During how many weeks does the whole intervention last? (Numerical; to be dichotomised at the median) For how many weeks does the peak engagement period of intervention last? (Numerical; to be dichotomised at the median) What is the level of engagement with the children? (High/Low)
6. Integration	Is the intervention integrated into the normal curriculum/habits? (Yes/Partially/No)
7. Flexibility	Is the intervention designed to be implemented in a flexible manner/tailored to specific participants? (Yes/No)
8. Choice	Is choice of activity/diet designed into the intervention? (Yes/No)
9. Fun factor	How enticing would you find this strategy? (Boring/Neutral/Fun) How enticing do you think children in the intended age group would find this strategy? (Boring/Neutral/Fun)
10. Resonance	Is the intervention experienced by children via someone external or unusual? (Yes/No)
11. Mechanism of action and recipient	Does the intervention have an explicit component of modifying the child's behaviour? (Yes/No) Does the intervention have an explicit component of education/information provision for the child? (Yes/No) Does the intervention have an explicit component aiming to change the social environment of the child? (Yes/No) Does the intervention have an explicit component aiming to change the physical environment of the child? (Yes/No)
12. Commercial interests	Are commercial interests involved in the trial and/or intervention? (Yes/No)

Reproduced from Spiga *et al.*¹ This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY NC 4.0) licence, which permits others to distribute, remix, adapt and build upon this work, for non commercial use, provided the original work is properly cited. See: <https://creativecommons.org/licenses/by-nc/4.0/>. The table above includes minor additions and formatting changes.

BOX 2 Elaboration on items included in the coding scheme for the interventions

Setting

This is a measure of the setting where the intervention is delivered. Possible answers were 'school', 'home' or 'community or other non-school/home' (e.g. club, gym, shop, library, healthcare centres). Within setting we also coded each intervention according to whether the intervention protocol included home-based activities for the children (e.g. cooking or games activities with parents, additional homework).

Mode of delivery to the child

This is a measure of how the child experiences the intervention, that is, as an individualised intervention (e.g. a leaflet about healthy meals given to each student at school; a visit to an healthcare centre, homework with parents, a website to view at home), through a group of children (e.g. school classes or scout troop meeting), or both (e.g. school classes and homework activities). Within mode of delivery we also coded the intervention according to whether it was delivered electronically (i.e. via digital media, online website or app) and in what capacity (i.e. exclusively, significantly, as a minor component or not at all).

Realm targeted

This is a measure of whether the intervention seeks to change 'diet' (e.g. introduction or replacement of food beverages with healthier options; re-organisation of food display in the school canteen or in shops; education on healthy diet; cooking classes; healthy meal box for the family), 'activity', including increase in physical activity (e.g. modified or additional physical activity classes at school) and/or reduce sedentary time at home (e.g. active video games), or 'both diet and activity', and in what capacity (i.e. exclusively or substantially to indicate the main component, minimally to indicate a minor component, or not at all).

Multifactoriness/dimensionality

This is a measure of how complex the intervention is, including how many ways the children are targeted, for example at multiple levels or in multiple phases. Questions within this category include whether the intervention has multiple components, that is, uses at least three different strategies (e.g. classroom activities, changes in the canteen food and homework activities), is delivered in multiple phases, that is, uses different strategies or settings at different times (e.g. a more active phase followed by a less active 'maintenance' phase or a 'top-up' phase), and is delivered in a continuous manner, that is without breaks between the beginning and the end of the intervention (during the whole school-year) or for a discontinuous period (e.g. lectures delivered for 12 weeks/year for 2 years).

Peak intensity and duration

This is a measure of how intensely the intervention is experienced by the child and it covers the duration and frequency of the intervention. Questions within this category include the duration in weeks of the whole intervention and of the peak engagement (if different from the whole intervention). It also measures the level of engagement with the children during the peak period, using the number of sessions of engagement per week as guidance so that the intervention are coded as 'high' engagement if there is one or more sessions of engagement with the children per week and 'low' if less than one session of engagement with the children per week.

Integration

This is a measure of the extent to which the intervention is 'normalised' within the school curriculum or normal habits of the child (e.g. as part of regular homework and/or provider). This measure provides an indication of how much 'extra effort' (by the provider and/or the recipient) would be required for the intervention to be successful. Examples of interventions that are completely integrated include modification of physical activity classes or the addition or replacement of regular school meals with healthier options. Examples of interventions that are partially integrated are those with a combination of integrated activities and something extra (e.g. after school program or homework). Examples of interventions that are not integrated at all are those in which the school needs to add something to an existing programme (e.g. an extra physical activity class extending school hours or home activities with the parents) or when the child needs to sign up for/agree to after-school classes.

Flexibility

This is a measure of the extent to which the intervention can be implemented flexibly, within the intervention protocol. That is, whether an intervention is adapted to the particular classroom/household at teachers/parents' discretion (e.g. an intervention consisting of the replacement of regular meals with healthy meals where the healthy meals are decided by each participating school kitchen staff).

Choice

This is a measure of the extent to which children are free to make the intervention work for them (e.g. an intervention in which the child is able to choose which sport they do, or which food to eat).

Fun factor

This is a measure of the extent to which the intervention is expected to be enjoyable for the age group to whom it is delivered. We anticipated that some interventions that involve games, songs, plays may look fun to everyone, whereas interventions that includes sport activities or cooking with the parents may not look fun to everyone and interventions that included classroom lectures or replacement of sugar sweetened drinks with water may not look fun to anyone. We also considered that some interventions may be appropriate for children aged 5–11 years but not for older children (e.g. a song about healthy eating), and vice versa, a video game intervention designed for older children (12–18 years old) may not be fun for a 5-year-old child. We designed the questions and answers for this category to be suitable and appropriate for CYP as they were invited to help us with coding the interventions for this item (see methods section on fun factor).

Resonance

This is a measure of the extent to which the intervention is likely to attract the respect of the young people, particularly through the credibility of the person delivering the intervention. For example, an intervention may be experienced by children via someone external or unusual (e.g. a sport coach, a professional athlete, an influencer, a dietician or a nurse) or someone familiar to them (form teacher or a parent/carer).

Mechanism of action and recipient

This is a measure of who is the direct recipient of the intervention [e.g. child, the teacher(s), parent(s), the child's environment or others] and how the intervention aims to achieve a change in the child's dietary and/or activity behaviour. Options for the latter are 'behaviour', 'education', 'social environment' and 'physical environment'. An intervention that has an explicit component of modifying the child's behaviour is an intervention in which the child learns by doing something (e.g. a session of physical activity or a workshop on healthy nutrition in which the children are involved in cooking a meal). An example of an intervention that has an explicit component of education or information is the provision of literature or lessons in which there is no activity involving the child doing something. An example of an intervention that has an explicit component aiming to change the social environment of the child at school or home is an intervention in which teachers are instructed to encourage children to change their dietary or activity behaviours or parents are educated on healthy food. Examples of interventions that have an explicit component aiming to change the physical environment of the child at school or home are interventions that include placement of healthy foods in the school canteen, provision of exercise equipment at school or in the community, drawing running tracks in the playground or changing the school meal menu. For interventions using multiple mechanisms, we answered Yes to all relevant options.

Commercial interests

This is a measure of whether commercial interests are involved in the trial or in the delivery of the intervention, such as an intervention within a study that was funded by industry (e.g. food or pharmaceutical industry) or an intervention that include use of equipment supplied by a manufacturer of sport equipment, or provision of food/drinks by a food supplier.

For all but one of the coding items above, two assessors from the research team independently coded each of the 250 interventions in the data set. For the item 'Fun factor', we recruited 35 children and young people aged 6–18, from whom four independently coded each intervention.

We also coded some features of the studies (age group, income-level of the country, whether children from low socioeconomic backgrounds were specifically targeted), the length of follow-up and the risk-of-bias assessment. *Table 2* provides the results of this coding in the simplified form that fed directly into the analyses we will be presenting. The simplification of items from *Table 1* to *Table 2* was based largely on statistical considerations such as the amount of information available in the coded data and the presence of high correlations between some pairs of items.

TABLE 2 Results of the coding of intervention features, study-level features and time-point-level features

Item	Description	Coding	n (%)
Intervention-level items (n = 250 interventions)			
School	Was the intervention delivered in a school (in full or in part)?	Yes (vs. no)	71
Home	Was the intervention delivered in the home (in full or in part) OR did it include any home activity for the child?	Yes (vs. no)	42
Community	Was the intervention delivered in the community or other setting (in full or in part)?	Yes (vs. no)	28
Individual	Was the intervention delivered to the child individually (either exclusively OR both individually and as part of a group)?	Yes (vs. no)	48
Electronic	Did the intervention involve any electronic component (exclusively/significantly/ as a minor component)?	Yes (vs. no)	21
Diet and activity	Did the intervention aim to change both diet and activity?	Yes (vs. no)	55
Activity	Did the intervention aim to change activity alone?	Yes (vs. no)	27
Multi-strategy	Did the intervention use multiple strategies (three or more)?	Yes (vs. no)	64
Duration	Was the intervention longer than 30.3 weeks? (30.3 weeks was the median length of follow-up)	Yes (vs. no)	50
Intensity	Was the level of engagement with the children high during the peak engagement period? (high = more than around 1 engagement per week)	Yes (vs. no)	61
Integration	Was the intervention integrated into the normal curriculum/habits?	Yes (vs. no)	47
Flexibility/choice	Was the intervention designed to be implemented in a flexible manner OR to include choice for the child?	Yes (vs. no)	46
Fun factor	Was the intervention considered fun?	Yes (vs. no)	61
Resonance	Was the intervention experienced by children via someone external or unusual?	Yes (vs. no)	52
Behaviour	Did the intervention have an explicit component of modifying the child's behaviour?	Yes (vs. no)	67
Education	Did the intervention have an explicit component of education/information provision for the child?	Yes (vs. no)	74
Social	Did the intervention have an explicit component aiming to change the social environment of the child?	Yes (vs. no)	70
Environment	Did the intervention have an explicit component aiming to change the physical environment of the child?	Yes (vs. no)	32
Study-level items (n = 204 studies)			
Age	Did the trial target secondary school age children (12–18) rather than primary school age children (5–11)?	Yes (vs. no)	27
Income country	Was the income status of country in which the trial was conducted High, according to World Bank criteria (rather than Low or Middle)?	Yes (vs. no)	86
SES	Was the socioeconomic status of the participants mixed, rather than targeting groups with low socioeconomic status (based on categorisations described by the trial authors)?	Yes (vs. no)	77
Time-dependent items (n = 261 observed time points)			
Medium	Was the follow-up time medium-term (9 months to < 15 months)?	Yes (vs. no)	39
Long	Was the follow-up time long-term (> 15 months)?	Yes (vs. no)	34
Risk of bias	Was the intervention at high risk of bias?	Yes (vs. no)	24

Objective 3: Synthesise the evidence

We analysed the results of the trials using a Bayesian multilevel metaregression analysis to examine which features were associated with the greatest effectiveness. The statistical analysis required development of novel methodology^{17,18} and the analysis plan was written in advance of the analysis and posted on the University of Bristol's research repository (reproduced in [Report Supplementary Material 3](#)). In summary:

1. Our outcome variable was standardised BMI (depicted zBMI). This is an age- and sex-standardised version of the usual BMI measure, regarded as more suitable for children.¹⁹
2. We measured the effectiveness of an intervention by the difference in mean change from baseline of zBMI between the intervention group and the control group.
3. Because many trials reported BMI (or other measures) rather than zBMI, we developed a method to map from results on these scales to results on the zBMI scale.¹⁷
4. We included the 'main effects' of all of the items in the [Table 2](#) in the model. Some coded aspects of the interventions were not included due to data limitations.
5. We were concerned that different items may work in tandem, such that there could be synergistic or antagonistic effects. In other words, the impact of one item may depend on whether another item is present. Statisticians call this 'interaction'. In our data set there was a very large number of potential interactions (over 16 million) and it would have been infeasible to explore them all. We therefore explored two types of interactions: the possibility that items have different effects in (1) different age groups and (2) depending on whether the intervention targets diet, activity or diet and activity. This still produces a very large number of possibilities, and we used a sophisticated methodology to select the ones that the data determined to be most important.

Our findings were published as a preprint and subsequently in *BMJ Public Health*.^{20,21} The analysis included 204 trials (255 intervention arms). In line with the Cochrane Reviews, we found that on average the interventions were effective [mean difference (MD) in zBMI -0.037 , 95% credible interval -0.053 to -0.022]. Assuming a population in which zBMI follows a standard normal distribution, and using results presented in appendix 4 of the Cochrane Review,¹² this corresponds to a reduction in the prevalence of overweight from 16% to 15% or of overweight from

2.3% to 2.1% (with cut-offs of zBMI = 1 for obesity and zBMI = 2 for obesity as per the WHO).²² The largest effects were associated with medium term follow-up (9 to < 15 months) and older children (12–18 years). We also found evidence of small but beneficial effects for interventions that targeted physical activity alone rather than diet alone (difference in MDs -0.227 , -0.362 to -0.090 ; corresponding to reductions in proportions from 15% to 10~% for overweight or from 2.1% to 1.2% for obesity) and small unfavourable impacts of interventions involving a change to the structural environment, the majority of which were in the school food environment (difference in MDs 0.05, 0.017 to 0.085). Accounting for interactions between covariates, we found that the most effective combination of intervention characteristics was to intervene in the school setting, with an individualised element to delivery, targeting physical activity, using multiple strategies of short duration and high intensity, and involving modification of behaviour through participation in activities.

Objective 4: Investigate inequity

The fourth objective was to explore the extent to which individual characteristics associated with inequity impact on intervention effectiveness. We initially planned to collect individual participant data to do this. However, establishing data sharing agreements with a large number of trials around the world proved logistically challenging. Furthermore, contemporaneous work on prospective meta-analyses of treatments of COVID-19 suggested a more efficient way forward, by requesting aggregated data by subgroup from the trialists rather than individual participant data.²³

We attempted to contact authors of all trials that compared an intervention with a control group (236 of the 244 trials). We sought results (for zBMI or BMI) broken down by any of the following baseline characteristics [known as the PROGRESS (place of residence, race/ethnicity/culture/language, occupation, gender/sex, religion, education, socioeconomic status, social capital) characteristics²⁴]:

- Place of residence (e.g. urban vs. rural).
- Race/ethnicity/culture/language (categorised as the dominant ethnic group vs. the minority ethnic group in the location of the trial).
- Occupation (of parents, e.g. professional or managerial occupation vs. other occupation).
- Gender/sex (male vs. female).
- Religion (e.g. categorised as the dominant religion vs. the minority religion in the location of the trial).
- Education (e.g. categorised as higher education vs. no higher education).

- Socioeconomic status (categorised as higher vs. a lower socioeconomic status, as defined by the trial authors).
- Social capital (e.g. categorised as two parents living in the same residence as the child vs. not).

We received a response from the authors of 138 studies (58% response rate) and obtained relevant subgrouped data from 64 studies (27%). In addition, we were able to extract subgrouped data from 20 publications, including three studies for which authors provided additional data. We ended up with useable data from 81 studies (34% of the total).

Our statistical analysis focussed on the difference in intervention effectiveness between children with different characteristics. For example, in our investigation of gender/sex, we estimated the effect of intervention in the boys of a specific trial, then estimated the effect of the intervention in the girls of the same trial, then computed the difference between them. These interaction constructs describe how much more (or less) effective the intervention is in boys compared with girls. After estimating these interactions for each trial separately, we performed a meta-analysis of these differences across all of the trials providing data by gender/sex. This gave us our best estimate of whether interventions, in general, are more effective in boys or girls.

Our findings were published as a preprint and subsequently in *eClinicalMedicine*.^{25,26} The analysis found no substantial differences in effectiveness for different subgroups across almost all of the PROGRESS factors. However, in the younger age group (5–11 years), the effect of interventions on zBMI appeared to be greater in boys.

Objective 5: Collate evidence on costs

We examined the studies included in the two Cochrane reviews for any cost data.²⁷ Eighty-five of the trials reported costs related to the intervention or the trial, or had a full economic evaluation associated with it. For only five trials was a full economic evaluation reported within the trial paper. Most of the costs reported were incentives for participation (41 trials). Thirty studies included intervention costs, although the reporting of these data was inconsistent. It was unclear who was paying these intervention costs in most cases, making the attribution of costs to sectors difficult. Only one study reported healthcare resource use data, although some estimated the cost of obesity related chronic conditions in linked decision models. In general, the availability of cost or economic data was too scarce for us to address this objective well.

Objective 6: Consult stakeholders about the findings

Our final objective was to bring together a panel of public health professionals to provide recommendations on practice and future research from the project. We held a 3-hour stakeholder meeting in February 2024 with 10 invited public health professionals, a young person, a teacher, five project staff and the chair of our Advisory Board, Prof Jeremy Grimshaw (University of Ottawa), who chaired the meeting. Public health professionals worked in local councils (of Bristol City, South Gloucestershire, Essex County and Swindon Borough), the Health Security Agency and the Office for Health Improvement and Disparities at the Department of Health and Social Care. In advance of the meeting, we held two workshops, one with children and young people, and one with teachers, to present our results and elicit their views and interpretations. The young person and the teacher who attended the stakeholder meeting were also present at these workshops and presented the workshop outputs to the main meeting.

The project team presented the main results of the project to the stakeholder meeting, focussing on the findings from Objectives 3 and 4. Participants noted that, even though we did not find strong evidence of very effective intervention features, our findings do not imply that interventions are ineffective. They pointed out that the findings could easily be misinterpreted in this way and that the framing and messaging of our findings, particularly within a policy and local authority context is very important so that initiatives to improve diet and encourage physical activity are not undermined. They highlighted that messaging from this research should underline the importance of both diet and physical activity for children's overall health and well-being, and particularly their mental health. There was general agreement that the potential role of physical activity in the prevention of childhood obesity is overshadowed by the role of diet in current policy and practice.

From a policy perspective, stakeholders noted that the UK currently considers parental/family involvement in interventions and the use of a whole system approach as being important factors of successful initiatives and interventions. They urged the project team to consider these factors, alongside high-level structural changes that are currently recommended (such as school food standards, school fruit and vegetable schemes, and local planning restrictions of certain types of food outlets) in their interpretation and recommendations. They appreciated that these types of interventions were not included in this research because they have seldom been evaluated in randomised trials. However, they were concerned about

how the messages from the research would be interpreted and implemented in the context of the current whole system approach landscape and noted that this landscape is changing. It was suggested that the recommendations from this research should be framed within this context and provide practical suggestions for policy and practice, particularly for local, place-based stakeholders, around types of interventions they might include to further improve existing policy and local initiatives.

A further topic emerging from workshop discussions was how best to present the findings of this research (and to present dietary recommendations for the prevention of childhood obesity in general) within the context of food insecurity and the fact that children living in underserved areas of the UK are more likely to be living with both obesity and food insecurity. It was agreed that this was a particularly challenging message.

Discussion/interpretation

We found that, on average, behaviour change interventions aiming to prevent obesity in children aged 5–18 years result in slightly lower BMI or zBMI. Because the vast majority of children included were normal weight or overweight, this should translate to a reduction in the proportion of children developing obesity. Although the beneficial effects of the interventions are small, they may have a considerable impact on public health at the population level where this is feasible. There is, however, considerable variation in effectiveness across interventions. Our main synthesis found that the most effective characteristic to include in an intervention to prevent obesity was targeting of physical activity. We stress again that this does not mean that attempts to modify diet should be abandoned. Physical activity and consumption of a healthy diet during childhood offer many important benefits in addition to contributing to healthy weight and growth. It is reasonable for interventions to prevent obesity in children to consider placing additional focus on the promotion of physical activity and to consider effective intervention characteristics as identified here. We also saw that interventions were on average more effective in the older age group.

Our investigation of whether intervention effects differed by baseline characteristics associated with inequity found little evidence that they did. This is heartening, since it suggests that the types of interventions that have been studied in randomised trials do not increase inequities. However, it also suggests that they might not *reduce* inequities. Nonetheless, confidence intervals around the

estimated differences in effectiveness between subgroups are reasonably wide, particularly for the older age group (12–18 years), so there remains uncertainty around this. We did observe a suggestion that interventions may have larger effects in younger boys (5–11 years) than in younger girls, a difference that was not observed for older children (12–18 years). In the UK as in many other countries, physical education is often taught at primary school in mixed gender groups, while for older children there is more variation. It may be that interventions for younger children yield greater benefits if efforts were made to make them equally engaging and enjoyable for boys and girls. However, in older children, where increased BMI may correspond with decreased percentage body fat in males but not females, a greater effect of interventions in males compared with females could be masked by examining BMI only. It would be interesting to examine these issues with alternative measures such as percentage body fat.

Strengths of our research include the large amount of data, the robust and sophisticated methods and the close involvement of children, young people and other stakeholders. We accumulated evidence from 244 randomised trials and undertook multiple meta-analyses on subsets of these trials to answer questions about the effects of general strategies for trying to prevent obesity in children. Two hundred and four of the trials contributed to analyses to examine specific intervention features to try and explain heterogeneity in results, and 81 of the trials contributed new information, mostly unpublished, allowing us to investigate how intervention effectiveness varies by baseline characteristics associated with inequity. These are larger numbers than any previous attempts to address similar aims in this field. Our methods followed the highest standards used by the Cochrane Collaboration and led to the development of novel statistical methods allowing us to make the most of the data. Our involvement of children and young people from the start, including their participation in the coding of intervention features and full inclusion in our Advisory Board, sought to ensure our methods and interpretations aligned with the people most directly impacted by the interventions under study.

Our research is not without limitations. In most of the work, we were reliant on the nature of the interventions that had been studied in randomised trials. These were mainly school based, of finite duration, targeted at individuals or groups of individuals (rather than systems), with short follow-up and were published between 1990 and 2023. Some of the earlier interventions would likely be implemented in different ways now, particularly by using digital approaches based on smart phones and even artificial intelligence. Only a small proportion of the

interventions studied had a substantial digital element (8% of the trials in ages 5–11 and 22% of the trials in ages 12–18). We nonetheless examined interventions that had been examined in non-randomised studies by over-viewing 24 systematic reviews of non-randomised studies. The evidence here was less robust but suggested that interventions with multiple components working at multiple levels in multiple settings may be most effective. This aligns with our finding from randomised trials that interventions delivered through multiple strategies were more effective than those that were not. We approached the trial authors only for the investigation around inequity and did not ask for information to fill in the many other aspects that had not been reported in sufficient detail. Our coding of intervention features relied on the information reported in papers, which was often brief and incomplete. In the inequity investigation, many trialists were unable to provide data or did not respond, so the trials included comprised only a minority of those potentially available. Furthermore, in order to maximise response rates and make the analysis straightforward, we asked for a simple dichotomisation of inequity factors at baseline, which necessitates considerable simplification of complex phenomena. Information on costs or cost-effectiveness was very limited despite the fundamental importance of these considerations when planning or rolling out interventions. We were surprised at the large proportion of trials providing incentives for participating in the trial, many of these trials were undertaken in the USA. Such incentives would generally not be available outside of a trial context, although it is unclear how much they may have affected results.

Patient and public involvement

Our involvement of members of the public began while preparing the initial proposal (see [Table 3](#) for a summary of public involvement). We held a workshop of children and young people identified through an e-mail call to members of our local Young Peoples Advisory Group (YPAG) to help us develop the initial plan while preparing the funding application.

At the start of the project, we recruited two young people (aged 16 at the start) to join our project Advisory Group, who were also identified through an e-mail call to the YPAG. They participated fully in Advisory Group meetings, where their input was regularly and actively sought by the chair and welcomed by all present (see also [Table 3](#)).

A key part of the project was the development of a new analytic framework to inform the re-analysis of trial data. We developed this through a series of workshops

including two with children and young people and two with schoolteachers. We held two further workshops (one with children and young people and one with schoolteachers) towards the end of the project to help us interpret the results. One representative from each of these workshops joined us at the closing stakeholder meeting at which we sought to derive some recommendations for practice and for research.

We invited members of the YPAG to join the research team by coding all the interventions according to the 'Fun factor', the extent to which they thought the interventions would be fun or boring by children of the age targeted by the interventions, based on short descriptions extracted from the trial reports. Thirty-five children and young people (aged 6–18) volunteered and participated in the coding.

The work on the involvement of children and young people in the development and application of analytic framework was presented at the Cochrane Colloquium 2023 within the 'Patient or healthcare consumer involvement' symposium.

Equality, diversity and inclusion

Considerations of inequity were central to the project. In Objective 4 we directly addressed the problem that some sectors of society, including some with lower socioeconomic status and with minority ethnic backgrounds, have higher rates of obesity. The interventions of interest in our work were largely addressed to general populations. It is important that efforts to prevent the development of obesity in children at the population level do not widen inequities within the population by having greater effects in the sectors with the lowest risk of developing obesity. Our investigations, based on data from 81 trials, did not find evidence that inequities would be exaggerated after implementation of the sorts of interventions included in the trials. However, neither did we find evidence that inequities are likely to be reduced, which would be a preferable outcome.

Our work on this project led members of the project team being invited to participate in equality, diversity and inclusion (EDI)-related activities. Dr Spiga was invited to address a workshop on inequity at the London Cochrane Colloquium in London in September 2023, and also to join a collaboration with the WHO Health Equity group on developing a tool for assessing equity in guidelines. She is now the Bristol representative on a best practice working

TABLE 3 Summary of public involvement

Date	People involved	Issues discussed	Impact on the project
16 March 2020	Four children and young people aged 11–13	We presented the plans for the project and invited comments and suggestions for what sorts of intervention features we should look at.	Helped shape the proposal and provided early items for the list of important features to feed into the analytic framework (including the ‘fun factor’ of an intervention, role of family).
2 September 2021	Two school attenders participated in Advisory Group meeting 1/3	Introduction to the project; preliminary thoughts on grouping ages and what outcome(s) to focus on; planning of workshops with children, young people, parents and teachers	An important distinction between primary school and secondary school age was agreed, and to address BMI and zBMI as joint main outcomes
11 January 2022	Five children and young people aged 13–18	We asked (1) What sorts of approaches do you think might work?; (2) From the ideas generated, what sorts of approaches might work best?; (3) Are there approaches that might work for all age groups? particularly well for those most likely to gain weight?; and (4) Are there combinations of approaches that might be particularly good or particularly bad?	The group reiterated the need to make interventions fun for the children and to consider the home environment (and parents, e.g. getting children involved in making meals). They also pointed out the importance of the person delivering the intervention having credibility with the children (which led to our ‘Resonance’ feature in Table 1). Accessibility of healthy food at school was also an issue, as was the ability to choose activities (e.g. which sports at school, leading to ‘Choice’ and ‘Flexibility’ features)
12 January 2022	Four children and young people aged 12–16, each with a parent	As above	Many similar themes came out of this discussion as from the first. It was stressed that interventions may work quite differently in younger children (primary school age) compared with older children (secondary school), reinforcing the plan to separate analyses into these age groups
8 February 2022	Two school attenders participated in Advisory Group meeting 2/3	Project update; emerging analytic framework after recent PPI sessions; plans for future PPI	Some items in the emerging framework were proposed to be dropped as they are unlikely to be informative or information is unlikely to be reported. Plans were made for consultation with teachers
12 January 2023	Four teaching staff from primary schools	We asked (1) What sorts of approaches do you think might work?; (2) From the ideas generated, what sorts of approaches might work best?; (3) Are there approaches that might work for all age groups? Particularly well for those most likely to gain weight?; and (4) Are there combinations of approaches that might be particularly good or particularly bad?	Resource and time constraints are important: embedding the programme within the curriculum may be more efficient than changing the existing curriculum. Suggestions for interactions: (1) the importance of setting for different types of interventions, for example physical activity interventions are readily delivered at school, but it is more difficult to control children’s diets if they bring lunch boxes from home; (2) educational interventions may be more effective in younger children, because older children are more independent
23 January 2023	Four teaching staff from primary schools	As above	Highlighted the importance of involving the parents to ensure continuity of school-based interventions, and of empowering the children (e.g. involving them in preparing meals)
15 June 2023	Two school attenders participated in Advisory Group meeting 3/3	Project update; which interactions to look at in the main synthesis; planning of stakeholder discussion meeting	The Advisory Group recommended asking for a no-cost extension to give us enough time to consider the results carefully
10 January 2024	Six children and young people	Presentation and discussion of main project findings	Expressed surprise at the lack of clear effects of many features expected to be important. In group activities, children may encourage each other to exercise more than they would if not in a group (e.g. in a football game). Insights offered into differences between boys and girls. In primary schools, boys have traditionally tended to do more sport than girls (e.g. at breaks and lunch times). In secondary school, girls perhaps have become more self-conscious about their looks and may be more likely to try and stay at a healthy weight

continued

TABLE 3 Summary of public involvement (continued)

Date	People involved	Issues discussed	Impact on the project
31 January 2024	Four teaching staff from primary and secondary schools	Presentation and discussion of main project findings	Children have more control over their activity levels than their diets. Insights into differences between boys' and girls' enjoyment of physical activity. Secondary school girls tend to have lower baseline activity levels than boys which may increase the impact of an intervention. They also start to become conscious of body image which might motivate them to engage with an intervention
13 February 2024	One young person and one teacher join stakeholder discussion meeting	Presentation and discussion of main project findings	The young person and teacher had agenda slots to present the thoughts of the immediately preceding workshops
1 March 2024	Two school attenders from our Advisory Group	Paper submitted to NIHR Journals Library (<i>Public Health Research</i>) about the analytic framework, with two school attenders among the authors (and many others acknowledged for their contributions)	Publication

group across the nine NIHR Evidence Synthesis Groups in the UK.

We paid attention to EDI considerations in the running of the project too. We sought a diverse group of children and young people for our patient and public involvement (PPI) workshops and coding exercise, and managed to include a good mixture of genders and ethnic backgrounds. Our Advisory Board comprised three males and four females.

Impact and learning

Engagement with stakeholders

We identified the need to engage with stakeholders early, including children and young people, school staff and public health professionals (including local authorities and national institutions). An important part of the project was the series of discussion workshops and one-to-one discussions we held with stakeholders to develop our analytic framework. This not only produced a relevant framework for re-analysing the trial data, but it led to opportunities to present our work at meetings and conference to help disseminate the results (see [Publications](#)).

Impact on statistical methodology

The complexity of the data set led to development of new statistical methods. The data included a mixture of active and inactive interventions, multiarm trials and multiple follow-up times. To analyse these data using our novel analytic framework we needed to develop a bespoke

synthesis model, which we reported in a methodological paper.¹⁸ Our synthesis was based on component-based network meta-analysis, which represents complex interventions as a sum of separate intervention components (allowing for interactions between them) and uses a meta-regression framework to examine the impact of each of these components. Our model had to distinguish between (1) studies of an active intervention versus control, where the components apply only to the active interventions and (2) head-to-head comparisons of active interventions, where only differences between the components of these active interventions can be estimated. A meta regression model was then used with covariates on three levels: intervention, study and follow-up time. It incorporates a correlation structure to account for trials with multiple intervention arms and multiple follow-up times.

The data also included a mixture of different measurement scales. Some trials reported raw BMI scores while others reported BMI standardised by age and sex, either as a Z-score or a percentile. To maximise the precision of our estimates we sought to include all of the trials in one analysis. This required novel methods of mapping between results on the different scales.¹⁷

Collaborations

We developed two collaborations during the course of the project. Prof Berit Lilienthal Heitmann (University of Copenhagen, Denmark) was known to co-applicant Prof Summerbell but not to the chief investigator or his colleagues in Bristol. We discovered that she was interested in doing a project similar to our inequity

investigation but with a focus on baseline weight status rather than the PROGRESS inequity factors. We therefore joined forces and wrote a protocol jointly to address weight status as well as PROGRESS factors (see annex to [Report Supplementary Material 2](#)), and proceeded as a collaborative venture.

Second, the inequity investigation involved a large collaboration with authors of the included trials. We wrote the paper from Objective 5 with the 'Inequity in Obesity Prevention Trialists Collaborative Group', which comprised 66 trialists and 14 other collaborators.

Lessons learnt for future research

One of the major lessons we learnt from this research arose from the inequity investigation in Objective 5. We originally intended to request individual participant data from as many trials as possible. In retrospect, this was probably a poor plan, since the resources required to administer the data transfer agreements and to clean, check and analyse the data set could have been substantially higher than those available. Fortunately, the COVID-19 pandemic gave us experience of an alternative approach: to ask the trialists for summary data by subgroup. This facilitated the same analyses with a small fraction of the resources. We consider ourselves to have been very successful in this approach, having collected unpublished data from 64 studies in this way.

We believe that our approach to contacting the trialists helped us obtain a higher-than-expected response rate. Coinvestigator Prof Summerbell is well known in the field (much more so than our Bristol-based researchers). Through her honorary visiting academic status at University of Bristol, we were able to send e-mails from Prof Summerbell's e-mail address and have the replies received by the research team. Furthermore, each e-mail was personalised with information about what we had extracted from the recipient's trial and a link to a spreadsheet into which they could easily enter means, standard deviations and sample sizes per subgroup. The process of generating and sending the e-mails was implemented through Microsoft Automate. This allowed a general e-mail template to be adapted by looking up information to populate various fields.

Further dissemination

We presented our findings at numerous meetings and conferences (listed under [Publications](#)). A podcast about the findings of the two Cochrane Reviews, and their importance, was released alongside the Cochrane Reviews and is publicly available at www.cochrane.org/podcasts/10.1002/14651858.CD015328.pub2.

Implications for decision-makers

The National Institute for Health and Care Excellence (NICE) identified our Cochrane Reviews as providing important evidence to inform major new guidance to replace eight existing guidance documents: *Overweight and obesity management: preventing, assessing and managing overweight and obesity* [GID-NG10182; www.nice.org.uk/guidance/indevelopment/gid-ng10182]. This guidance was released in November 2024. We liaised closely with NICE during preparation of the Cochrane Reviews and shared regular updates, including full data sets of the information we had extracted from the trials. We produced summary tables, meta-analyses and Grading of Recommendations Assessment, Development, and Evaluation assessments for the NICE Committee and presented these to the Committee in October 2022 (results, ages 12–18), 28 November 2022 (preliminary results, ages 5–11) and 12 June 2023 (final results, ages 5–11).

Our work contributes all the evidence to one evidence review underlying the draft NICE guideline: *[H] Evidence reviews for the effectiveness of healthy living programmes in preventing overweight and obesity in children and young people* (available from www.nice.org.uk/guidance/gid-ng10182/documents/html-content-2).

Our work is also being considered as part of the World Health Organization's development of their guidance on integrated management of obesity in children which is expected to be launched in the first half of 2025.

Research recommendations

1. Examine the effects of components of whole-systems approaches

Because our Cochrane Review identified very few 'whole-systems' approaches to tackle prevention of childhood obesity, we identify a need for randomised trials and other studies of such approaches. We recognise that whole-systems approaches are challenging to investigate in randomised trials, particularly if they address systems at a high level. Research into the effects of multilevel, community, or other interventions that better address systemic and structural factors related to obesity, at present is concentrated on non-randomised studies, which are subject to greater biases than randomised trials. We suggest that more interventions focus on environmental and political factors that drive obesity, and on the wider determinants of health that drive inequalities in diet, physical activity and obesity.

- In planning of future intervention trials, consider the combinations of components identified as being associated with the greatest effectiveness

Because our re-analysis of randomised trial results derived the combination of intervention features associated with the most beneficial effect, we suggest that those developing interventions aiming to prevent obesity in children and young people consider the list of features included in this. They were, for older children: set in a school, with an element that is delivered individually, targeting physical activity more than diet, containing multiple strategies, having high intensity, being of short duration, delivered by someone resonant with the children, and aiming to modify behaviour through participation. For the younger age group, resonance may not be so important, and instead interventions that are integrated into the curriculum or daily habits may be more effective. Indeed, in our discussions with teachers it was suggested that younger children are more influenced by their teachers than older children, while the older children are more influenced by peers or external role models. This might explain our observation that resonance to the children of the person delivering the intervention appeared effective for older but not younger children.

- In future studies of the effects of interventions to prevent childhood obesity, routinely collect a comprehensive set of baseline characteristics around inequities

Because of the importance of inequities in obesity prevalence, we suggest that future trialists collect and report baseline information on all PROGRESS factors (place, race, occupation, gender/sex, religion, education, socioeconomic status and social status) and that they examine whether the effect of the intervention differs according to these factors.

- In future studies of the effects of interventions to prevent childhood obesity, include children with disabilities

Because very few data are available from existing trials, we suggest that future studies on the effects of interventions to prevent childhood obesity allow the inclusion of, and consider actively seeking enrolment of, children living with disabilities.

- Future studies in this area should follow good practice in conduct and reporting

As in many systematic reviews, we were unable to make the best possible use of existing evidence because of limitations in the conduct and reporting of the trials. We particularly encourage future researchers to follow

reporting standards such as CONSORT²⁸ and wherever possible to make their data available on repositories.

- Future evidence syntheses should consider the methodology implemented here

The methodology we developed and implemented here has widespread application to evidence syntheses addressing the effects of complex interventions. We urge evidence synthesists to consider adopting it in future investigations. We are aware of a subsequent application in an evidence synthesis around interventions to increase uptake of vaccines (<https://fundingawards.nihr.ac.uk/award/NIHR135130>; accessed 12 June 2025).

Conclusions

The take-home messages from our project are that (1) interventions to prevent childhood obesity can work in terms of preventing excess weight gain, with effects that are typically small at the individual level, (2) physical exercise is at least as important as diet as a behaviour to target; (3) many aspects of interventions and of randomised trials influence the magnitude of intervention effect and the variability in magnitude cannot easily be explained by obvious candidate features; and (4) there is not strong evidence that interventions work differently in those with different PROGRESS characteristics at baseline.

Additional information

CRedit contribution statement

Julian PT Higgins (<https://orcid.org/0000-0002-8323-2514>): Conceptualisation, Funding acquisition, Supervision, Methodology, Investigation, Writing – original, Writing – reviewing and editing.

Francesca Spiga (<https://orcid.org/0000-0002-6904-2247>): Investigation, Writing – reviewing and editing.

Annabel L Davies (<https://orcid.org/0000-0003-2320-7701>): Investigation, Writing – reviewing and editing.

Jennifer C Palmer (<https://orcid.org/0000-0002-8073-2505>): Investigation, Writing – reviewing and editing.

Sarah Dawson (<https://orcid.org/0000-0002-6682-063X>): Investigation, Writing – reviewing and editing.

Deborah M Caldwell (<https://orcid.org/0000-0001-8014-7480>): Conceptualisation, Funding acquisition, Methodology, Investigation, Writing – reviewing and editing.

Lucy Condon (<https://orcid.org/0009-0006-1626-4934>): Supervision, Investigation, Writing – reviewing and editing.

Fiona B Gillison (<https://orcid.org/0000-0002-6461-7638>): Conceptualisation, Investigation, Writing – reviewing and editing.

Eve Tomlinson (<https://orcid.org/0000-0002-0969-602X>): Investigation, Writing – reviewing and editing.

Theresa HM Moore (<https://orcid.org/0000-0003-3719-6361>): Conceptualisation, Investigation, Writing – reviewing and editing.

Katie Breheny (<https://orcid.org/0000-0001-6886-4049>): Investigation, Writing – reviewing and editing.

James Nobles (<https://orcid.org/0000-0001-8574-4153>): Conceptualisation, Investigation, Writing – reviewing and editing.

Sharea Ijaz (<https://orcid.org/0000-0001-5727-1790>): Conceptualisation, Investigation, Writing – reviewing and editing.

Jelena Savović (<https://orcid.org/0000-0002-2861-0578>): Conceptualisation, Investigation, Writing – reviewing and editing.

Rona M Campbell (<https://orcid.org/0000-0002-1099-9319>): Conceptualisation, Investigation, Writing – reviewing and editing.

Carolyn D Summerbell (<https://orcid.org/0000-0003-1910-9383>): Conceptualisation, Funding acquisition, Supervision, Investigation, Writing – reviewing and editing.

Acknowledgements

Full project team

Core researchers

- Prof Deborah M Caldwell (University of Bristol)
- Dr Annabel Davies (University of Bristol)
- Prof Julian PT Higgins (*chief investigator*) (University of Bristol)
- Dr Theresa HM Moore (University of Bristol)
- Dr Jennifer Palmer (University of Bristol)
- Dr Jelena Savović (University of Bristol)
- Dr Francesca Spiga (University of Bristol)
- Prof Carolyn D Summerbell (Durham University)
- Eve Tomlinson (University of Bristol)

Collaborators

- Mike Bell (University of Bristol)
- Prof Rona M Campbell (University of Bristol)
- Lucy Condon (University of Bristol)
- Prof Fiona Gillison (University of Bath)
- Prof Berit Heitmann (University of Copenhagen, Denmark)
- Dr Rebecca Hodder (University of Newcastle, Australia)
- Dr Sharea Ijaz (University of Bristol)

- Dr James Nobles (Leeds Beckett University)
- Prof Luke Wolfenden (University of Newcastle, Australia)
- Inequity in Obesity Prevention Trialists Collaborative Group (see Palmer *et al.*²⁶ in [Box 1](#) for members)

Advisory Board

- Maddie Coleman (school attender)
- Prof Jeremy Grimshaw (*chair*) (University of Ottawa, Canada)
- Prof Graham Moore (Cardiff University)
- Prof Miranda Pallan (University of Birmingham)
- Elizabeth Sheldrick (school attender)
- Prof Lesley Stewart (University of York)
- Prof Tom Trikalinos (Brown University, USA)

We are hugely grateful to the children, young people and teaching staff who shared their experiences and perspectives in our workshops and contributed importantly to the project. We particularly thank Maddie Coleman and Elizabeth Sheldrick who also participated enthusiastically as members of our Advisory Board.

We thank the following children, young people and parents participating in our workshops: Ameilia Holford, Amelie Low, Daniel Seretny, Elaine S Seretny, Francesca Quick, George Thomas, Havi Carel, Karen Low, Lucy Naser, Lucy Thomas, Nino Faber Gray and Riya Baghirathan Nicholls. We are also indebted to the children and young people who participated in coding: Abdi Ali, Alice Matthews, Amaani Isse, Amelie Low, Amiira Isse, Archie Cazalet, Arwen Sofia Sequeira White Wandschneider, Ayaan Isse, Elizabeth Sheldrick, George Thomas, Harry Allbless Roberts, Hudda Mahamed, Isaac Hodge, Isaac Tregidgo, Jake Andrews, Joe Freer, Joseph Thomas, Katie Bond, Lottie Freer, Lowenna Negus, Matilda Hodge, Matilda Tregidgo, Max Andrews, Millie Freer, Oliver Leary, Oscar Lopez-Cottrell, Rahma Farah, Riya Baghirathan Nicholls, Shafia Mahamed, Sol Okasha, Sophie Phillips, Stanley Thomas, Tejas Ramanan and Theo Donnelly.

We thank the following teachers for participating in workshops: Stephen Breeze, Joanne Davies, Robert Davies, Gill Hampton, Martin Holmes, Emily Proffit, Gill Richards and Joseph Harley-Easthope. We thank the following public health professionals participating in workshops and informal discussions: Justine Womack (Office for Health Improvement and Disparities South West, OHID SW), Penny Marno (Swindon Borough Council), Lewis Bird (Swindon Borough Council), Sarah Amos (South Gloucestershire Council), Georgie MacArthur (North Somerset Council) and Caoimhe Gowran (Bristol City Council).

Finally, we thank the rest of our Advisory Board, especially its chair, Prof Jeremy Grimshaw, for their valuable advice.

Data-sharing statement

The vast majority of the data collected for Objective 1 are presented in the extensive tables and appendices of the Cochrane

Reviews. The data and codes that support Objective 3 (the main synthesis) are available at the GitHub repository: https://github.com/AnnieDavies/Obesity_Synthesis. For Objective 4 (the investigation around inequities), only aggregated data by subgroup were collected from the trialists; these data are presented in the figures in the supplementary materials to the paper. Data collected for Objective 5 (costs) are presented in the corresponding paper. No data were generated for Objectives 2 and 6. Any other queries or data requests should be submitted to the corresponding author for consideration.

Ethics statement

This evidence synthesis project was based on existing evidence and did not involve research participants or collection of new data. As such, ethical approval was not necessary. The vast majority of information used was extracted from publications. Our collection of aggregate data from the trialists did not permit the identification of individuals.

Information governance statement

NIHR is committed to handling all personal information in line with the UK Data Protection Act (2018) and the General Data Protection Regulation (EU GDPR) 2016/679. Under Data Protection legislation NIHR is the Data Processor; the Department for Health and Social Care (DHSC) is the Data Controller, and we process personal data in accordance with their instructions. You can find out more about how we handle personal data, including how to exercise your individual rights and the contact details for DHSC's Data Protection Officer here: www.nihr.ac.uk/nihr-privacy-policy.

Disclosure of interests

Full disclosure of interests: Completed ICMJE forms for all authors, including all related interests, are available in the toolkit on the NIHR Journals Library report publication page at <https://doi.org/10.3310/AKHD0407>.

Primary conflicts of interest: Francesca Spiga, Julian PT Higgins, Deborah M Caldwell and Jelena Savović were supported in part by the NIHR Bristol Evidence Synthesis Group. Julian PT Higgins, Theresa HM Moore and Jelena Savović were supported in part by the NIHR Applied Research Collaboration West (ARC West) at University Hospitals Bristol and Weston NHS Foundation Trust. Julian PT Higgins is a NIHR Senior Investigator (grant number NIHR203807). Julian PT Higgins had expenses paid by the organisers to give an invited talk at the 30th European Congress on Obesity in 2023. Rona M Campbell was a member of the NIHR Public Health Research programme funding committee until January 2021.

Department of Health and Social Care disclaimer

This publication presents independent research commissioned by the National Institute for Health and Care Research (NIHR). The views and opinions expressed by authors in this publication

are those of the authors and do not necessarily reflect those of the NHS, the NIHR, MRC, NIHR Coordinating Centre, the Public Health Research programme or the Department of Health and Social Care.

This synopsis was published based on current knowledge at the time and date of publication. NIHR is committed to being inclusive and will continually monitor best practice and guidance in relation to terminology and language to ensure that we remain relevant to our stakeholders.

Publications

Journal articles

Moore THM, Tomlinson E, Spiga F, Higgins JPT, Gao Y, Caldwell DM, *et al.* Interventions to prevent obesity in children aged 5 to 11 years old [protocol]. *Cochrane Database Syst Rev* 2022:CD015328. <https://doi.org/10.1002/14651858.CD015328>

Moore THM, Tomlinson E, Spiga F, Higgins JPT, Gao Y, Caldwell DM, *et al.* Interventions to prevent obesity in children aged 12 to 18 years old [protocol]. *Cochrane Database Syst Rev* 2022:CD015330. <https://doi.org/10.1002/14651858.CD015330>

Spiga F, Davies A, Tomlinson E, Moore THM, Dawson S, Breheny K, *et al.* Interventions to prevent obesity in children aged 5 to 11 years old. *Cochrane Database Syst Rev* 2024:CD015328. <https://doi.org/10.1002/14651858.CD015328.pub2>

Spiga F, Tomlinson E, Davies A, Moore THM, Dawson S, Breheny K, *et al.* Interventions to prevent obesity in children aged 12 to 18 years old. *Cochrane Database Syst Rev* 2024:CD015330. <https://doi.org/10.1002/14651858.CD015330.pub2>

Spiga F, Picton H, Savović J, Moore THM, Caldwell DM, Summerbell CD, Higgins JPT. Population- and community-based interventions for preventing childhood obesity: an overview of systematic reviews of non-randomised studies of intervention [Submitted].

Davies AL, Higgins JPT. A complex meta-regression model to identify effective features of interventions from multi-arm, multi-follow-up trials. *Stat Med* 2024;43:5217–33. <https://doi.org/10.1002/sim.10237>

Davies AL, Ades AE, Higgins JPT. Mapping between aggregate level BMI data on different measurement scales in a meta-analysis of childhood obesity prevention interventions. *Res Synth Methods* 2024;15:1072–93. <https://doi.org/10.1002/jrsm.1758>

Davies AL, Spiga F, Caldwell DM, Savović J, Palmer JC, Tomlinson E, *et al.* Factors associated with effectiveness of interventions

to prevent obesity in children: a synthesis of evidence from 204 randomized trials. *BMJ Public Health* 2025;3:e001707. <https://doi.org/10.1136/bmjph-2024-001707>

Palmer JC, Davies AL, Spiga F, Heitmann BL, Jago R, Summerbell CD, Higgins JPT. Do the effects of interventions aimed at the prevention of childhood obesity reduce inequities? A re-analysis of randomized trial data from two Cochrane reviews. *eClinicalMedicine* 2025;81:103130. <https://doi.org/10.1016/j.eclinm.2025.103130>

Spiga F, Davies AL, Palmer JC, Tomlinson E, Coleman M, Sheldrick E, et al. Investigating differential effects of interventions to prevent obesity in children and young people: a novel analytic framework [published online ahead of print 29 October 2025]. *Public Health Res* 2025. <https://doi.org/10.3310/QLPD8523>

Breheny K, Spiga F, Summerbell CD, Higgins JPT. An evaluation of economic evidence included in published randomised controlled trials of interventions to prevent obesity in children [published online ahead of print 19 November 2025]. *Public Health Res* 2025. <https://doi.org/10.3310/GJJH1321>

NICE guidelines

Overweight and obesity management (GID-NG10182). Supporting evidence 'Interventions to prevent obesity in children aged 5 to 11 years old' and supporting evidence 'Interventions to prevent obesity in children aged 12 to 18 years old'.

Conference papers: invited

Higgins J. *Obesity Clinical Trial Research: Avoiding Pitfalls, Embracing Excellence [Closing Plenary]*. 30th European Congress on Obesity, Dublin, May 2023.

Higgins J. *Evidence Synthesis for Components of Childhood Obesity Prevention Effectiveness (ESCOPE)*. South West Children's Healthy Weight and Physical Activity Community of Practice, Online, May 2023.

Spiga F, Tomlinson E. *Equity in Cochrane Reviews: Interventions for Preventing Obesity in Children*. Cochrane Colloquium, London, September 2023.

Higgins J. *Towards Optimal Public Health Interventions for Preventing Obesity in Children: A Novel Evidence Synthesis (Keynote Address)*. School of Public Health Research Symposium, University of Adelaide, Australia, December 2025.

Conference papers: contributed

Spiga F, Davies A, Tomlinson E, Moore THM, Gao Y, Dawson S, et al. *Interventions to Prevent Obesity in Children and Adolescents Aged 5 to 18 Years Old: A Cochrane Systematic Review and*

Meta-analysis of Randomised Controlled Trials [PO3.095]. 30th European Congress on Obesity, Dublin, May 2023.

Davies AL, Spiga F, Tomlinson E, Palmer J, Summerbell CD, Higgins JPT. *A Complex Synthesis Technique for Extracting Effective Characteristics of Interventions*. Society for Research Synthesis Methodology, Paris, July 2023.

Spiga F, Davies A, Tomlinson E, Palmer J, Coleman M, Sheldrick E, et al. *Involvement of Children and Young People in Development of an Evidence Synthesis Framework for What Interventions Best Prevent Childhood Obesity*. Cochrane Colloquium, London, September 2023.

Spiga F, Davies A, Tomlinson E, Moore THM, Dawson S, Savović J, et al. *Interventions to Prevent Obesity in Children and Adolescents Aged 5 to 18 Years Old: A Cochrane Systematic Review and Meta-analysis of Randomised Controlled Trials*. South West Public Health Scientific Conference, Online, March 2024.

Davies AL, Ades AE, Higgins JPT. *Mapping between Measurement Scales in Meta-analysis, with Application to Measures of Body Mass Index in Children*. Society for Research Synthesis Methodology, Amsterdam, June 2024.

Spiga F, Palmer J, Davies AL, Summerbell CD, Higgins JPT. *Meta-analysis of Subgroup Interactions Based on Aggregate Data Contributed by Trialists: A Success Story Examining Interventions to Prevent Childhood Obesity*. Society for Research Synthesis Methodology, Amsterdam, June 2024.

Davies AL, Spiga F, Caldwell DM, Savović J, Palmer JC, Tomlinson E, et al. *Factors Associated with Effectiveness of Interventions to Prevent Obesity in Children: A Synthesis of Evidence from 204 Randomized Trials*. UK Congress on Obesity (UKCO), Oxford, September 2024.

Palmer JC, Davies AL, Spiga F, Heitmann BL, Jago R, Summerbell CD, Higgins JPT; the Inequity in Obesity Prevention Trialists Collaborative Group. *Do the Effects of Interventions Aimed at the Prevention of Childhood Obesity Reduce Inequities? A Re-analysis of Randomized Trial Data from Two Cochrane Reviews*. UK Congress on Obesity (UKCO), Oxford, September 2024.

Heitmann BL, Davies AL, Spiga F, Thorsteinsdottir F, Palmer JC, Larsen SC, Jago R, Higgins JPT, Summerbell CD. *Are Public Health Interventions Which Aim to Prevent Obesity Differentially Effective for School-aged Children of Ideal Weight Compared with Children Who Are Already Living with Overweight/Obesity? A Re-analysis of Randomized Trial Data from Two Cochrane Reviews*. UK Congress on Obesity (UKCO), Oxford, September 2024.

Seminars

Higgins J. *Risk of Bias and Accounting for Bias in Meta-analysis* [keynote speaker]. Outreach event of the winter school on Design and Analysis of Clinical Trials, Ghent University, Belgium, February 2023.

Spiga F. *Addressing Health Inequity in Evidence Synthesis: An Example from a Systematic Review of Interventions for Child Obesity Prevention*. Department Seminar at the Institute for Risk Assessment Sciences (IRAS), Utrecht University, The Netherlands, June 2024.

Higgins J, Condon L, Coleman M, Sheldrick E. *Involving Children and Young People in an Evidence Synthesis Around Prevention of Childhood Obesity*. PPI in Action Webinar Series, Online, December 2024.

Study registration

Cochrane Reviews were preregistered in the Cochrane Database of Systematic Reviews (CD015328, CD015330). Study protocols were posted on the NIHR website (<https://fundingawards.nihr.ac.uk/award/NIHR131572>).

Funding

This synopsis presents independent research funded by the National Institute for Health and Care Research (NIHR) Public Health Research programme as award number NIHR131572.

This synopsis provided an overview of the research award *Towards optimal public health interventions for preventing obesity in children: a novel evidence synthesis*. For other articles from this thread and for more information about this research, please view the award page (www.fundingawards.nihr.ac.uk/award/NIHR131572).

About this synopsis

The contractual start date for this research was in July 2021. This synopsis began editorial review in October 2024 and was accepted for publication in July 2025. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The Public Health Research editors and publisher have tried to ensure the accuracy of the authors' synopsis and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this synopsis.

Copyright

Copyright © 2026 Higgins *et al.* This work was produced by Higgins *et al.* under the terms of a commissioning contract issued by the Secretary of State for Health and Social Care. This is an Open Access publication distributed under the terms of the Creative Commons Attribution CC BY 4.0 licence, which permits unrestricted use, distribution, reproduction and adaptation in any medium and for any purpose provided that it is properly

attributed. See: <https://creativecommons.org/licenses/by/4.0/>. For attribution the title, original author(s), the publication source – NIHR Journals Library, and the DOI of the publication must be cited.

Copyright and credit statement

Every effort has been made to obtain the necessary permissions for reproduction, to credit original sources appropriately and to respect copyright requirements. However, despite our diligence, we acknowledge the possibility of unintentional omissions or errors and we welcome notifications of any concerns regarding copyright or permissions.

List of supplementary material

Report Supplementary Material 1

Towards optimal public health interventions for preventing obesity in children: protocol for a novel evidence synthesis (Version 1, 18 May 2021)

Report Supplementary Material 2

Towards optimal public health interventions for preventing obesity in children: protocol for a novel evidence synthesis (Version 2, 17 March 2023), with annex

Report Supplementary Material 3

Analysis plan for a complex synthesis of interventions aimed at preventing childhood obesity (2 August 2023)

Supplementary material can be found on the NIHR Journals Library report page (<https://doi.org/10.3310/AKHD0407>).

Supplementary material has been provided by the authors to support the report and any files provided at submission will have been seen by peer reviewers, but not extensively reviewed. Any supplementary material provided at a later stage in the process may not have been peer reviewed.

The supplementary materials (which include but are not limited to related publications, patient information leaflets and questionnaires) are provided to support and contextualise the publication. Every effort has been made to obtain

the necessary permissions for reproduction, to credit original sources appropriately, and to respect copyright requirements. However, despite our diligence, we acknowledge the possibility of unintentional omissions or errors and we welcome notifications of any concerns regarding copyright or permissions.

List of abbreviations

BMI	body mass index
EDI	equality, diversity and inclusion
MD	mean difference
NICE	National Institute for Health and Care Excellence
NIHR	National Institute for Health and Care Research
PPI	patient and public involvement
PROGRESS	place of residence, race/ethnicity/culture/language, occupation, gender/sex, religion, education, socioeconomic status, social capital
YPAG	Young Peoples Advisory Group
zBMI	standardised body mass index

References

- Spiga F, Davies A, Palmer J, Tomlinson E, Coleman M, Sheldrick E, *et al.* A novel analytic framework to investigate differential effects of interventions to prevent obesity in children and young people. *medRxiv* 2024. <https://doi.org/10.1101/2024.03.07.24303614>
- NCD Risk Factor Collaboration. Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. *Lancet* 2024;**403**:1027–50.
- World Health Organization. *Obesity and Overweight (1 March 2024)*. 2024. URL: www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed 12 June 2025).
- Brown T, Moore TH, Hooper L, Gao Y, Zayegh A, Ijaz S, *et al.* Interventions for preventing obesity in children. *Cochrane Database Syst Rev* 2019;**7**:CD001871.
- UK Government. *Childhood Obesity. POSTnote Number 640 April 2021*. London: The Parliamentary Office of Science and Technology. URL: <https://researchbriefings.files.parliament.uk/documents/POST-PN-0640/POST-PN-0640.pdf> (accessed 12 June 2025).
- Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. *J Epidemiol Community Health* 2013;**67**:190–3.
- McGill R, Anwar E, Orton L, Bromley H, Lloyd-Williams F, O'Flaherty M, *et al.* Are interventions to promote healthy eating equally effective for all? Systematic review of socioeconomic inequalities in impact. *BMC Public Health* 2015;**15**:457.
- HM Government. *Tackling Obesity: Empowering Adults and Children to Live Healthier Lives*; 2020. URL: www.gov.uk/government/publications/tackling-obesity-government-strategy/tackling-obesity-empowering-adults-and-children-to-live-healthier-lives (accessed 12 June 2025).
- HM Government. *Childhood Obesity: A Plan for Action, Chapter 2*. London: Department of Health and Social Care; 2018.
- Rutter H, Savona N, Glonti K, Bibby J, Cummins S, Finegood DT, *et al.* The need for a complex systems model of evidence for public health. *Lancet* 2017;**390**:2602–4.
- Sniehotta FF, Araújo-Soares V, Brown J, Kelly MP, Michie S, West R. Complex systems and individual-level approaches to population health: a false dichotomy? *Lancet Public Health* 2017;**2**:e396–7.
- Spiga F, Davies AL, Tomlinson E, Moore TH, Dawson S, Breheny K, *et al.* Interventions to prevent obesity in children aged 5 to 11 years old. *Cochrane Database Syst Rev* 2024;**5**:CD015328.
- Spiga F, Tomlinson E, Davies AL, Moore TH, Dawson S, Breheny K, *et al.* Interventions to prevent obesity in children aged 12 to 18 years old. *Cochrane Database Syst Rev* 2024;**5**:CD015330.
- Moore THM, Tomlinson E, Spiga F, Higgins JPT, Gao Y, Caldwell DM, *et al.* Interventions to prevent obesity in children aged 5 to 11 years old. *Cochrane Database Syst Rev* 2022;**7**:CD015328.
- Moore THM, Tomlinson E, Spiga F, Higgins JPT, Gao Y, Caldwell DM, *et al.* Interventions to prevent obesity in children aged 12 to 18 years old. *Cochrane Database Syst Rev* 2022;**7**:CD015330.
- Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, *et al.*, editors. *Cochrane Handbook for Systematic Reviews of Interventions*. 2nd edn. Chichester (UK): John Wiley & Sons; 2019.

17. Davies AL, Ades AE, Higgins JPT. Mapping between measurement scales in meta-analysis, with application to measures of body mass index in children. *Res Synth Methods* 2024;**15**:1072–93.
18. Davies AL, Higgins JPT. A complex meta-regression model to identify effective features of interventions from multi-arm, multi-follow-up trials. *Stat Med* 2024;**43**:5217–33.
19. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;**320**:1240–3.
20. Davies AL, Spiga F, Caldwell DM, Savović J, Palmer JC, Tomlinson E, *et al.* Factors associated with effectiveness of interventions to prevent obesity in children: a synthesis of evidence from 204 randomized trials. *medRxiv* 2024;2024.06.19.24309160. <https://doi.org/10.1101/2024.06.19.24309160>
21. Davies AL, Spiga F, Caldwell DM, Savovic J, Palmer JC, Tomlinson E, *et al.* Factors associated with the effectiveness of interventions to prevent obesity in children: a synthesis of evidence from 204 randomised trials. *BMJ Public Health* 2025;**3**:e001707.
22. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007;**85**:660–7.
23. Sterne JAC, Murthy S, Diaz JV, Slutsky AS, Villar J, Angus DC, *et al.*; WHO Rapid Evidence Appraisal for COVID-19 Therapies (REACT) Working Group. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. *JAMA* 2020;**324**:1330–41.
24. O'Neill J, Tabish H, Welch V, Petticrew M, Pottie K, Clarke M, *et al.* Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. *J Clin Epidemiol* 2014;**67**:56–64.
25. Palmer JC, Davies AL, Spiga F, Heitmann BL, Jago R, Summerbell CD, Higgins Julian PT; Inequity in Obesity Prevention Trialists Collaborative Group. Do the effects of interventions aimed at the prevention of childhood obesity reduce inequities? A re-analysis of randomized trial data from two Cochrane reviews. *medRxiv* 2024;2024.06.10.24308372. <https://doi.org/10.1101/2024.06.10.24308372>
26. Palmer JC, Davies AL, Spiga F, Heitmann BL, Jago R, Summerbell CD, Higgins JPT; Inequity in Obesity Prevention Trialists Collaborative Group. Do the effects of interventions aimed at the prevention of childhood obesity reduce inequities? A re-analysis of randomized trial data from two Cochrane reviews. *EClinicalMedicine* 2025;**81**:103130.
27. Breheny K, Spiga F, Tomlinson E, Summerbell CD, Higgins JPT. An evaluation of economic evidence included in published randomised controlled trials of interventions to prevent obesity in children [published online ahead of print 19 November 2025]. *Public Health Res* 2025. <https://doi.org/10.3310/GJJH1321>
28. Hopewell S, Chan AW, Collins GS, Hrobjartsson A, Moher D, Schulz KF, *et al.* CONSORT 2025 statement: updated guideline for reporting randomised trials. *BMJ* 2025;**389**:e081123.