UK National Screening Committee

Screening for obesity in children ≤5 years

External review against programme appraisal criteria for the UK National Screening Committee (UK NSC)

Version: 2018 Update

Bazian Ltd.

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The UK NSC advises Ministers and the NHS in all four UK countries about all aspects of screening policy. Its policies are reviewed on a 3 yearly cycle. Current policies can be found in the policy database at http://www.screening.nhs.uk/policies and the policy review process is described in detail at http://www.screening.nhs.uk/policyreview

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Abbreviations List

ADP	Air displacement plethysmography
ALSPAC	Avon Longitudinal Study of Parents and Children
aOR	Adjusted odds ratio
BAI	Body adiposity index
BIA	Bioelectrical impedance analysis
BMI	Body Mass Index
CDC	Center for Disease Control
CHD	Coronary heart disease
CI	Confidence interval
CVD	Cardiovascular disease
D_2O	Deuterium dilution method
DBP	Diastolic blood pressure
DEXA	Dual-energy X-ray absorptiometry
FMI	Fat mass index
HSE	Health Survey for England
HTA	Health Technology Appraisal
IOTF	International Obesity Task Force
LR	Likelihood ratio
MA	Meta-analysis
MD	Mean difference
MRC-NSHD	Medical Research Council National Survey of Health and Development
NA	Not applicable
NC	Neck circumference
NCMP	National Child Measurement Programme
NIR	Near-infrared interactance
NPV	Negative predictive value
PICO	Population, intervention, comparator, outcome
PPV	Positive predictive value
RCT	Randomised controlled trial
SBP	Systolic blood pressure
SFT	Skin fold thickness

SR	Systematic review
T2DM	Type 2 diabetes
UK90	British 1990 growth curve
USPSTF	US Preventative Services Task Force
WC	Waist circumference
WHO	World Health Organisation
WHtR	Waist-to-height ratio
WHR	Waist-to-hip ratio

Plain English Summary

Obesity is a growing concern among both children and adults. It can cause serious health problems such as heart disease and diabetes.

Obese children may become obese adults and develop these health problems. Screening children for obesity would be to identify those who are obese. The aim of this would be to help them lose weight in order to prevent health problems in later life. This review looks at whether there is evidence that screening children up to 5 years of age can achieve this.

The UK National Screening Committee recommends that children should not be screened for obesity.

This was recommended in 2006 for the following reasons:

- the test may not be reliable enough to distinguish between children who are obese and those who are not
- there was a lack of evidence to be sure that obese children would develop health problems in later life
- there was a lack of evidence to be sure that treating children is safe and effective in the long term

This review examines evidence produced over the past 12 years to see if this has changed.

The review found that overweight or obese children up to 5 years of age may remain overweight or obese later in life. But it is not clear whether this leads to health problems. Some long-running studies suggest that there might be a risk of some overweight or obese children developing diabetes. Other studies do not suggest that child obesity is not linked with problems like heart disease.

But problems with the studies make it difficult to be sure of these results. For example, only a small group of the original participants were available at the end of the studies. This makes the results less reliable. They also looked at children born over 60 years ago when obesity was much less common.

The main test is measurement of body mass index (BMI) which uses height and weight. Other tests for obesity are also available. But no research has been published about the accuracy of these tests in children up to 5 years of age.

Interventions are available for overweight and obese children. These usually aim to increase physical activity and change diet. Sometimes they include parents as well as children. These have resulted in small reductions in weight over a short period of time. But it is not clear if the weight reductions would continue over a longer period of time without ongoing support. At the same time the studies did not look at children found through screening. This is important as children found in this way might respond in a different way to the offer of these interventions.

The studies did not look at whether any harms resulted from the weight loss treatments.

For these reasons the conclusion of the review is that screening for obesity in children up to 5 years of age should not be recommended.

Executive Summary

Purpose/aim of the review

This review aims to examine evidence for obesity screening in children aged 5 years and under. We aimed to review whether there is evidence that a BMI measure or alternative non-BMI screen test could be used for the purposes of obesity screening.

In 2006 the UK National Screening Committee recommended against obesity screening in children. This review considers whether the volume and direction of evidence produced since then supports obesity screening in this age group.

A separate review examines screening in older primary school children aged 7-11 years. Six years was a bridging age between the two reviews. Studies in children aged 6 years were mostly included in this review; though some studies have considered children of 6 years alongside older children so have been covered by the 7-11 review.

Background

Obesity is a major cause of hypertension, metabolic problems, cardiovascular disease and cancer in adults. Obesity rates in children are rising, and obese children are thought more likely to become obese adults and develop these health complications.

The current review intended to look at whether there was evidence that screening children using BMI measurement and initiating interventions affected health outcomes in adolescence and adulthood and, if so, whether the current UK NSC recommendation not to implement a screening programme should be reconsidered..

Previous UK NSC recommendation

The current UK National Screening Committee (UK NSC) recommendation not to screen for obesity in children dates from 2006. This is because there was:

- A lack of prospective evidence that child obesity is associated with adult morbidity
- The suggestion that BMI is not a reliable enough measure of obesity as defined by excess body fat.
- Uncertainty whether child height – for example if a child was tall or short for their age – could have an influence on the reliability of the BMI measure, likelihood of obesity persisting or affecting longer term health.
- A lack of evidence that treatment is effective in the long-term and is not associated with adverse outcomes, including psychological effects

- A lack of trials comparing child obesity screening programmes with no screening or with other approaches

The current review aimed to address these gaps in the evidence for children aged 5 and under (including relevant studies that went up to age 6). It aimed to clarify evidence on the natural history of obesity in young children, examine the test performance of BMI or alternative tests for diagnosing obesity, and look at the safety and effectiveness of treatment in this age group.

This review did not address obesity screening in older primary school children, which is addressed by a companion review.

We looked for evidence on the influence of height in relation to obesity screening, but this review did not aim to evaluate evidence for screening of growth-related conditions.

Findings and gaps in the evidence
The evidence available does not answer all of the uncertainties about obesity screening in this age group:

- Questions remain over the natural history of obesity in young children. Several large prospective cohorts find that overweight or obese 4-5 year olds are more likely to be overweight or obese in adolescence and early adulthood. Most studies have assessed combined categories of overweight/obesity due to the small proportion of children, in the past, with obesity, and have looked at persistence into adolescence rather than to later adulthood. Identifying obese young children may also identify only a proportion of those who will become obese in later adolescence or adulthood so may have limited impact on the overall rate of adult obesity. Several studies suggest that most weight and BMI gains occur after the age of 5.
- There is insufficient evidence that obesity at age ≤5 predicts later adult morbidity. Few long-term prospective cohorts have followed obese young children into adulthood and assessed cardiometabolic outcomes. The few cohorts available found no association with coronary heart disease or stroke, and the association with type 2 diabetes only just reached statistical significance. There were various quality limitations to this evidence, including that cohorts commenced over 60 years ago so may have limited relevance to child populations today. This further reduces confidence in the findings No studies examined the association with hypertension.
- Several diagnostic cohorts have assessed the test performance of overweight or obese BMI thresholds against a validated reference standard of excess adiposity in children and adolescents. However, there is no performance data specific to children age ≤5. There is also no evidence on the performance of alternative non-BMI screen tests in this age group.
- No studies have directly assessed interventions in screen-detected populations. There is evidence from a small number of trials that multicomponent behavioural interventions for overweight or obese children aged ≤5 and their parents have small but statistically significant effects in reducing child BMI. It's unclear if these changes were clinically meaningful. There is no evidence to inform the best format of treatment, frequency and duration of sessions in this age group. It is unclear whether effects would be maintained

in the long-term, reducing risk of obesity in later childhood or adolescence, or whether ongoing maintenance would be required.

- There is minimal data on potential adverse effects from providing interventions to young children and their parents.
- No studies were available to inform whether child height influences the likelihood of young child obesity persisting into adolescence or adulthood, predicting later morbidity; on BMI test performance; or has influence on the harms or benefits of treatment.

Recommendations on screening that can be made on the basis of the current review

The current level of evidence seems insufficient to support a recommendation for screening for obesity in children ≤5 years – including children at school entry (aged 4-5), or younger toddlers or preschool children.

Further high quality studies need to address the uncertainties identified. Diagnostic studies need to evaluate test performance of BMI and alternative non-BMI screen tests specifically in the ≤5 year age group, and see whether this is influenced by child height or growth.

Randomised controlled trials or comparative studies need to follow children and their families in the long term to see whether treating young children is associated with harms, and whether effects on BMI are sustained and reduce the risk of long-term health problems.

This external review has several limitations. It was a rapid review process conducted over 12 weeks and was not a fully comprehensive assessment of obesity screening in all children or adolescents. However, there is confidence that this process would identify any large relevant studies of obesity screening or treatment. Due to the large body of evidence identified, selection and appraisal of studies followed a pragmatic process, starting with systematic reviews before proceeding to the lower hierarchy of evidence. This process was undertaken by two reviewers, with any queries resolved through discussion with a third reviewer and with the UK NSC. We did not include non-English language studies, abstracts, protocols or grey literature. There were also some publications where the full text could not be identified.

Introduction

Obesity in children

Health Survey for England (HSE) data from 2014/15 showed that around a third of all children and adolescents aged 2 to 15 are overweight or obese.[1] During the same period the National Child Measurement Programme (NCMP) reported that almost 1 in 10 children aged 4 to 5 (Reception) and 1 in 5 children aged 10 to 11 (Year 6) were obese.

Obesity is associated with various adverse health effects, including metabolic problems, cardiovascular disease and cancer. It is possible that obese children are more likely to remain obese into adulthood, and to be at increased risk of adverse health problems in the long term.

This review looks at the evidence relating to the long term outcomes of child obesity; the accuracy of BMI, or alternative tests, for detecting childhood obesity; and the effect of interventions aimed at reducing weight in children identified as overweight or obese.

The purpose of the review is to gauge whether the evidence in these areas suggests that the current UK NSC recommendation on screening for obesity in childhood should be reconsidered.

The focus of this review is the ≤5 years.

Basis for current recommendation

The UK National Screening Committee (NSC) does not recommend screening for obesity in children. This policy dates from 2006 and coincided with the publication of a Health Technology Assessment (HTA) by Fayter et al.[2] This systematically reviewed the evidence on the value of monitoring height and weight to identify growth- and obesity-related conditions in primary school children.

The review concluded that the growth monitoring programme has potential utility and cost-effectiveness for detecting stature-related disorders, although it still did not meet all NSC screening criteria for this. For use in detection and treatment of obesity, the review identified several more uncertainties:

- A lack of long term prospective cohorts demonstrating that child obesity is associated with morbidity in adulthood. Studies would need to identify the predictors for adverse outcomes in order to better define which children are at highest risk from obesity and should be treated.
- BMI may not be a reliable enough indicator of obesity as defined by excessive adiposity/body fat. It may also give misleading results if the child is tall or short for their age. Better understanding was needed of the BMI thresholds that are associated with morbidity and would indicate a need for referral and treatment.
- A lack of evidence on a treatment that is effective in the long term, and a need to demonstrate that identifying and treating obese children is not associated with adverse outcomes. Without evidence for a safe and effective treatment that gives long term benefit, the value of obesity detection would be questionable.
- A lack of trials comparing child obesity screening strategies with no screening or with alternative obesity prevention programmes, and their long-term outcomes.

- Primary prevention of obesity in children was likely to be the most cost effective step, and it was uncertain whether all effective preventative strategies have been implemented.

Current update review

This review was undertaken as part of the UK NSC's cycle of regular policy recommendation updates. The review was prepared by Bazian Ltd. in discussion with the UK NSC.

An initial review considered whether the volume and direction of the evidence produced between 2005 and June 2016 indicates that the previous recommendation should be reconsidered. The search was updated to include literature published between June 2016 and December 2017.

Three main UK NSC criteria were considered, with particular focus given to areas the 2006 review identified as uncertain, or supported by insufficient evidence. The main criteria and key questions reviewed were:

Table 1. Key questions for current review on obesity screening in children.

Criterion	Key Questions (KQ)	# KQ Studies Included
2) The epidemiology and natural history of the condition, including development from latent to declared disease, should be adequately understood and there should be a detectable risk factor, disease marker, latent period or early symptomatic stage	1a) Does obesity in childhood persist into later adolescence or adulthood? For example, how likely is an obese 2 year old to be obese at 5, 11 or early adulthood?)	5 studies
	b) Does obesity in childhood predict the development of morbidity in adulthood, for example, hypertension and type 2 diabetes?	1 SR, 1 primary study)
	c) Does child height have an influence on the likelihood of obesity persisting into adulthood or the development of hypertension and T2DM?	0 studies
5) There should be a simple, safe, precise and validated screening test.	2a) What is the performance of a BMI or alternative screening test for identifying children with obesity?	0 studies
	b) Do child characteristics such as height have an influence on test performance?	0 studies
10) There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment.	3a) What is the effectiveness and safety of treatments or interventions for obese children? Looking at: • effectiveness for treating obesity • effectiveness for preventing hypertension and T2DM in children and young adults • any identified harms/adverse effects	1 SR, 3 RCTs plus one additional cohort

	(including psychological)	
	b) Does child height have an effect on the outcomes (benefits and harms) of treatment?	0 studies

The key questions were derived through discussion by UK NSC members and members of the UK NSC Fetal, Maternal & Child Health Reference Group. Subsequent discussion between Bazian Ltd and the UK NSC Secretariat further developed the questions and provided information required for developing the search and literature appraisal strategy**.**

The review was split into two parts. The current review aims to addresse obesity screening in children of 5 years or age or under, though we allowed evidence in children up to age 6.

A companion review examines evidence for screening older primary school children, aged 7-11 years, allowing evidence up to age 12.

Table 2 describes the study eligibility for each key question by population, intervention, comparator and outcome (PICO), set up *a priori* at the scoping stage.

Table 2. Study inclusion and exclusion criteria by key question

Key question	Inclusion criteria						Exclusion criteria
	Population	Intervention	Reference Standard	Comparator	Outcome	Study type	
1) Natural history	Age <6 years. General child population covering a range of BMIs or range of heights. Specific cohorts of obese children, or those of different height.	NA	NA	NA	a)Obesity in later childhood or adolescence or adulthood b) Adult hypertension, CVD or T2DM.	Prospective cohorts or systematic reviews of these studies	Non-systematic reviews, case-controls or retrospective cohorts. Papers only in non-English language, editorials and communications, grey literature and conference abstracts.
2) Screening test	Age <6 years. General child population. We would consider how test performance varies by height or other	BMI or alternative non-BMI screen tests.	Validated measure of excess adiposity.	None	Sensitivity, specificity, predictive values	Cross-sectional test accuracy studies, cohort studies and systematic reviews of these	Non-systematic reviews, papers only in non-English language, editorials and communications, grey literature and conference abstracts.

	characteristics.					studies.	
3) Treatment	Age <6 years. Screen-or clinically-detected children with obesity, including studies assessing the influence of treating children with different height or other characteristics.	Diet activity or otherwise behavioural or lifestyle interventions. Drug treatment	NA	Observation, no treatment, usual care, alternative treatment or later treatment.	BMI or weight-related. Obesity-related morbidity in later childhood or adulthood. Adverse effects, including physical or psychological.	RCTs or systematic reviews of these studies.	Studies of primary prevention, including policy, community and school-based interventions. Non-RCTs, trial protocols, non-human studies, Non-systematic reviews, papers only in non-English language, editorials and communications, grey literature and conference abstracts.

A systematic literature search of three databases was performed for studies published between January 2005 and June 2016. This search was then updated from June 2016 to December 2017. The search strategies are detailed in the appendix.

After de-duplication the 2005-16 search yielded 7,914 references addressing obesity in children and adolescents. Of these 1,440 were assessed as being potentially relevant to the key questions outlined in Table 1. These studies were further filtered at title and abstract level, and 86 relevant to the ≤5 age group were selected for appraisal at full text.

The 2017 update search yielded 2,065 unique references, of which 240 were assessed as being potentially relevant to the key questions outlined in Table 1. These studies were further filtered at title and abstract level, and 21 were selected for appraisal at full text.

Selection and appraisal of studies was undertaken by two reviewers, with any queries resolved by discussion with a third reviewer, or with the UK NSC. Any refinements to the inclusion criteria as outlined in Table 2 (e.g. need to move down the hierarchy of evidence), and further information on the evidence selection process for each key question, is discussed in the evidence description for each criterion in the report below.

Each criterion was summarised as 'met', 'not met' or 'uncertain' by considering the results of the included studies in light of the volume, quality and consistency of the body of evidence. Several factors were assessed to determine the quality of the identified evidence, including study design and methodology, risk of bias, directness and applicability of the evidence. Factors that were determined to be pertinent to the quality of the body of evidence identified for each criterion are outlined in the results sections, as well as the comment section of the Appendix tables.

The review was checked within Bazian Ltd's quality assurance process.

Appraisal against UK NSC Criteria

These criteria are available online at http://www.screening.nhs.uk/criteria.

2. The epidemiology and natural history of the condition, including development from latent to declared disease, should be adequately understood and there should be a detectable risk factor, disease marker, latent period or early symptomatic stage

Description of the previous UK NSC evidence review conclusion and current questions

The 2006 Fayter et al. HTA[2] review noted a lack of large, long-term prospective cohorts demonstrating that child obesity is associated with adverse morbidity in adulthood. It concluded that the predictors for adverse outcomes in adulthood need to be better understood in order to more clearly define the screen-detected child population with obesity and know which children are at highest risk and should be offered treatment or other interventions.

To this end, the current review aimed to assess three key questions:

1) Does obesity in childhood persist into adulthood? For example, how likely is an obese 2-5 year-old to be obese at 11 years of age, or in early adulthood?
2) Does obesity in childhood predict the development of adult morbidity, in particular hypertension and type 2 diabetes?
3) Does child height, as a possible mediator, affect the likelihood of obesity persisting into adulthood, or the development of type 2 diabetes or hypertension?

We intended to identify large prospective cohorts of young children (age ≤5 years) with obesity (diagnosed by any measure) that were followed into adolescence or adulthood and which tracked obesity or assessed morbidity outcomes. Any studies assessing the influence of child height on the likelihood of obesity persisting into adulthood, or resulting in morbidity outcomes, would also be assessed. Systematic reviews of prospective cohorts tracking obesity or morbidity outcomes would also be reviewed.

Description of the evidence

In the original 2016 search 428 studies were identified as potentially relevant during first-pass title sifting, and were further assessed in more depth at abstract level by a second reviewer. Due to the reasons listed under exclusions below, many of these studies were not found to be relevant to the key questions on second-pass appraisal and could be excluded at abstract level. Nineteen were reviewed at full text.

Description of the evidence appraised for each individual key question is as follows:

1. Child obesity predicting later obesity

The Simmonds et al. 2015 HTA[3] review (Appendix 1) provided the initial source of data for this analysis. This review identified large prospective cohorts (n ≥1000) published prior to 2013 assessing whether childhood BMI predicted obesity in adulthood. Though their analyses focused on tracking obesity in children aged over 6 years, they did identify any studies in younger children, of which there was one main UK cohort (Liddle et al. 2012[4], Appendix 2) which assessed BMI at age 5 to predict BMI at age 21. This cohort was therefore included in the analysis.

After the 2013 search-date of the Simmonds HTA[3] we identified two additional cohorts. Pearce et al. (2016)[5] reviewed NCMP data to see whether BMI at the first measurement age 4-5 predicts BMI at the 10-11 year measurement (Appendix 3). Graversen et al. (2015)[6] was a Finnish cohort looking at whether BMI age 5 predicts BMI in adolescence (13-16) or adulthood (age 31) (Appendix 4).

Two further UK cohorts were identified, which do not look at whether child obesity predicts later obesity, but provide some additional information of relevance. Stuart et al. (2016)[7] is a large nationally-representative UK cohort that identifies the trajectories of BMI from early childhood at age 3 and 5 years through to BMI at 7 and 11 years (Appendix 5). Hughes et al. (2016)[8] was another UK cohort assessing the theory that most weight gain in childhood occurs between birth and 5 years of age (Appendix 6).

Therefore a total of 5 studies were included for question 1. These are presented in Table 3.

We excluded studies that only gave the proportion of a cohort that were overweight or obese at different ages but didn't report any analyses of how obesity ≤5 years tracked to obesity in later childhood, adolescence or adulthood. We also excluded studies that tracked diet and activity patterns through childhood but not BMI.

2. Child obesity predicting adult morbidity

The Simmonds et al. 2015 HTA[3] review (Appendix 1) also provided the main source of data for this question. They analysed large prospective cohorts (n ≥1000) published prior to 2013 assessing whether obesity in children and adolescents is a risk factor for cardiovascular disease, type 2 diabetes and/or cancer in adults. Simmonds meta-analysed 3 cohorts looking at whether obesity age ≤6 predicts coronary heart disease (CHD) or stroke in adulthood, and reported results for one study assessing the association with type 2 diabetes, and 1 assessing the link with breast cancer. The Liddle et al. (2012)[4] cohort also provided some data on adult blood pressure differences between children of normal and obese BMI age 5 years. No additional studies of relevance were identified after the 2013 search date.

Therefore the analyses from the Simmonds HTA and the Liddle cohort were included for this question (Table 4).

3. Influence of child height on obesity persistence or prediction of morbidity

We did not identify any studies that provided information on whether child height has an influence on the likelihood of obesity persisting or predicting adult morbidity. Potentially relevant studies identified did not assess height as a potential mediator.

For example, one UK cohort (Navti et al. 2014[9]) looked at the association between BMI, adiposity and height in adolescents and found higher obesity prevalence in the higher quartiles for height at ages 4 to 9 and 9 to 14, i.e. the taller a child is for their age the more likely they are to be obese, but didn't show how this related to persistence or later morbidity. Another UK time series analysis (Buchan et al. 2006[10]) had similar findings: over the previous 16 years BMI had increased the most among taller children.

Other reviews had looked at the association between rapid growth or rate of change in BMI across childhood and later obesity, but this was variably defined and did not clearly match to the question of BMI/adiposity in childhood in relation to height and whether this predicts later obesity. Therefore no studies met inclusion criteria for this question.

Reasons for exclusion across all 3 key questions:

- Retrospective cohorts
- Cohorts with baseline age >6 years, including mean baseline age
- Cohorts excluding obese children
- Studies assessing the prevalence of child obesity or the BMI distribution in a specific year or looking at how it has changed between two sets of years
- Looking at how prevalence of child obesity or BMI differs across regions, between countries, between genders, or depending on other factors such as ethnicity or socio-demographics
- Studies reviewing how trends in population obesity prevalence are associated with trends in prevalence of chronic diseases, such as hypertension, but not specifically looking at whether child obesity is predictive of these outcomes
- Cross sectional studies looking at whether child obesity is associated with current metabolic risk factors, such as lipid profile, but not assessing whether it is prospectively associated with outcomes
- Cross sectional studies purely reviewing the prevalence of type 2 diabetes or metabolic syndrome in children at one point in time
- Studies looking at the lifestyle/environmental factors associated with child obesity; for example child activity, diet (including whether breastfed) or parental factors, such as BMI, educational level or income
- Studies looking at whether child lifestyle factors are associated with later adolescent or adult obesity, but not examining whether child BMI/obesity is directly related to adult obesity
- Associations between child weight or obesity and mental health effects such as self-esteem, anxiety or depression
- Studies projecting future country-profile obesity

Results

Question 1: Tracking obesity into adolescence and adulthood

Table 3: Prospective studies assessing whether obesity in young childhood predicts obesity in later childhood/adolescence or adulthood

Study	Design	Setting	Participants	Child assessment	Adolescent/adult follow-up	Child measure to predict follow-up assessment
Liddle et al. 2012[4] (Appendix 2)	Prospective birth cohort (born 1981-83)	Australia, unclear measurement setting	N=1755	BMI at 5 years Overweight/obese IOTF definition (male >17.42 kg/m^2, female >17.15 kg/m^2) Triceps SFT at 5 years	BMI at 21 years Overweight/obese WHO definition (>25 kg/m^2)	Overweight/obese BMI to predict overweight/obese BMI: aOR 5.5 (95% CI 4.2 to 7.3) • BMI mean difference at 21 vs. normal child BMI: 4.4kg.m^2 (3.9 to 5.0) Overweight/obese SFT to predict overweight/obese BMI: aOR 2.6 (95% CI 2.0 to 3.4) • BMI mean difference at 21 vs. normal child SFT: 2.6kg.m^2 (2.0 to 3.2)
Pearce at el. 2015[5] (Appendix 3)	Prospective cohort (2006/7 to 2012/14)	UK, NCMP school assessments	N=1863	BMI at 4-5 years Overweight (≥85%) or obese (≥95%) on UK 1990 growth chart	BMI at 10-11 years Overweight (≥85%) or obese (≥95%) on UK 1990 growth chart	Obese BMI to predict overweight/obese BMI: • All: aOR 65.27 (95% CI 37.59 to 113.35) • Boys: aOR 50.14 (24.35 to 103.26) • Girls: aOR 90.28 (38.17 to 213.55) Obese BMI to predict obese BMI: • All: aOR 43.16 (95% CI 26.21 to 71.08) • Boys: aOR 38.31 (19.91 to 73.03) • Girls: aOR 50.30 (22.86 to 110.65) (Overweight BMI at 5 also significantly increased odds of overweight or obese BMI)
Graversen et al. 2015[6] (Appendix 4)	2 prospective birth cohorts (born 1966 and 1986)	Finland, unclear measurement setting	N=4111 (1966) N=5414 (1986)	BMI at 5 years Overweight/obese IOTF definition (male >17.42 kg/m^2, female >17.15 kg/m^2)	Age 13-16 overweight/obesity Adult overweight and obesity (unclear age) IOTF	1966 cohort BMI at 5 years to predict adolescent overweight/obese: • Boys: OR 1.36 (95% CI 1.07 to 1.73) • Girls: OR 1.63 (1.31 to 2.04) BMI at 5 years to predict adult overweight/obese: • Boys: OR 1.13 (0.97 to 1.30) *ns* • Girls: OR 1.25 (1.07 to 1.45) BMI at 5 years to predict adult obesity: • Boys: OR 1.32 (1.04 to 1.66)

						• Girls: OR 1.56 (1.27 to 1.93) AUC 70% to predict adolescent overweight/obese and adult obesity 1986 cohort IOTF definitions of overweight/obese BMI at 5 to predict adolescent overweight/obese in terms of test accuracy: • Boys: Sn 25.4%, Sp 96.1%, PPV 60.5%, NPV 84.6% • Girls: Sn 39.7%, Sp 94.2%, PPV 51.0%, NPV 91.1%
Stuart et al. 2016[7] (Appendix 5)	Prospective birth cohort (born 2000-02). Study of BMI trajectories	UK, home assessments	N=9669	BMI at 3 years (IOTF)	BMI at 5, 7 and 11 years (IOTF)	Four distinct trajectories identified: • Obese age 3 who continue obese at all subsequent ages (3.1%) – obese • Just below overweight age 3 who become overweight at all ages (14.4%) – overweight • Just below overweight age 3 who stay just below overweight at all ages (37.8%) – mid normal • Normal BMI age 3 who stay normal weight at all ages (44.8%) – low normal No trajectory of decreasing BMI identified. No latent onset BMI groups identified. Overweight and mid-normal groups had diverged by age 5.
Hughes et al. 2011[8] (Appendix 6)	Prospective birth cohort (born 1991-92) Study of BMI change.	UK, clinic assessments	N=1358	Age 1-5 BMI on UK 1990 growth chart	Age 5-15 years BMI on UK 1990 growth chart	BMI z scores significantly increased between most years: • 1–5 years: 0.10 (0.04 to 0.15) • 5–9 years: 0.06 (0.01 to 0.12) • 9–11 years: 0.04 (0.01 to 0.08) • 11–13 years: -0.02 (-0.06 to 0.01) *ns* • 13–15 years: 0.04 (0.005 to 0.08) Largest BMI increase 7 to 9 years: 0.22 (0.18 to 0.26). Doesn't support hypothesis that most weight gain occurs before school entry (age 4-5).

Abbreviations: aOR, adjusted odds ratio; AUC, area under curve; BMI, body mass index; CI, confidence interval; IOTF, international obesity task force; NPV, negative predictive value; ns, non-significant; PPV, positive predictive value; SFT, skin fold thickness; Sn, sensitivity; Sp, specificity

Three of the five studies calculated the adjusted odds of overweight or obesity in adolescence or early adulthood if the child had an overweight or obese BMI at ≤5 years. One of the studies (Liddle[4]) additionally reviewed the predictive ability of an overweight/obese triceps skinfold thickness at ≤5 years. Graversen[6] reviewed two separate birth cohorts, and used the odds calculated in the 1966 cohort to develop a predictive model. They verified the performance of this model, alongside that of the IOTF overweight/obesity definitions, in the second 1986 cohort.

The last two studies (Stuart[7] and Hughes[8]) did not assess the persistence of overweight/obesity from young childhood to adolescence specifically, but assessed trajectories of change in BMI.

The total body of studies is relatively small, but all five studies were of good sample size including >1000 participants which should have sufficient power to address the study question.

All studies are from Western countries, with three being from the UK, which makes them highly applicable to the population of interest. Among these one UK study examines relatively recent data routinely collected as part of the NCMP at ages 4-5 and 10-11.In terms of quality, all studies benefit from being of prospective design. However, there are some limitations common to all, a notable one being loss to follow-up. Despite the large sample size of the four birth cohorts, these participants represent only between a quarter and a half of the full cohort who entered the study. The remainder did not have baseline and follow-up measures available. The Liddle[4] cohort in particular found differences, including socioeconomic status and parental education, between those who completed all assessments and those unavailable for follow-up. People of higher BMI may also be more reluctant to have body measures taken. As such, the prevalence of obesity among those not measured could be higher, which may have altered analyses of the persistence of obesity had these measures been available. The UK study by Pearce et al[5] has a more acceptable attrition rate with the sample representing 80% of those eligible. However, there may still be differences among those who were not re-measured at 10-11 years.

Other common limitations across studies include the possible influence of not adjusting for confounding from health and lifestyle factors. Additionally with the exception of two UK cohorts where participants were born after the year 2000, the remaining three studies include children born in the 1980s, early 90s and 1960s in the case of the Graversen[6] cohort. There are differences in terms of environmental and lifestyle factors between young children today and those born 30 to 50 years ago. The prevalence of obesity differs today, as may the likelihood of child obesity persisting to older ages.

Regarding outcomes and the consistency of findings there are a few notable points.

The studies used different definitions of overweight and obesity. Two of the UK studies used the UK 1990 growth charts, while others used the International Obesity Task Force. Also the key question ideally aimed to assess whether obesity at ≤5 years persisted or predicted obesity in adolescence or adulthood. Of the three studies giving predictive data (Liddle,[4] Pearce[5] and Graversen[6]) only the Pearce[5] study looked at whether obesity age 4-5 was associated with obesity age 10-11. The other two studies assessed the broader categories of overweight/obesity both at baseline and follow-up assessment. The remaining two studies (Stuart and Hughes) look at a broader measure of BMI change over time. Therefore there is actually little data solely regarding obesity-to-obesity persistence.

The timing of the follow-up assessments also varied. While all studies included an assessment around the age of 5 years, most studies only looked at follow-up to later childhood/adolescence. Only two of the studies included an adult measure, though Liddle[4] only looked to young adulthood at 21 years, and the timing of assessment for the Graversen[6] 1966 birth cohort was unclear. Therefore most of the evidence has looked at whether overweight/obesity at age 5 persists into later childhood only.

In terms of the direction of results, the first three studies broadly suggest that overweight/obesity at age 5 significantly increases risk of subsequent overweight/obesity. Liddle[4] and Graversen[6] assess the predictive ability of overweight or obesity overall and find it a reasonable indicator, with odds ratios reflecting a 30-60% risk increase (Graversen[6]) to up to five-fold risk increase (Liddle[4]). The Pearce[5] study specifically analysed obesity at age 4-5 year and found it increased risk of obesity at age 10-11 by much greater odds. The reason for this may be that obesity is more likely to predict subsequent obesity than is the broader category of overweight to obesity. However, the confidence intervals are also extremely wide which limits confidence in the association. This may be due to the small proportion of reception age school children that were obese (8.2%). This was a limitation also observed by Graversen et al,[6] who reported needing to assess overweight/obese as a group because of too few children being obese to make the associations reliable.

The Graversen[6] study also gave predictive data for the 1986 cohort, which showed that using the IOTF definition for children with overweight/obese at age 5 identifies roughly between a quarter and a third who will be overweight/obese by 13-15 years. The PPV suggests that just over half of those who are overweight or obese at age 5 will still be overweight or obese in adolescence. Therefore this suggests that while it may be beneficial to identify and treat obese children aged 5 who are at risk of later problems, this may have limited impact on the wider obesity epidemic in adolescents and adults.

This finding is generally supported by the Hughes[8] UK study of BMI change through childhood, which suggests that most gains in weight and BMI occur around the ages of 7-9, and are not set prior to the age of 5 as has been previously speculated. However, this is in contrast to the Stuart[7] UK study which identified trajectories of birth weight and suggests that those that are going to become overweight or obese are already in these two categories by age 5. They found no evidence of late-onset obesity, and no trajectories of decreasing BMI.

Therefore though the broad finding could still be considered that overweight/obesity age 5 generally predicts later overweight/obesity, there is some inconsistency across these findings.

Question 2: Child obesity predicting adult morbidity

Table 4: Prospective studies assessing whether obesity in young childhood predicts morbidity in later childhood/adolescence or adulthood

Study	Design	Setting	Participants in meta-analyses	Child assessment	Adolescent/adult follow-up	Child measure to predict follow-up assessment
Simmonds et al. 2012[3] (Appendix 1)	Systematic review Search date 2013	4 prospective cohorts: Aberdeen study (1950 to 2000), UK school measure Boyd Orr studies (1937 to 1995), UK unclear setting Helsinki study (1935 to 2003), Finland school measure MRC-NSHD study (1946 to 1999), UK school measure	CVD: Aberdeen, Boyd Orr and Helsinki studies, n=18,855 T2DM: Aberdeen study, n=11,106 Breast cancer: MRC-NSHD study n=2187	Obesity age ≤6 years Assessed by BMI, definitions not reported.	CHD, stroke, T2DM, breast cancer in adulthood (age range 27 to 73 years) Method of diagnostic confirmation not reported.	• CHD: OR 0.93 (95% CI 0.83 to 1.05) (meta-analysis of Aberdeen, Boyd Orr and Helsinki cohorts) *non-significant* • Stroke: OR 0.94 (0.75 to 1.19) (meta-analysis of 3 studies as above) *ns* • Type 2 diabetes: OR 1.23 (1.10 to 1.37) (1 study: Aberdeen) • Breast cancer: OR 0.88 (0.67 to 1.16) (1 study: MRC-NSHD) *ns*
Liddle et al. 2012[4] (Appendix 2)	Prospective birth cohort (born 1981-83)	Australia, unclear measurement setting	N=1755	BMI at 5 years Overweight/obese IOTF definition (male >17.42 kg/m2, female >17.15 kg/m2) SFT at 5 years	Blood pressure at 21 years	Mean difference in BP age 21 for age 5 overweight/obese BMI vs. normal BMI • SBP: 2.4mmHg (95% CI 0.5 to 4.3) • DBP: 1.1mmHg (0.1 to 2.2) Mean difference in BP age 21 for age 5 overweight/obese SFT vs. normal SFT • SBP: 2.3mmHg (0.5 to 4.2) • DBP: 0.7mmHg (-0.4 to 1.8) *ns*

Abbreviations: BMI, body mass index; CHD, coronary heart disease; DBP, diastolic blood pressure; IOTF, international obesity task force; ns, non-significant; SBP, systolic blood pressure; SFT, skin fold thickness

The evidence looking at whether obesity at age ≤5 predicts adult morbidity is limited in volume and quality. The Simmonds[3] systematic review was high quality, but though it identified 37 studies assessing the association between child/adolescent obesity and adult morbidity overall, only four cohorts specifically looked at the link with young child measures.

These four cohorts found no evidence that obesity in children age ≤5 is associated with heart disease or stroke. The association with type 2 diabetes reached statistical significance but was weak and suggests no meaningful association.

No evidence was found for the specific outcome of hypertension. The Liddle[4] cohort does find that blood pressure was a few mmHg higher in adults who were obese at age 5 compared to those with normal child BMI. However, it is unclear whether these small differences could have clinical significance and affect the incidence of diagnosed hypertension.

In terms of quality, these prospective cohorts were all of large sample size and applicable to the UK setting. However, most have looked at child assessments around 60 or more years previously. Definitions of BMI, prevalence of child obesity, along with environmental, socioeconomic, health and lifestyle factors associated are likely to be vastly different from children today. No adjustment was made for confounding factors that are likely to be involved in the association with later morbidity. Loss to follow-up is also a source of potential bias across cohorts. The outcome definitions are also unclear. Self-reported diagnoses of CHD, stroke and T2DM may be inaccurate.

Due to the small number of studies and the above quality limitations, it is difficult to conclude with any certainty whether or not young child obesity is associated with later adult morbidity.

<u>Addendum: Evidence available at the July 2017 update search</u>

KQ1: Obesity tracking into later childhood and adulthood

A single prospective study of relevance was identified which indicates that children who are obese age 5 years are likely to remain obese age 11 years

Study	Population	Exposure	Outcomes
Mead et al. 2016[11] Prospective cohort, UK	Millennium Cohort Study, n=12,076 children born 2000 to 2002	BMI age 5 years 10% overweight (n=1249), 6% obese (n=746	% chance of different BMI status age 11 years: • Of obese children, about 11% will be normal BMI, 20% overweight and 68% still obese

KQ2: Obesity predicting morbidity in later childhood and adulthood

Potentially relevant studies are listed below, which do not indicate clear links between adiposity in young childhood and adolescent or adult blood pressure, diabetes or metabolic syndrome.

Study	Population	Exposure	Outcomes
Koskinen et al. 2017[12] 4 prospective European and US cohorts	N=5803 across 4 cohorts that measured risk factors for MetS in childhood and adulthood	MetS from age 3-18 including BMI ≥75th centile	RR of child MetS predicting outcomes at mean 33yrs, by risk factor of BMI ≥75th centile: Adult MetS: • High BMI at 3-4 years: RR 1.20 (0.67 to 2.13) *ns*

			• High BMI at 5-7 years: RR 2.39 (1.73 to 3.29) Adult type 2 diabetes: • High BMI at 3-7 years: RR 1.65 (0.60 to 4.50) ns
Hanvey et al. 2017[13] Prospective cohort, Australia	N=252 with BMI measured at least four times during childhood	BMI measured at birth, ≤2 years and between 4 and 6.5 years	Consistently overweight vs. normal BMI for predicting cardiovascular function at 10-14 years: • Systolic BP: mean difference 2.3 (-2.5 to +7.2) *ns* • Diastolic BP: -0.8 (-4.4 to +2.7) *ns*
Umer et al. 2017[14] Systematic review with meta-analysis of cohort studies assessing link between child obesity and adult blood pressure and cholesterol	N=23 studies N=14 studies in MA assessing blood pressure	BMI measured at 2-18 years (most studies using BMI as a continuous variable rather than an obesity cut-off)	• Child BMI positively associated with both systolic and diastolic blood pressure at aged 19 to 62 years • Associations were reversed when adjusting for adult BMI as a potential mediator

Summary: Criterion 2 not met.

KQ1. Prospective cohorts applicable to the UK generally suggest that a child who is overweight or obese at age 5 has increased risk of later overweight or obesity. However, most evidence has assessed combined categories of overweight/obesity due to the small proportion of children with obesity, and has looked at persistence into adolescence rather than to later adulthood. The cohorts also show some inconsistency in findings with some suggesting that children who are going to be obese are already obese at age 5, and others suggesting that weight and BMI gains occur after the age of 5. Therefore assessment around age 4-5 may only identify a small proportion of those who will become obese in adolescence and adulthood. This means that treatment/preventative interventions targeted at obese young children may have limited impact in tackling obesity as a whole in later life.

KQ2. Few cohorts have examined whether obesity at age 5 or younger predicts adult morbidity. There was no association with CHD or stroke, and links with T2DM only just reached statistical significance. These studies additionally have various quality and applicability limitations, limiting the strength of this evidence. Child cohorts were born 60+ years ago and may not be applicable to children today, and various potential confounders may be influencing the association. No studies specifically examined hypertension outcomes.

KQ3. No studies have directly examined whether child height influences the risk of obesity persisting or predicting adult morbidity.

5. There should be a simple, safe, precise and validated screening test.

Description of the previous UK NSC evidence review conclusion and current question

BMI assesses weight relative to height according to age. Obesity is defined as an excessive accumulation of body fat. The 2006 Fayter et al. HTA[2] review noted that BMI only gives an indirect measure of total body fat and may not be a reliable enough indicator of obesity. It may also give misleading results if the child is short or tall for their age.

Fayter et al.[2] noted previous diagnostic accuracy studies had varied in the BMI obesity threshold used, reference standard used to validate the result, and child age range covered. They highlighted a need to better understand the BMI thresholds that would indicate a high risk of morbidity and need for referral and treatment.

The current UK NSC question therefore aimed to address these uncertainties and see whether new studies have been published since the Fayter[2] review that assess the accuracy of a BMI measure to diagnose obesity as confirmed by a validated reference standard measure of total body fat in children aged ≤5 years.

We would also review any identified studies assessing the performance of possible alternative non-BMI screen tests, such as waist or neck circumference, against a validated reference standard of excess adiposity.

If evidence was available, we also aimed to look at the influence of child characteristics such as height on the performance of the BMI measure.

Description of the evidence

At the original 2016 search a total 175 studies were identified as potentially relevant during first-pass title sifting, and were further assessed at abstract level by a second reviewer. Most studies were excluded at abstract level due to the reasons listed below. Twenty-five were reviewed at full text.

The Simmonds et al.[3] 2015 HTA review (Appendix 7) provided the main source of data for this analysis. It searched for studies published up to 2013 that had assessed the performance of a child BMI measure, or alternative non-BMI screening tests, to detect obesity as diagnosed by a validated reference standard of excess adiposity in nationally representative populations. Valid methods were a multicomponent model, dual-energy X-ray absorptiometry (DEXA), deuterium dilution or densitometry, of which multicomponent is considered to be the gold standard.

BMI screening test

Simmonds[3] et al. identified a total 30 relevant studies assessing the diagnostic accuracy of a BMI measure. Of these they meta-analysed 11 high quality studies that had assessed the performance of a BMI measure using the standard thresholds of the 85th centile for diagnosing overweight and the 95th centile for diagnosing obesity, and had assessed this in an unselected sample of boys, girls or children of both sexes who were representative of the UK child population.

This main limitation of this meta-analysis is that it does not assess BMI test performance specifically in children age ≤5 years. The pooled studies inform on the accuracy of the overweight/obese BMI measure in children and adolescents, in general. Most studies were in children over 5 years. Only 2 of the 11 meta-analysed studies had included younger children and even they were in predominantly older age groups (i.e. 3-18 or 5-18 years).

Because of this, we separately reviewed at full text all 8 of the 30 studies identified by Simmonds[3] (including those not meta-analysed) that had included children age ≤5 to check that none gave BMI performance data specific for that age group. None had.

We also reviewed at full text any studies assessing BMI accuracy published after the Simmonds[3] 2013 search date. No later studies were identified that covered the age range of ≤5 years.

An additional systematic review with meta-analysis on the diagnostic performance of BMI was identified (Javed et al. 2015[15]), but this was excluded for several reasons. The search date was early 2013, the same as the Simmonds [3] HTA, and it meta-analysed a larger number of studies. However, the inclusion criteria did not require studies to have assessed BMI against a validated reference standard of excess adiposity, or in nationally representative populations. Studies used a range of reference standards including skinfold thickness and bioelectrical impedance analysis (BIA), which are considered to be imprecise measures of adiposity (and may themselves be considered as alternative screening tests). Performance data was also not given for specified BMI thresholds, and studies had used variable definitions of overweight or obesity. Therefore the Simmonds[3] HTA was considered the preferable meta-analysis for BMI.

However, because the Simmonds meta-analysis was not relevant to children aged less than five years it was not included in this review. The results are reported in the review addressing screening at age 7 – 11 years.

Alternative non-BMI screen tests

The Simmonds et al.[3] HTA also identified studies assessing the performance of alternative non-BMI screening tests for obesity. It did not meta-analyse these studies, but gave a narrative synthesis of their results. Simmonds[3] identified ten studies assessing skinfold thickness, four assessing waist circumference, three waist-to-hip ratio, two waist-to-height ratio, and one study assessed BIA.

However, again all of these 20 studies were conducted in children above the age of 5 years. Two of the studies did report age ranges that included age 5. One study has assessed the accuracy of skinfold thickness in children aged 5 to 18 (mean 12 years), and the other assessed the accuracy of waist circumference to diagnose obesity in children aged 5 to 15 (mean 9.8 years). As the mean age in both of these studies was considerably above 5 years, these two individual studies were excluded. They were not considered to have included a large enough sample of young children to give reliable information on the possible accuracy of these tests in children aged ≤5.

We reviewed the literature published after the 2013 Simmonds et al.[3] search date to identify any further studies assessing the performance of non-BMI screening tests against a validated reference standard for obesity. Two relevant studies were identified, one assessing neck circumference, and the other waist-to-height ratio. However, both of these studies were again conducted in older children (mean ages 9.8 and 11 years, respectively), so were excluded from this review as they did not provide applicable data on test accuracy in younger children.

Therefore again no individual studies of alternative non-BMI screening tests met the inclusion criteria.

We did not include studies assessing the performance of non-BMI tests to detect children meeting BMI obesity thresholds, or looking at their overlap with BMI categories. This is because the test performance of the BMI measure itself is being assessed by this review, and it may not be a suitable reference standard for diagnosing excess adiposity.

We also excluded studies:

- Conducted exclusively in children >6 years, including mean age (that is, the results of individual primary studies; those in the meta-analysis were included)
- Looking at the agreement in BMI across different reference curves
- Looking at correlation between different measures over time, for example how change in BMI correlates with change in percentage body fat
- Looking at the inter-rater reliability of measures
- Simply reviewing how child obesity prevalence differs according to the test used
- Assessing the performance of BMI or other tests to detect children with cardiometabolic risk factors rather than to identify children with excess adiposity/obesity
- Analysing specific population samples, for example children of specific ethnic group, or those referred to hospital clinics (e.g. cardiology)
- Assessing the validity of assessment tools in completely overweight or obese populations
- Looking at the performance of lifestyle tests to identify children with overweight/obese BMI, for example dietary scores or physical activity tests
- Reviewing the accuracy of self-report or parental-reported measures to identify children with obesity
- Assessing the validity of tools to assess quality of life in overweight or obese children
- Examining the reliability/consistency of recording of overweight/obesity in GP databases
- Evaluating the use of GP databases/electronic health records as a means of identifying overweight/obese children
- Looking at interventions to increase screening practices by doctors, or screening uptake by parents (mostly non-UK studies)
- Reviewing the consistency of NCMP measures across English schools/regions

Addendum: Evidence available at the July 2017 update search

No further studies were identified that assessed the performance of BMI or an alternative non-BMI test in children under 5 years against a validated reference standard of excess adiposity.

Summary: Criterion 5 not met.

The evidence is not available to answer the key question of whether BMI is a reliable indicator of obesity as defined by excess adiposity in the target population. No studies gave specific data on the test performance of BMI or non-BMI screening tests against a validated reference standard in children aged ≤5 years.

There were no studies available to inform how height may influence test performance.

10. There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment.

Description of the previous UK NSC evidence review conclusion and current question

The Fayter et al. HTA[2] review highlighted a lack of evidence that identifying and providing interventions for overweight and obesity in children is effective in the long term and is not associated with adverse outcomes. Without evidence for a safe and effective intervention that gives long term benefit, the value of obesity screening would be questionable.

The current review aimed to see whether there is evidence that interventions for obese children aged ≤5 years are safe and effective.

We would look at evidence of effect both for managing current overweight/obesity, and for preventing longer term morbidity in older childhood and adulthood, such as hypertension and type 2 diabetes. We would look at evidence for any harms or adverse effects of treatment, including psychological outcomes.

If the evidence was available we also aimed to identify whether child characteristics such as height had an influence on the effects of treatment.

Current NICE guidelines[16] on the identification, assessment and management of adults and children with obesity recommend tailored clinical intervention for children with a BMI ≥91st centile (overweight indicating clinical assessment), depending on the needs of the individual child and family. Multicomponent strategies involving behaviour change strategies that focus on diet and activity are recommended as the treatment of choice. Behavioural interventions are advised to be based on stimulus control, self-monitoring, goal setting, problem solving and rewards. Overweight or obese parents would also be encouraged to lose weight. Drug treatment is not recommended for children under 12 years of age, except in exceptional circumstances.

This key question therefore aimed to review evidence for the safety and effectiveness of lifestyle and behavioural interventions for young children (with or without family involvement). As individual children with obesity would be identified through a screening programme, we focused on individually-targeted treatments for young children diagnosed with overweight/obesity rather than general community-, school- or policy-based measures. Children with obesity could be either screen-detected or clinically-detected.

Description of the evidence

A total of 880 studies were identified as potentially relevant to this question at initial first pass appraisal. Due to the large number of potentially relevant studies, a pragmatic approach was taken to second pass appraisal. All systematic reviews (n=244) were reviewed initially before moving onto the lower hierarchy of evidence. A total of 42 systematic reviews were acquired at full text. Many of these reviews could be excluded at abstract or full text level due to the exclusions listed at the end of this section.

One 2016 Cochrane review[17] was a complete match to the PICO. This review identified RCTs investigating single or multicomponent dietary, activity or behavioural interventions provided to overweight/obese preschool children ≤6 years and/or their parents. This review was included as the main evidence for this question and earlier SRs were excluded. We then focused on reviewing RCTs published after the search date of this Cochrane review (March 2015).

Two additional RCTs[18, 19] relevant to the PICO were identified, both of which assessed parent motivational interviewing/counselling. One additional RCT[20] was identified by the 2017 update search which provided one year follow-up of one of the trials included by the Cochrane review.

Two additional systematic reviews were identified by the update search. The USPSTF[21] review identified no evidence available on the benefits and harms of screening children and adolescents for excess weight. It pooled trials looking at weight loss by number of contact hours of behavioural interventions for overweight to obese children aged 2-18. Heerman et al. [22] similarly conducted meta-regression of trials of behavioural interventions for overweight to obese children aged 2-18 years to see whether an optimal treatment dose was associated with improved outcomes. These reviews had limited evidence applicable to children ≤6 years. Given that the interventions and their delivery format would have most relevance to primary school children or adolescents they have been included in the second review for children aged 7-11 years.

No studies investigating treatment of screen-detected populations were identified. Neither did studies assess the influence of height or growth on treatment effects.

Only RCT-level evidence was considered eligible for the assessment of treatment effectiveness. However, due to the minimal RCT evidence on harms, any prospective cohort studies were also reviewed that could be relevant to the question of harms of treatment or quality of life effects.

One UK prospective cohort[23] evaluated the effect of providing weight feedback through the NCMP, including the psychological effects on parents and children. This study was included given the lack of evidence on adverse effects in the RCTs. It was also considered to be of particular relevance given its applicability to the UK population.

Therefore 5 studies in total were included for this question, summarised in Tables 5 and 6.

We excluded studies:

- Exclusively in children aged >6 years, including mean baseline age
- Excluding obese children
- Drug treatment (not licensed in <12s)

- Assessing only assessing the effect of interventions on diet and activity outcomes (e.g. screen time) but not evaluating the effect on overweight/obesity
- Evaluating surgery and inpatient treatment
- Assessing the effect of treatment on current cardiometabolic risk factors, e.g. lipid profile, rather than studies including exclusively overweight/obese populations where treatment had been indicated for the purpose of weight management
- Primarily assessing whether there's a difference in treatment response between children of different severities of obesity, rather than evaluating the effect of an intervention as such
- Looking at school- or community-based diet, activity or educational interventions aimed at the primary prevention of obesity in the general child population, including general health promotion
- Assessing interventions to engage parents in weight feedback
- Assessing interventions to improve parent recognition of child overweight or obesity
- Qualitative studies looking at factors associated with parental uptake of interventions
- Assessing interventions to increase doctors' screening practices, recording of obesity or implementation of interventions
- Solely assessing the effect of overweight/obesity on child's quality of life rather than the effect of treatment
- Evaluating quality of life assessment tools or patient reported outcome measures (PROMs)
- Studies assessing the effect of school activity programmes on quality of life of all children, not overweight/obese children specifically
- Assessing factors that hinder child participation in healthy lifestyle measures, like diet or activity
- Studies with outcome data collected for <50% of trial participants
- Trial protocols
- Cost effectiveness studies

Results

Table 5: Multicomponent interventions for the treatment of overweight or obese children aged ≤5 years

Study	Design	Population/studies	Intervention	Comparator	Outcome (all mean difference, 95% CI)
Colquitt et al. 2016[17] (Appendix 7)	Systematic review of RCTs with meta-analysis Search March 2015	7 RCTs (n=923), 5 pooled in MA Inclusion: Children age ≤6yrs (mean 4-6) with overweight or obesity (variably defined) 4 US, 1 UK, 1 Netherlands, 1 Iran	4 trials multicomponent lifestyle intervention – dietary physical, and/or behavioural (e.g. motivational interviewing) 1 trial single component dietary Duration: ≥6 months	No intervention, usual care or concomitant therapy (given to both arms)	Multicomponent vs. control • BMI z score: -0.26 units (-0.37 to -0.16) at treatment end; -0.38 (-0.58 to -0.19) at 12-18m (4 trials, n=210) • Body weight: -1.18 kg (-1.91 to -0.45) treatment end; -2.81 (-4.39 to -1.22) 12 to 18m • BMI centile: -1.54 (-2.82 to -0.26) treatment end; -3.47 (-5.11 to -1.82) 12-18 months (2 trials, n=49) Single dietary component • BMI z score: -0.10 units (-0.11 to -0.09) at treatment end (1 trial, n=163)
Taylor et al. 2015[18] (Appendix 8)	RCT Community setting, New Zealand	N=206 overweight/obese children (≥85th centile) Mean age 6.5 years	Low Intensity family-based intervention (including motivational interviewing) Duration: 24 months	Usual care (general guideline advice on diet and activity)	• BMI z score: -0.12 units (-0.20 to -0.04) • BMI: -0.34 kg/m2 (-0.65 to -0.03) • Waist circumference: -1.15 cm (-2.5 to -0.5) • Waist-to-Height ratio: -0.01 (-0.02 to -0.00) • Body fat: -0.6% (-1.2 to 0.1) ns
Resnicow et al. 2015[19] (Appendix 9)	RCT General practice setting, US	N=457 overweight or obese children (≥85th <97 centile), excluding highest level of obesity Mean age 5.1 years	Motivational interviewing from GP (4 sessions); OR Motivational interviewing (4 sessions) plus Dietitian counselling (6 sessions) Duration: 24 months	Usual care (general guideline advice on diet and activity)	BMI centile mean decrease from baseline to 2 years each group (standard deviation): • MI alone: 3.8 units (0.96) • MI plus dietitian: 4.9 units (0.99) • Usual care: 1.8 units (0.98) Significant difference MI plus dietitian vs. usual care (p=0.02)
Rifas-Shiman et al. 2017[20] (Appendix 10)	RCT two year follow-up: one year maintenance period after one year intervention (original trial covered by Colquitt et al.) General practice setting, US	N=475 children aged 2-6 years with obesity (BMI ≥95th centile) or overweight (85th to <95th centile) if at least one parent was overweight. Mean age 4.9 years at baseline, 7 years at follow-up	Motivational interviewing from GP (4 sessions plus 4 calls); plus maintenance (two calls) Duration: 12 month intervention, 12 month maintenance	Usual care	No significant difference between groups in change from baseline to 2 years: • BMI: +1.11 MI vs. +1.22 usual care (difference -0.08, 95% CI -0.53 to +0.36) • BMI z score: -0.20 MI vs. -0.18 usual care (difference -0.04, 95% CI -0.14 to +0.06) (neither any benefit at original one year follow-up)

Table 6: NCMP weight feedback evaluation

Study	Population	Intervention	Comparator	Results
Falconer et al. 2014[23] (Appendix 11) Prospective cohort NCMP, UK July 2010 to July 2011	N=3,397 children/parents completing baseline and follow-up questionnaires N=180 overweight N=105 obese 56% of children age 4-5 years 44% age 10-11 years	Written feedback on the child's BMI and healthy lifestyle information, including telephone calls for parents of obese children	Not applicable	Effect of parental feedback on overweight or obese children: • parental recognition of child's weight: obese increase by 23.5% after feedback, overweight recognition increased by 11.1% • parental recognition of health risks: obese *ns*, overweight +7% • children with recommended physical activity: obese +12.6%, overweight *ns* • no effect on healthy diet or screen time • no effect on weight-related teasing or self-esteem Children age 4-5 specifically (overweight and obese groups combined) : • parental recognition of child's weight: +16.9% • parental recognition of health risks: +8.1% • no effect on physical activity, healthy diet or screen time • no effect on weight-related teasing or self-esteem 21% of parents of overweight and 24% of obese reported feeling ashamed

The combined studies generally suggest that multicomponent interventions, including activity, diet and behavioural interventions for children with overweight/obesity and/or their parents, may have small but statistically significant effects on reducing child BMI. However, it is difficult to know how clinically meaningful these effects may be, and the body of evidence as a whole is small and provides variable and rather low quality evidence.

The evidence is applicable to the target age group and to predominantly Western populations. However, the studies cover interventions in overweight and obese children, rather than specifically obese children. This carries the limitation that the studies are not able to inform on the effectiveness of interventions specifically for obesity. Children with overweight are likely to outnumber those with obesity in these trials, and yet those with obesity are likely to be higher risk, may be harder to treat, and may benefit from different approaches. It is not possible to assess these possibilities from this evidence.

The studies variably defined BMI using different reference curves and threshold levels that may not be directly comparable. Method of child identification also varied, with most children identified through their GP. This may differ from identification through screening.

With these population applicability issues in mind, relatively few high quality RCTs were available. The recent 2016 Cochrane review identified only 5 RCTs that could be pooled in meta-analysis, with the majority of participants coming from a single trial. Only two further RCTs relevant to the PICO were identified after-2016, with an additional study presenting the two year follow-up for a previously published trial.

The trials were also highly heterogeneous. They varied widely in terms of the actual treatment programme delivered, its setting and providers, and frequency and intensity of sessions. The lack of an “attention control” in some trials may make it difficult to know for certain how much of the observed effect stems from the specific content of the programme delivered, or how much is an effect of regular contact with professionals at the education/counselling sessions. Neither do all trials have the same findings. The studies by Resnicow et al. and Rifas-Shiman et al. both apparently included 4 sessions of motivational interviewing from the GP, the latter trial including additional phone calls and two further maintenance sessions. Yet this Rifas-Shiman trial found no effect of either the original 12 month intervention or 12 month maintenance.

Overall this makes it difficult to apply the findings from these varied interventions in practical terms. It is difficult to know which programme elements are most effective and what would be the optimal format if setting up a treatment programme following screen identification.

The Colquitt et al. systematic review included evidence on whether weight or BMI changes were maintained 6-12 months after treatment cessation. However, other than this, the trials did not assess longer term outcomes. There was no evidence whether treatment would prevent morbidity in later childhood, adolescence or adulthood. It is unclear whether interventions would have to be ongoing in order to give sustained effect.

Another limitation of particular importance to the key question is the lack of data on potential adverse effects of treatment. Only a single trial (included in the Cochrane review) reported on adverse effects, stating none were found.

An analysis of NCMP programme outcomes included data on some adverse effects following feedback of results to parents. This suggested that providing parents with feedback on their child’s obesity/overweight status has no effect on the child’s self-esteem or teasing. However, obesity interventions may have more wide ranging adverse effects than simple obesity feedback, particularly considering that multicomponent treatment programmes are likely to require parent commitment and input.

The included studies had other quality limitations and potential for bias. Some studies lacked assessor blinding to treatment group, and had high drop-out rates. There is a risk that the outcomes may be overstated because attrition may be greater among those with greater environmental or lifestyle risk factors and at higher risk of obesity-related morbidity. With most evidence coming from non-UK trials, the demographic may also not be applicable to the UK.

There was limited evidence available examining the effect of child dietary or physical activity interventions alone.

No evidence was identified that assessed whether child characteristics, such as height, had an influence on the effectiveness or harms of treatment.

Overall the applicable evidence suggests that multicomponent treatment may have a small effect on BMI during and post-intervention. However, it is unable to inform precisely which elements of treatment programmes are most effective; what intensity or frequency of sessions to give; how long treatment would need to continue to sustain effects; effects on later cardiometabolic morbidity; and whether there may be any short or long term harms of identifying and treating obese young children.

Summary: Criterion 10 not met.

No direct evidence on health outcomes in screen-detected populations was identified by the review.

A small number of trials indicate that multicomponent interventions for overweight or obese children aged ≤5 years and their parents can have small but statistically significant effects on reducing BMI in the short term. The studies did not evaluate whether the level of weight loss was clinically meaningful.

However, the body of evidence relevant to this young age group is limited. The optimal format or duration of interventions is unclear. There was no evidence on the effect of interventions in obese children, specifically. As such it is difficult to know what would be the best form of multicomponent treatment to deliver to obese young children, particularly when children are identified through a screening programme.

It is unclear whether effects would be maintained in the long-term, reducing risk of obesity or morbidity in later childhood or adolescence, or whether ongoing maintenance would be required.

There was a notable lack of evidence on the potential harms of providing interventions to young children and their parents.

Neither was there evidence whether particular child characteristics, such as height, may have an influence on the effectiveness and harms of treatment.

Conclusions

Implications for policy

This review assesses obesity screening for children aged ≤5 years against select UK National Screening Committee (UK NSC) criteria for appraising the viability, effectiveness and appropriateness of a screening programme.

This review assessed key questions to determine if evidence published since 2005 suggests that the current UK NSC recommendation not to offer screening for obesity in childhood should be reconsidered. A separate review considers younger children aged 7-11 years.

The volume, quality and direction of evidence currently available does not conclusively answer all key questions and as such does not provide sufficient evidence that screening in this age group is beneficial and does not result in harms. Several uncertainties remain across key criteria:

- Uncertainty whether obesity at age ≤5 predicts later obesity. Prospective cohorts generally suggest that overweight or obesity age 4-5 increases risk of overweight or obesity in later childhood/adolescence. However, there was limited evidence assessing obese children and prediction of obesity specifically, and no assessment of obesity as an outcome in later adulthood. Additionally identifying obese young children may identify only a fraction of those who will become obese in later adolescence or adulthood.
- Insufficient evidence that obesity at age ≤5 predicts later adult morbidity. Few prospective cohorts have followed obese young children into adulthood and assessed cardiometabolic outcomes. The few cohorts available found no association with coronary heart disease or stroke, and the association with type 2 diabetes only just reached statistical significance. There are various quality limitations to this evidence, including that cohorts commenced over 60 years ago so may have limited relevance to child populations today. This reduces confidence in the findings. No studies examined the association with hypertension.
- Several diagnostic cohorts have assessed the test performance of overweight or obese BMI thresholds against a validated reference standard of excess adiposity in children and adolescents. However, there is no performance data specific to children age ≤5. There is also no evidence on the performance of alternative non-BMI screen tests in this age group.
- No studies have directly assessed interventions in screen-detected populations. There is evidence from a small number of trials that multicomponent behavioural interventions for overweight or obese children aged ≤5 and their parents have small but statistically significant effects in reducing child BMI. It’s unclear if these changes were clinically meaningful. There is no evidence to inform the best format of treatment, frequency and duration of sessions in this age group. It is unclear whether effects would be maintained in the long-term, reducing risk of obesity in later childhood or adolescence, or whether ongoing maintenance would be required.
- There is minimal data on potential adverse effects from providing interventions to young children and their parents.
- No studies are available to inform whether child height influences the likelihood of young child obesity persisting into adolescence or adulthood, predicting later morbidity; on BMI test performance; or has influence on the harms or benefits of treatment.

Limitations of the rapid review process

This rapid review process was conducted over a period of 12 weeks.

This review was restricted in scope to examine the evidence for obesity screening in children of 5 years and less. A separate review has assessed obesity screening in older children aged 7-11 years.

Searching was limited to four bibliographic databases and did not include grey literature sources. Although it is not generally recommended that study design filters be used in search strategies, filters were applied in order to manage the literature yield within the timeframe of this rapid review.

The rapid review was guided by a protocol developed *a priori*. Literature search and first pass appraisal were predominantly undertaken by one information specialist. Second pass appraisal and study selection was then conducted by two analysts. Decisions on study inclusions, or any queries or scope refinement were then resolved in a meeting with a third senior analyst and with UK NSC.

Due to the rapid review process and large number of potentially relevant studies identified there were restrictions to the number of studies that could be reviewed at full text. Therefore systematic reviews were prioritised for review at second pass appraisal – particularly for the treatment question where the largest body of evidence was identified. We then subsequently sifted down through the lower hierarchy of primary literature for each question, depending on the systematic reviews identified. If a high quality systematic review matching the key question and PICO had been identified, we then focused on reviewing the search results post-dating the search date of that review. We used standard, systematic approaches for full text appraisal study selection, data extraction, and validity assessment.

We did not include studies that were not available in English language, and did not review abstracts, conference reports or poster presentations. We were also unable to contact study authors or review non-published material. We were also unable to locate full text reports for some potentially relevant articles.

Methodology

Literature search and first pass appraisal were performed by the National Screening Committee. The search results were passed to Bazian Ltd. Who performed second pass appraisal, accessed full texts and prepared the draft report. This was further adapted in discussion with the UK NSC.

Each criterion was summarised as ‘met’, ‘not met’ or ‘uncertain’ by considering the results of the included studies in light of the volume, quality and consistency of the body of evidence. Several factors were assessed to determine the quality of the identified evidence, including study design and methodology, risk of bias, directness and applicability of the evidence. Factors that were determined to be pertinent to the quality of the body of evidence identified for each criterion are outlined in the results section as well as the comment section of the Appendix tables.

Search strategy

SOURCES SEARCHED: Medline, Embase, Psycinfo, and the Cochrane Library.

DATES OF SEARCH: January 2005 – June 2016

All searches carried out on 2 June 2016

	Medline	Embase	Cochrane	Psycinfo	Total	Unique
Natural history	1726	2560	237	-	-	-
Test accuracy	554	583	91	-	-	-
Interventions	1441	1489	1205	807	-	-
Screening	1227	1419	1250	337	-	-
Total by database (combined with OR)	**4257**	**5314**	**1332**	**1065**	**11968**	**7914**

After automatic and manual de-duplication, 7,914 unique references were sifted for relevance to the review.

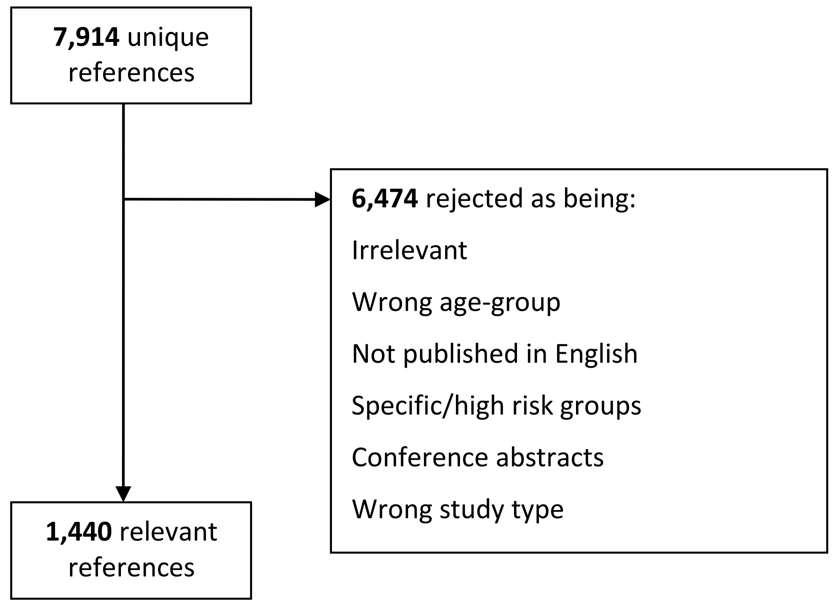
Inclusions and exclusions

Inclusions

- From the age of 2 up to the age of 11 (include age ranges if more than half the range is 11 or under)
- Mean age under 11
- Systematic reviews
- (Randomised) controlled/comparative trials
- Other study types for natural history and the test (more appropriate than RCTs/comparative trials)
- Other study types for screening (relatively few studies met the criteria for RCTs/comparative trials)
- Other study types for the surgical and pharmacotherapy interventions (relatively few studies met the criteria for RCTs/comparative trials)
- Populations in the UK and Ireland, Europe, USA, Australia, New Zealand.

Exclusions

- Over the age of 11 (exclude age ranges if more than half the range is above 11)
- Mean age is over 11
- Studies not in English
- Editorials, opinion pieces, comments, non-systematic reviews etc. for interventions



The 1,440 broadly relevant references were broadly categorised as follows:

Systematic reviews • Natural history (29) • The test (11) • Interventions (244) • Screening (7)	**291**
Guidelines/recommendations • Interventions (22) • Screening (8)	**30**
(Randomised) controlled/comparative trials • Interventions (419) • Interventions (protocols/pilots/feasibility studies) (134) • Screening (10)	**563**
Other study types • UK and Ireland epidemiology (93) • Natural history (263) • The test (121) • Interventions	**556**

(surgery/pharmacotherapy) (26) • Screening (18) • QoL/harms after interventions (35)	
Total	**1440**

2017 Update search

SOURCES SEARCHED: Medline, Embase, Psycinfo, and the Cochrane Library.

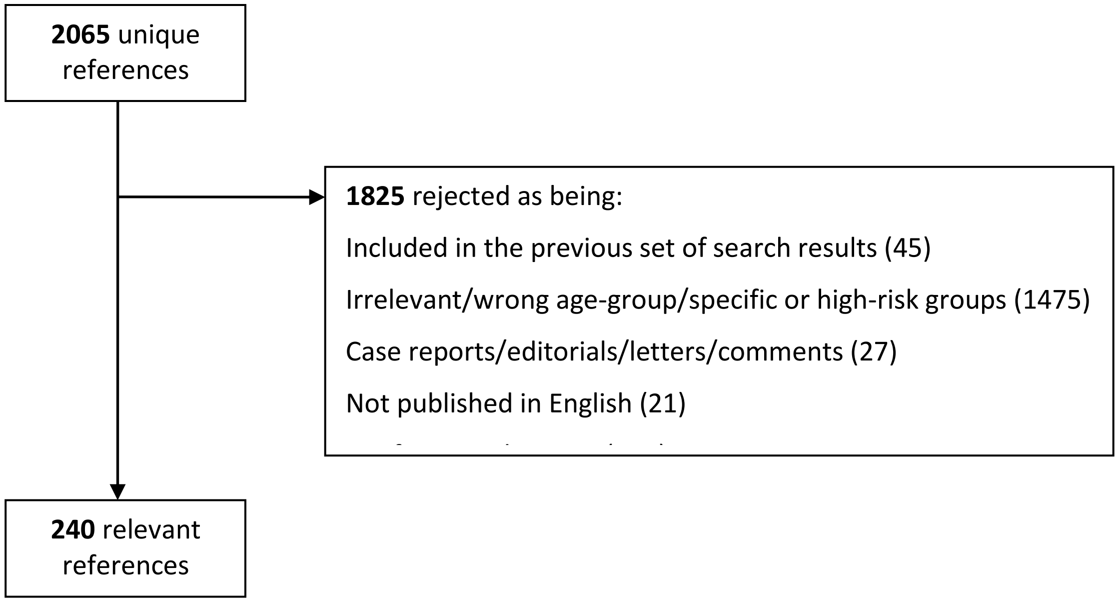
DATES OF SEARCH: June 2016 – November 2017

All searches carried out on 28 November 2017

Search results

	Medline	Embase	Cochrane	Psycinfo	Total	Unique
Natural history	377	575	73	-	-	-
Test accuracy	90	141	13	-	-	-
Interventions	307	375	295	78	-	-
Screening	339	522	420	363	-	-
Total by database (combined with OR)	**946**	**1419**	**443**	**413**	**3221**	**2065**

After automatic and manual de-duplication, 2,065 unique references were sifted for relevance to the review. Inclusions and exclusions were as above for the original search.



Appendices

Appendix number	1
Relevant criteria	2
Publication details	Simmonds M, Burch J, Llewellyn A, et al. The use of measures of obesity in childhood for predicting obesity and the development of obesity-related diseases in adulthood: a systematic review and meta-analysis. Health Technology Assessment (Winchester, England). 2015;19(43):1-336.[3]
Study details	Systematic review funded by the National Institute for Health Research (NIHR) Health Technology Assessment programme.
Study objectives	1) To investigate the ability of simple measures of obesity in childhood, such as body mass index (BMI), to predict the persistence of obesity from childhood into adulthood 2) To investigate whether obesity in children and adolescents is a risk factor for cardiovascular disease, type 2 diabetes and/or cancer in adults, and to see whether the results vary according to the measure of obesity used
Inclusions	Large prospective cohorts (n ≥1000) including population-based samples of obese children and/or adolescents (aged 2–18 years). Obesity measures could include any simple measures of BMI, NC, WC, WHR, WHtR, BAI, Ponderal Index, Benn's Index, FMI, SFT, BIA and NIR

	Additional specific criteria: <u>Question 1</u> • Studied that re-measured obesity at a later time in adolescence or adulthood (at least 5 years later) • Adult obesity measures could include BMI or the validated standards for adiposity (multicomponent model, D2O, hydrostatic weighting, ADP or DEXA) • Studies had to give data on the predictive accuracy of weight status in childhood /adolescence and obesity/overweight in adulthood. <u>Question 2</u> • Studies that measured adult outcomes of cardiovascular disease, type 2 diabetes or cancer • Studies reporting RRs, ORs, HRs, or summary estimates of predictive accuracy between childhood obesity and adult type 2 diabetes, cancer or CVD (including CVD death, myocardial infarction, stroke, heart failure, hypertension, hypercholesterolaemia and metabolic syndrome) Extensive databases searched including MEDLINE, EMBASE, PsycINFO and Cumulative Index to Nursing and Allied Health Literature (CINAHL) searched 2007 (Q1) or 2008 (Q2) to 2013. Searches used terms encompassing the key concepts of “obesity/adiposity”, “children/adolescents”, “adults”, and “Tracking/cohort/longitudinal/follow-up studies” (Q1) and “CVD/diabetes/cancer” (Q2). This was supplemented by reference checking and citation searching, which included studies identified by the Singh (2008) and Brisbois (2012) reviews identified by the current NSC review (Q1), and for adult morbidity (Q2) the reviews by Park (2012), Reilly (2011), Lloyd (2010 and 2012), and Owen (2009).
Exclusions	• Retrospective cohorts and case-controls • Studies with population size <1000 • Studies conducted in normal weight populations • Studies only reporting correlations between child and adult measures (Q1)
Analysis	<u>Question 1</u> Tracking from childhood obesity (BMI > 95th centile) or overweight (> 85th centile) to adult obesity (BMI > 95th centile or over 30 kg/m^2) or adult overweight (> 85th centile or >25 kg/m^2). Ages split into the following age categories and tracking could be across any: • childhood (ages 7–11 years) • adolescence (ages 12–18 years) • adulthood (age 20 years and over) • longer-term (age over 30 years) Studies in those under 7 were excluded from this analysis to avoid the potential

<table>
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for adiposity rebound, where BMI declines up to around 7 years.
<u>Question 2</u>
Child ages grouped into:

under 7 years
7–11 years
12–18 years

Outcomes that were protocol specified in ≥2 cohorts assessed in meta-analyses:

Adult-onset type 2 diabetes
Coronary heart disease
Stroke
Hypertension
Breast cancer
All other cancers combined.

</td></tr>
<tr><td>Population</td><td>
<u>Question 1</u>
N=23 studies tracking child/adolescent obesity into adulthood.
All studies assessed BMI, only 1 reviewed another measure.
8 studies covered age 4-5, only 2 specifically young children.
The 2 studies in under-7s were not included in the analysis due to rebound adiposity. Liddle (2012) tracked obesity at age 5 to adulthood (age 21) (identified by this review and analysed below in Appendix 2). Mamun (2005) analysed the same cohort tracking obesity at age 5 to adolescence (age 14).
<u>Question 2</u>
N=37 studies assessing the association with adult morbidities
All studies assessed BMI, 3 also assessed WC.
14 studies covered age 4-5, only 4 gave specific results for ≤6 years, one of which was identified by the NSC review search (Lawlor 05), others pre-dated 05

3 cohorts included in meta-analysis for association with adult CHD and stroke (Lawlor 2005; Gunnell 1998 and Jeffreys 2004; and Forsen 2004)
1 cohort reporting association with T2DM (Lawlor 2005)
1 cohort reports association with breast cancer (De Stavola, 2004)

Study characteristics:

Lawlor 2005 (Aberdeen study, 1950 to 2000), inception in 1950s Scotland.

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</table>

	Recruitment n=12,150, mean age 4.9, follow-up of n=11,106 to 48 to 54 years of age. Low risk of bias. • Forsen 2004 (Helsinki 1934 study, 1934 to 2003), inception 1934 in Finnish school/outpatient setting. Recruitment n=5486 females, age range 0-11, follow-up of n=3003 to age 27-64. High risk of attrition bias, otherwise low risk of bias. • De Stavola 2004 (MRC-NSHD study, 1946 to 1999), inception 1946 in UK school setting. Recruitment n=2547 females, age range 2-15, follow-up of n=2187 to age 47-53. High risk of outcome bias, otherwise low risk of bias. • Gunnell 1998 (Boyd Orr study, 1937 to 1995), inception 1937 in unknown setting in England and Scotland. Recruitment n=unknown, 49% male, age range 2-14, follow-up of n=2399 up to 73 years of age. High risk of attrition bias, otherwise low risk of bias. • Jeffreys 2004 (Boyd Orr study, 1937 to 1995). Recruitment n=2997, 49% male, age range 2-14, follow-up of n=2347 up to 66 years of age. Risk of selection and reporting bias, otherwise low risk of bias.
Results	<u>Question 1</u> Liddle (2012) cohort as Appendix 2 below <u>Question 2</u> Odds of adult morbidity with each standard deviation increase in BMI at age ≤6 years: • CHD: OR 0.93, 95% CI 0.83 to 1.05 (meta-analysis of 3 studies) • Stroke: OR 0.94, 95% CI 0.75 to 1.19 (meta-analysis of 3 studies) • Type 2 diabetes: OR 1.23, 95% CI 1.10 to 1.37 (1 study) • Breast cancer: OR 0.88, 95% CI 0.67 to 1.16 (1 study) Graphical representation of sensitivity of 85th centile of BMI age 5 for predicting: • Diabetes: 20% sensitivity • CHD: roughly 15 to 25% (no results given for 95th centile) (Results for other age groups not given in this review)
Comments	This was a high quality systematic review that should have identified all pre-2013

	studies tracking obesity into adulthood, or predicting adult morbidity from child obesity. Cohorts prospective and of good sample size but analyses limited by the small number of studies. All studies representative of Western countries, though the school setting for child measurements was only reported for 2/5 studies. All cohorts inception prior to 1950 and so may have limited representation to children today in terms of so sociodemographics, health and lifestyle. Adult morbidity outcomes are unclear in terms of assessment and definition and may include self-reported morbidity rather than medical confirmation. Additional risk of selection bias and high drop-out rate in some studies. Unclear adjustment for confounders, though reported to be low risk of bias.

Appendix number	2
Relevant criteria	2
Publication details	Liddle K, O'Callaghan M, Mamun A, et al. Comparison of body mass index and triceps skinfold at 5 years and young adult body mass index, waist circumference and blood pressure. Journal of Paediatrics & Child Health. 2012;48(5):424-9.[4]
Study details	Prospective birth cohort, Australia (Mater-University of Queensland Study of Pregnancy, MUSP)
Study objectives	To examine which measure of obesity at 5 years, body mass index (BMI) or triceps skinfold thickness, is most strongly associated with 21-year risk factors for cardiovascular disease (CVD), including BMI, waist circumference (WC), systolic blood pressure (SBP) and diastolic blood pressure (DBP).
Inclusions	Children born 1981 to 1983, who had measurements of triceps skinfold thickness (SFT), weight and height taken at age 5.
Exclusions	None additional.
Population	N=1755 (50% male, 93% European descent) with full data for analysis, average age at follow-up 20.5 years (range 18.2 to 23.1). Initial birth cohort 7223 (24.3% follow-up).
Test	Weight at both ages measured lightly clothed with scale accurate to 0.2kg. Portable stadiometer to measure height, without shoes, accurate to 0.1cm. At 5 years overweight or obesity was classified using the Cole-International Obesity Task Force: BMI >17.42 kg/m^2 for a boy and >17.15 kg/m^2 for a girl. At 21 years as per World Health Organization definitions: overweight BMI ≥25 and obese ≥30. Triceps SFT of the left arm measured by Harpenden Skinfold Caliper (British

	Indicators Ltd). Average of two measured recorded. Cut-offs for overweight and obesity said to be chosen to reflect similar proportions to those in the Cole BMI subgroups of obesity and overweight at 5 years and adjusted for age and gender. WC at 21 years measured horizontally at the umbilicus during expiration using the average of two measures. WC was defined as normal (<94 cm males, <80 cm females), overweight (94 to <102 cm males, and 80 to <88 cm females), and obese (≥102 cm males, ≥88 cm females). BP measured at rest for 5 minutes using the average of two measures. Adjusted for potential confounders of: maternal BMI (measured height and self-reported pre-pregnancy weight), age at pregnancy and education; child birthweight and gestational age at birth, and total family income at 5 years.
Comparator	NA
Results/outcomes	44 children with obese BMI at 5 years at 21 years: • BMI 25% normal weight, 34.1% overweight, 40.9% obese ($p<0.001$) • WC 38.6% normal, 20.5% overweight, 40.9% obese ($p<0.001$) • SBP mean 118.2, DBP mean 68.8 mmHg Overweight/obese BMI age 5 vs. normal BMI increased risk of 21 year old: • overweight/obese BMI: aOR 5.5 (95% CI 4.2 to 7.3) • BMI mean difference: 4.4kg.m^2 (3.9 to 5.0) • overweight/obese WC: aOR 1.6 (1.2 to 2.0) • WC mean difference: 8.3cm (6.8 to 9.8) • SBP mean difference: 2.4mmHg (0.5 to 4.3) • DBP mean difference: 1.1mmHg (0.1 to 2.2) Overweight/obese SFT age 5 vs. normal BMI increased risk of 21 year old: • overweight/obese BMI: aOR 2.6 (95% CI 2.0 to 3.4) • BMI mean difference: 2.6kg.m^2 (2.0 to 3.2) • overweight/obese WC: aOR 1.2 (95% CI 0.9 to 1.6) ns • WC mean difference: 4.8cm (3.3 to 6.3) • SBP mean difference: 2.3mmHg (0.5 to 4.2) • DBP mean difference: 0.7mmHg (-0.4 to 1.8) ns
Comments	Large non-selected birth cohort but high drop-out rate (data for only 24%). Those

	lost to follow-up more likely to be younger mothers, less well educated and with lower family income. May have been higher prevalence of obesity among drop-outs. Measurement setting unclear. Researchers note lack of consistency in WC measures. Otherwise data collection should be reliable. Possible influence of unadjusted confounders. Western cohort should be representative of UK population and applicable to the study question though limited by combined analysis of overweight/obese rather than obese only, and to a young adult measure.

Appendix number	3
Relevant criteria	2
Publication details	Pearce M, Webb-Phillips S, Bray I. Changes in objectively measured BMI in children aged 4-11 years: data from the National Child Measurement Programme. Journal of Public Health. 2015;6:6.[5]
Study details	Prospective analysis of data collected in the National Child Measurement Programme (NCMP) for South Gloucestershire, UK.
Study objectives	To look at the level of weight gain which occurs in children between the first and last year of primary school, by gender, and to look at whether weight status in the first year of primary school predicts becoming overweight or obese by the last year of primary school.
Inclusions	Children with height and weight measured on school entry to reception (age 4 to 5) in 2006/7 and re-measured in year 6 (age 10 to 11) in 2012/13.
Exclusions	None reported.
Population	N=1863 children with data available at both assessments (78.7% of all records available, 2405, which was coverage of 88 to 90% of students in the region).
Test	Weight and height measured and BMI calculated based on gender and age and classified using UK90 BMI reference curves. Adjusted for deprivation score. Probability of being overweight (BMI ≥85%) or obese (≥95%) at Year 6 (mean age 10.6) on the basis of BMI in reception year (mean age 4.9).
Comparator	NA
Results/outcomes	Reception age: 1.1% of children were underweight, 77.8% healthy weight, 12.9% overweight and 8.2% obese (total overweight and obese 21.1%). By Year 6: decrease in prevalence of healthy weight to 68.7% ($p<0.05$) and increase in prevalence of obesity to 16.3% ($p<0.05$).

	Between the two years there was:
	• a decrease in the proportion of children whose BMI was 50th to 74th centile: 29.8% in reception to 22.8% in year 6 (significant for girls, not boys)
	• a significant increase in the proportion with BMI >95th centile: 8.2% to 16.3%
	• by year 6 there was a significant increase in the prevalence of obesity: 8.2% (95% CI 7.0 to 9.5) in reception to 16.3% (95% CI 14.6 to 18.1) in year 6 ($p<0.05$)
	Of children who were overweight at Reception: 27% remained overweight, 30.3% had become obese and 42.7% achieved a healthy weight by Year 6.
	
	Of children who were obese in Reception: 68% remained obese, 16.3% had become overweight and 15.7% achieved a healthy weight by Year 6.
	
	Odds of being overweight or obese (BMI ≥85th centile) in year 6 according to reception BMI status (adjusted for deprivation):
	• Reception BMI 85 to 94.9 (number in this category at baseline):
	  ○ All (n=241): aOR 13.38 (95% CI 8.00 to 22.38)
	  ○ Boys (n=129): 8.90 (4.42 to 17.97)
	  ○ Girls (n=112): 20.11 (9.32 to 43.42)
	• Reception BMI ≥95 (number in this category at baseline):
	  ○ All (n=153): aOR 65.27 (95% CI 37.59 to 113.35)
	  ○ Boys (n=91): 50.14 (24.35 to 103.26)
	  ○ Girls (n=62): 90.28 (38.17 to 213.55)
	
	Odds of being obese (BMI ≥95th centile) in year 6 according to reception BMI status (adjusted for deprivation):
	• Reception BMI 85 to 94.9:
	  ○ All: aOR 10.78 (95% CI 7.58 to 15.33)
	  ○ Boys: 6.99 (4.30 to 11.37)
	  ○ Girls: 17.23 (10.17 to 29.20)
	• BMI ≥95:
	  ○ All: aOR 43.16 (95% CI 26.21 to 71.08)
	  ○ Boys: 38.31 (19.91 to 73.03)
	  ○ Girls: 50.30 (22.86 to 110.65)

Comments	Large non-selected UK cohort representative of NCMP in school setting with acceptable drop-out rate (20%) - though there is the risk that obese children may be less likely to be re-measured. Wide confidence intervals limit the association, likely due to small numbers in each group. Possible influence of unadjusted confounders.

	Only assessment of young childhood to later childhood rather than adult BMI measure.

Appendix number	4
Relevant criteria	2
Publication details	Graversen L, Sorensen TI, Gerds TA, et al. Prediction of adolescent and adult adiposity outcomes from early life anthropometrics. Obesity. 2015;23(1):162-9.[6]
Study details	Prospective birth cohort, Finland (Northern Finland Birth Cohorts, 1966 and 1986).
Study objectives	To test the ability of maternal BMI, birth weight, and early childhood BMI to predict adolescent overweight, adult overweight, and adult obesity and to test how well a prediction model developed in one cohort performs in a cohort born 20 years later in the same geographical area but with a much higher overweight prevalence.
Inclusions	First cohort, children born in 1966 in the study region with pregnancy, birth data and follow-up to the age of 31 years. Second cohort, children born in the same region between 1985 and 1986 with follow-up to 16 years of age.
Exclusions	None reported.
Population	1966 cohort: n=4111 (of 8463 eligible). 1986 cohort: n=5414 (of 9203 eligible).
Test	Prediction based on childhood BMI at 1, 3, 5 and 8 years were developed in the 1966 cohort to predict adolescent overweight, adult overweight and adult obesity (too few numbers to predict adolescent obesity). The accuracy of these models at 5 and 8 years of age were validated in the 1986 cohort. BMI classified International Obesity Task Force (IOTF) cut-offs for adult overweight BMI>25 and obesity BMI>30. BMI at other ages not reported.
Comparator	NA
Results/outcomes	1966 cohort: BMI at 5 years in males and females to predict: • Adolescent (13 to 16) overweight: OR 1.36 (95% CI 1.07 to 1.73) boys; 1.63 (1.31 to 2.04) girls • Adult overweight: 1.13 (0.97 to 1.30) boys; 1.25 (1.07 to 1.45) girls • Adult obesity: 1.32 (1.04 to 1.66) boys; 1.56 (1.27 to 1.93) girls At 5 years an AUC of 70% gave satisfactory prediction for adolescent overweight and adult obesity; 60-65% for adult overweight (male and female)

	Applied to 1986 cohort: BMI at age 5 years to predict adolescent overweight with threshold of being at risk set at the upper 10% of BMI values: • Females: Sensitivity (those who became overweight identified as at risk) 38.9%, Specificity (those who didn't become overweight identified as not at risk) 94.4%, PPV 51.5%, NPV 91.10 • Males: Sensitivity 28.2%, Specificity 94.2%, PPV 53.4%, NPV 84.8% BMI at age 5 years to predict adolescent overweight using IOTF overweight definitions (>17.1kg/m^2 for females [10.3% of values] and >17.4 kg/m^2 for males [8% of values]): • Females: Sensitivity 39.7%, Specificity 94.2%, PPV 51.0%, NPV 91.1% • Males: Sensitivity 25.4%, Specificity 96.1%, PPV 60.5%, NPV 84.6% Overall overweight at age 5 identifies about a quarter to a third who will be overweight in adolescence. Over half of those at-risk became overweight in adolescence.
Comments	Large non-selected prospective birth cohorts but high drop-out rate. May have been higher prevalence of obesity among drop-outs. Prediction models in this Finnish cohort may not be representative of current UK school setting though IOTF thresholds is likely to be applicable. Limited by combined analysis of overweight/obese in childhood and adolescence rather than obese only, and predictive data given for adolescence only. Only AUC given for adult obesity. Measurement setting unclear. Possible influence of unadjusted confounders.

Appendix number	5
Relevant criteria	2
Publication details	Stuart B, Panico L. Early-childhood BMI trajectories: evidence from a prospective, nationally representative British cohort study. Nutrition and Diabetes. 2016;6 (no pagination)(e198).[7]
Study details	Prospective birth cohort, UK (the Millennium Cohort Study)
Study objectives	To use group-based trajectory modelling to examine BMI trajectories in early childhood in a large, prospective, and nationally representative cohort study of

	British children.
Inclusions	Children born 2000 to 2002, 18,533 households identified through the Department of Work and Pensions Child Benefit system, uptake rate 68%.
Exclusions	None reported.
Population	N=9669 with measurements available at 3, 5, 7 and 11 years.
Test	BMI calculated based on height and weight with overweight and obese thresholds based on IOTF cut-offs for age and gender. Models adjusted for parental income, education and poverty indicator, maternal smoking, child birthweight and whether breastfed.
Comparator	NA
Results/outcomes	Four distinct trajectories identified: • children who were at low to normal BMI throughout the study period (retaining an average BMI of around 16) – 'low-normal' accounting for 44.8% of the study population (49.3% of boys, 42.1% of girls) • children with higher than average BMI only just below the 'overweight' threshold at age of 3, who remained consistently below the 'overweight' cut-off – 'mid-normal' accounting for 37.8% (boys 36.2%, girls 37.9%) • children just below the 'overweight' threshold at age 3, whose BMI continues to increase putting them above the overweight cut-off after this time – 'overweight', accounting for 14.4% (boys 11.7%, girls 16.2%) • children with BMI above obese cut-off at age 3 and who continue above the obese cut-off at all ages – "obese" accounting for 3.1% (boys 2.2%, girls 3.4%) Trajectories for boys and girls similar, though higher prevalence of overweight and obesity for girls than boys. Gender, ethnicity, parent educational status significantly associated with obesity. No trajectory of decreasing BMI identified, nor suggesting a change from overweight or obesity to normal BMI. No late-onset groups/latent trajectories identified. Mid-normal and overweight groups similar at age 3 but diverge around age 5, while obesity set at around age 5 years. Gives evidence to the idea that tracking – the persistence or relative stability of excess weight over time seen in adolescents and adults – also occurs from a very early age and that once overweight or obese trajectories they do not change.
Comments	Large prospective and current UK cohort adjusted for confounders should be representative of current population.

	However, data only account for 50% of eligible cohort. Overweight and obesity prevalence may be higher among those who aren't measured. Analysis may not give full accuracy on the number of trajectories.

Appendix number	6
Relevant criteria	2
Publication details	Hughes AR, Sherriff A, Lawlor DA, et al. Timing of excess weight gain in the Avon Longitudinal Study of Parents and Children (ALSPAC). Pediatrics. 2011;127(3):e730-6.[8]
Study details	Prospective birth cohort, UK (Avon Longitudinal Study of Parents and Children, ALSPAC)
Study objectives	To test the hypothesis that most excess weight gain occurs by school entry in a large sample of English children, and to determine when the greatest gain in excess weight occurred between birth and 15 years.
Inclusions	Children in Focus (CiF), a random 10% sample of the ALSPAC cohort (born in Southwest England in 1991 to 1992) who attended clinic measurements at 4, 8, 12, 18, 25, 31, 37, 43, 49, and 61 months. Also with clinic assessments 7, 9, 11, 13 and 15 years (as the full ALSPAC cohort).
Exclusions	Premature infants born at <37 weeks.
Population	N=1358 who attended at least one clinic assessment (n=625 by age 15).
Test	Weight and height. At each time point weight and BMI were expressed relative to UK 1990 growth reference curves as z scores. The z score is an indication of how many standard deviations the person is above or below the average for their age or gender which allows comparison across age and gender).
Comparator	NA
Results/outcomes	Mean weight and BMI z scores steadily increased, most markedly after school entry: • weight z score: 1 year 0.22, 3 years 0.20, 5 years 0.18, 7 years 0.22, 9 years 0.37, 11 years 0.54, 13 years 0.51, 15 years 0.48 • BMI z score: 1 year 0.20, 3 years 0.31, 5 years 0.28, 7 years 0.13, 9 years 0.34, 11 years 0.40, 13 years 0.34, 15 years 0.40 Mean difference in z score during follow-up: • Weight z score: • 0–5 years (n=932): mean change 0.04 (95% CI -0.03 to 0.12) non-

	significant weight change (ns) • 5–9 years (n=760): 0.19 (0.14 to 0.23) significant weight increase (s) • 9–11 years (n=766): 0.15 (0.12 to 0.18) s • 11–13 years (n=672): 0.001 (-0.03 to 0.03) ns • 13–15 years (n=562): -0.05 (-0.09 to -0.02) significant decrease • BMI z score: • 1–5 years (n=883): 0.10 (0.04 to 0.15) significant increase • 5–9 years (n=757): 0.06 (0.01 to 0.12) s • 9–11 years (n=766): 0.04 (0.01 to 0.08) s • 11–13 years (n=672): -0.02 (-0.06 to 0.01) ns • 13–15 years (n=562): 0.04 (0.005 to 0.08) s Largest observed BMI increase 7 to 9 years: 0.22 (0.18 to 0.26) Doesn't support the hypothesis that most weight gain occurs in early childhood prior to school entry (age 4-5) or that weight status is set by this time. Little change prior to 5, then 5 to 11 gains in weight and BMI. Therefore doesn't support the theory for prevention and treatment interventions to start in pre-school children.
Comments	UK population-based birth cohort. However from early 90s so may be less representative of children today. Findings for CiF subsample may not be the same as for the whole cohort, also attrition of around half by 15 years. Those lost to follow-up may include a higher prevalence of overweight and obese.

Appendix number	7
Relevant criteria	10
Publication details	Colquitt Jill L, Loveman E, O'Malley C, et al. Diet, physical activity, and behavioural interventions for the treatment of overweight or obesity in preschool children up to the age of 6 years. Cochrane Database of Systematic Reviews: John Wiley & Sons, Ltd; 2016.[17]

Study details	Systematic review with meta-analysis
Study objectives	To assess the effects of diet, physical activity, and behavioural interventions for the treatment of overweight or obesity in preschool children up to the age of 6 years.
Inclusions	RCTs including overweight or obese children with a mean trial age of 0 to 6 years at the start of the intervention. Studies had to compare any form of lifestyle intervention – dietary, physical activity and/or behavioural therapy – delivered as a single or multicomponent intervention and where the primary aim was to treat overweight/obesity. Comparators could be no intervention, usual care or an alternative/concomitant therapy that was also delivered to the intervention arm. Search on 10th March 2015 with no language restriction: Cochrane, Medline, Embase, PsycINFO, CINAHL, LILACS, WHO International Clinical Trials Registry, ClinicalTrails.gov.
Exclusions	Studies in critically ill children or those with a syndromic cause for obesity, such as Prader-Willi.
Population	11 RCTs (24 publications) met inclusion criteria, 7 (19) included in qualitative synthesis (Bocca 2012, Lanigan 2010, Quattrin 2012, Stark 2011, Stark 2014, Taveras 2011, Kelishadi 2009), 5 RCTs (15) pooled in meta-analysis. 4 trials US, 1 UK, 1 Netherlands, 1 Iran. Total population in 7 trials n=923; intervention arm 529, comparator 394. Over half of participants came from one trial (Taveras 2011, also a cluster RCT where the GP practice was randomised). Five trials were single centre, 2 multicentre. Children: 3 RCTs BMI ≥95% (2 specifying parent also overweight/obese); 2 RCTs BMI ≥85% and parent also overweight/obese (1 BMI ≥95% and no overweight parent); 1 IOTF definition ovweight/obesity; 1 RCT child ≥91%. In 5 trials mean child BMI was 18 to 22, and in 5 trials BMI z score 1 to 2.7. Age range 4-6 years in 6 trials, 2.5 years in one trial. In five trials reporting ethnicity White in 70 % (47-70% in one of them).
Intervention	Eligible: single or multicomponent lifestyle intervention – dietary, physical activity and/or behavioural 6 trials assessed multicomponent lifestyle interventions – nutrition, activity and behaviour though individual components different between trials. Two (Stark 2011 and 14) used the same intervention – Learning about Activity and Understanding Nutrition for Child Health (LAUNCH), involving 18 group-based clinic sessions and individual home visits over 6 months, targeting lifestyle

	behaviour modification and parenting skills. Quattrin (2012) family-based parenting and behavioural intervention involving 13 group sessions, individual meetings and 10 phone calls. Bocca (2012) 25 sessions of dietary advice, physical activity, and psychological counselling for parents. Taveras (2011) 'High Five for Kids', a behavioural intervention using motivational interviewing face-to-face and by telephone, educational modules, and behavioural goal setting. Lanigan (2010) 'Trim Tots' healthy lifestyle programme, including nutritional education, physical activity, and behavioural change components. 1 trial assessed a single dietary intervention (Kelishadi 2009) – (dairy rich and energy restricted plus healthy lifestyle education) 3 trials were conducted in outpatients, 2 in GP clinics, 1 in the community, 1 in a research clinic. Intervention duration 6 months in four trials, 16 weeks in Bocca (2012) and 2 years in Taveras (2011). Follow-up ranged from 1 to 3 years.
Comparator	Eligible: No intervention, usual care or an alternative/concomitant therapy that was also delivered to the intervention arm. All 7 included trials compared with usual care or control: 2 usual care, 2 enhanced usual care, 1 waiting list, 1 information control, 1 (Kelishadi 2009) healthy lifestyle education alone
Results/outcomes	Primary outcomes: change in BMI/weight and adverse effects (both measured at baseline to at least 6 months) BMI z score (difference in means): • End of multicomponent intervention vs. control: mean difference (MD) -0.26 units, 95% CI -0.37 to -0.16; p<0.00001 (4 trials, n=210; low-quality evidence) • 12-18 month follow-up: MD -0.38 units, 95% CI -0.58 to -0.19; p=0.0001; (4 trials, n=202) • Single component dietary vs. non-dietary intervention, end of intervention: dairy-rich diet and energy restricted, both MD -0.10 units (95% CI -0.11 to -0.09) (1 trial, n=163 [calculated]) Body weight: • End of multicomponent intervention vs. control: MD -1.18 kg, 95% CI -1.91 to -0.45; p=0.001 (4 trials, n=210, low-quality evidence) • 12 to 18 month follow-up: MD -2.81 kg, 95% CI -4.39 to -1.22, p=0.0005 (4 trials, n=202) BMI centile: • End of multicomponent intervention: MD -1.54 units, 95% CI -2.82 to -0.26 (2

	trials, n=50, low-quality evidence) • 12-18 month follow-up: MD -3.47 units, 95% CI -5.11 to -1.82 (2 trials, n=49) Adverse effects: • Only 1 trial reported on adverse effects and stated none were observed. Other secondary outcomes including measures other than BMI/weight, health-related QoL, behaviour change and child-parent relationship. Authors conclude: overall multicomponent interventions appear to be effective for overweight/obese children aged up to 6 years. However, the evidence is limited and trials have a high risk of bias. Most didn't look at adverse effects. Further research needed into AEs and dietary interventions alone.
Comments	High quality systematic review, where interventions were of sufficient duration (>6 months) and population age applicable to the study question. All pooled trials 2009 to 2014. Limited total body of evidence and variability in intervention design with only 5 pooled studies. Not exclusively in obese populations, and definitions varied. High or unclear risk of bias across trials related to lack of participant/assessor blinding and incomplete outcomes reported. In 4 RCTs completion rate was <80%. Overall low quality evidence that multicomponent interventions are more effective than comparators in reducing BMI and body weight. Only a single trial provided evidence for diet alone. Limited evidence for non-BMI/weight outcomes, and nothing on adverse effects. Limited assessment of participant views, parent-child relationship, or parenting. Morbidity, mortality, self-esteem or socioeconomic effects not measured by any trial.

Appendix number	8
Relevant criteria	10
Publication details	Taylor RW, Cox A, Knight L, et al. A Tailored Family-Based Obesity Intervention: A Randomized Trial. Pediatrics [Internet]. 2015; 136(2):[281-9 pp.][18]
Study details	RCT, New Zealand, enrolment from 9 GP surgeries and 1 hospital outpatients
Study objectives	To determine whether a 2 year family based intervention involving low intensity contact (monthly) was effective in reducing excessive weight compared with usual

	care
Inclusions	Phase 1 screening: Families with children aged 4 to 8 years (n=1093) recruited to first phase screening study. Child had body weight measures taken and families were randomised to feedback through usual care (n=540) or motivational intervening session. Phase 2 intervention: Children identified as overweight/obese ≥85th centile (n=271) followed at 2 weeks; n=206 (75%) agreed to participate and randomised to tailored package or usual care.
Exclusions	None specific reported.
Population	N=206 children, mean age 6.5 years, 45% male, ethnicity 75% European, BMI z score 1.69 intervention, 1.56 control, 70% mothers overweight. No significant difference between those who dropped out and participated.
Intervention	Tailored package (n=104) A single motivational interviewing multidisciplinary consultant session (parents, dietician, exercise specialist and psychologist) followed by regular contact with a mentor (1 nutritionist, 1 exercise specialist) over the following 2 years. The initial session was 1-2 hours. Families met with the mentor monthly during the first year, then every 3 months in year 2. Mentor sessions alternated between face-to-face (30-40mins) and phone calls (5-10mins). Goals were discussed and resources provided at each session.
Comparator	Usual care (n=102) Families met with researcher at baseline and 6 months and received individualised feedback abut child's diet and activity based on information collected at baseline and screening appointments. Generalised advice involved comparing child with guideline recommendations and publically available resources. Baseline appointment 30-45mins and 6 month follow-up 15-30mins with no additional information/resources provided.
Results/outcomes	Primary outcome BMI at 24 months. Tailored package vs. usual care at 24 months (adjusted for baseline value, age, sex, feedback condition): • BMI: MD -0.34 kg/m^2, 95% CI -0.65 to -0.03 • BMI z score: MD -0.12 units, 95% CI -0.20 to -0.04 • Waist circumference: MD -1.15 cm, 95% CI -2.5 to -0.5 • Waist-to-Height ratio: MD -0.01, 95% CI -0.02 to -0.00

	• Body fat: MD -0.6%, 95% CI -1.2 to 0.1 (ns) Small significant differences also observed for some behaviour variables: higher fruit and vegetable intake (1.0 [0.0 to 2.1]), lower non-fruit and veg intake (-0.3 [-0.5 to -0.0]), more physically active on accelerometer count (6 [4 to 115]). No significant effect on time in moderate/vigorous physical activity, sedentary time, sleep duration, sweet drink intake, quality of life scores (physical, emotional, social, school, psychosocial), parent factors and environment.
Comments	Good quality evidence that regular low-intensity support to families of young children can make small, significant changes to body weight over long assessment period up to 2 years. Screening recruitment scenario may be applicable to potential UK screening context. Allocation concealment and single blind (assessors). Study adequately powered to detect a 0.15 difference in BMI z score with 73 in each study arm. ITT analysis and high retention (n=181, 88%) to two years. No significant differences in characteristics for non-participants or drop-outs (with the exception of more likely to be from one-parent households).

Appendix number	9
Relevant criteria	10
Publication details	Resnicow K, McMaster F, Bocian A, et al. Motivational interviewing and dietary counseling for obesity in primary care: an RCT. Pediatrics [Internet]. 2015; 135(4):[649-57 pp.].[19]
Study details	RCT, US, 42 GP surgeries from the Pediatric Research in Office Settings Network of the American Academy of Pediatrics
Study objectives	To test the efficacy of motivational interviewing delivered by GPs and registered dietitians to parents of overweight children aged 2 through 8.
Inclusions	Children aged 2-8 with BMI centile ≥85 and <97 (unclear reference)
Exclusions	Children >97th centile, previously seen by a weight-loss specialist or involved in weight-loss programme, diabetes or other chronic medical illness
Population	N=457 overweight to obese children, mean age 5.1, mean BMI 91.8, male, 45%, White ethnicity 64% Participants represent 71% of recruited: original sample of n=645 but 5 practices

	dropped out (n=67, 81, 40 patients lost from the three groups). Drop outs included a higher number of Hispanics (30% vs. 18%) and parents of lower education (74% vs. 56%) and income (43% vs. 28%).
Intervention	• Group 1 (n=145 completers, 68% of recruited): Motivational interviewing to parents: 4 sessions provided by a trained GP, three in year 1 and 1 booster session in year 2 • Group 2 (n=154 completers, 66% of recruited): Motivational interviewing plus dietitian support: as group 2 plus 6 dietitian counselling sessions scheduled over 2 years (in-person or by phone) Motivational sessions focused on diet, activity, and screen time, with educational materials enhanced to fit with motivational interviewing and self-determination theory.
Comparator	• Group 3 (n=158 completers, 80% of recruited): usual care, with standard diet and activity education given to parents BMI measured at baseline, 1 and 2 year follow-up in all groups
Results/outcomes	Primary outcome: BMI centile at 2 years. Baseline, 2 years and mean difference (standard deviation), adjusted for baseline factors: • Group 1 (MI): 92.2 (3.3) to 88.1 (0.94), MD 3.8 units (0.96) • Group 2 (MI plus dietitian): 92.1 (3.4) to 87.1 (0.92), MD 4.9 units (0.99) • Group 3 (usual care): 91.5 (3.3) to 90.3 (0.94), MD 1.8 units (0.98) MI plus dietitian was significantly more effective than usual care (3.1 centile units difference, p=0.02) Exploratory analysis by sessions attended found that group 2 was more effective than usual care regardless of completion of more or less than 8/10 sessions. Group 2 was not significantly more effective, than usual care regardless of completion of more or less than 3/4 sessions.
Comments	BMI reference curve unclear and exclusion of the most obese children. Drop-out of five practices. Analysis was still adequately powered but there were social differences between those included and not. No attention control so difficult to say whether the effect was due to the specific content or the counselling session itself. May not generalise to other practices or healthcare systems in the US or elsewhere.

Appendix number	10
Relevant criteria	10
Publication details	Rifas-Shiman SL, Taveras EM, Gortmaker SL, et al. Two-year follow-up of a primary care-based intervention to prevent and manage childhood obesity: the High Five for Kids study. Pediatric obesity. 2017;12(3):e24-e7.[20]
Study details	Follow-up of randomised controlled trial
Study objectives	The planned two-year evaluation of the effectiveness of High Five for Kids, a cluster randomised controlled trial in 10 paediatric practices (original trial publication with one-year evaluation included by Colquitt et al.[17])
Inclusions	High Five for Kids was a primary care-based obesity intervention including 475 children aged 2-6 years with obesity (BMI ≥95th percentile) or overweight (85th to <95th percentile) if at least one parent was overweight (BMI ≥25 kg/m^2).
Exclusions	None further given.
Population	Trial completion at one year: 253/271 intervention and 192/204 control Trial completion at two years: 249/271 intervention (92%) and 192/204 control (94%). Baseline characteristics: mean age 4.9 years, 48% female, 57% white ethnicity, BMI 19.2, 56% obese (≥95th percentile), BMI z score 1.85, 96% of parents overweight or obese. Mean age at two-year follow-up: 7.0 years During the maintenance period: 62% made no further visits, 17% completed one further visit and 21% attended both.
Intervention	Intervention practices received primary care restructuring, and families received motivational interviewing by doctors and educational modules targeting television viewing and intakes of fast food and sugar-sweetened beverages. The intervention lasted for one year, where participants attended four in-person clinician visits and two phone calls. The maintenance period required two in-person clinician visits.
Comparator	Usual care.
Results/outcomes	BMI mean change at two-years: • +1.11 intervention vs. +1.22 control; adjusted mean difference -0.08 (95% CI -0.53 to +0.36) BMI z-score mean change: • -0.20 intervention vs. -0.18 control; adjusted mean difference -0.04 (95% CI -0.14 to +0.06)

	Additionally no change in TV viewing, sugar-sweetened beverage or fast food consumption. Analyses adjusted for child age, gender, ethnicity, baseline weight status, parent education, household income and time from baseline to follow-up. No subgroup differences in outcomes.
Comments	No meaningful improvements in weight or obesity-related behaviours at two years. Low adherence to maintenance, reasons unclear. Only two sessions, dose may have been insufficient. May be limited applicability in terms of population or format of the intervention.

Appendix number	11
Relevant criteria	10
Publication details	Falconer CL, Park MH, Croker H, et al. The benefits and harms of providing parents with weight feedback as part of the national child measurement programme: a prospective cohort study. BMC public health. 2014;14:549.[23]
Study details	Prospective cohort participating in the UK NCMP in five primary care trusts, May 2010 to July 2011.
Study objectives	To assess the effects of NCMP feedback on parents and children, and whether this is influenced by participant characteristics
Inclusions	N=18,000 eligible participants in the five NCMP areas and receiving weight feedback.
Exclusions	None reported
Population	N=3,397 parents completed baseline questionnaire (18.9% of eligible population); 1,844 (54%) completing follow-up questionnaires included in analysis. 55.5% of the study population were in reception (age 4-5 years) The study population vs. the total eligible population contained significantly fewer numbers with overweight (9.7% vs. 12.5%) or obesity (5.7% vs. 9.6%; p<0.01), and the lowest deprivation classes (class 1: 19.1% vs. 20.3%, class 2 24.6 vs. 28.8; p<0.01). Participants also contained over-representation of White ethnicity (66% vs. 54.5%) and fewer of Asian, Black or other ethnicity (p<0.01).
Intervention/test	Written feedback provided to parents within 6 weeks of measurement. This included the child's BMI category (UK 1990 growth curves) and information about healthy lifestyles from the Department of Health's Change4Life campaign and local health and leisure services. Parents of obese children additionally

	received “proactive feedback” by telephone call from the school nurse. Self-report questionnaires were administered at baseline and at 1 and 6 months after weight feedback.
Comparator	NA
Results/outcomes	Before and after assessments:

- Parental knowledge of childhood overweight/obesity and of this as a health problem
- Child’s diet (scores given for consumption in food categories: fruit, vegetable, sugary drink, sweet and savoury snacks)
- Child’s physical activity (adequate ≥1 hour per day)
- Child’s daily screen time (appropriate ≤2 hours per day)

Follow-up:

- Whether parents had sought further information about their child’s weight (e.g. from GP, nurses, pharmacist, friends, family)
- Emotions parents experienced at feedback (e.g. surprised, guilty, upset, ashamed, judged, indifferent)

Parental perception and behaviours, difference in proportion (%, 95% CI) before and after feedback:

Outcome	Healthy and underweight (n=1574)	Overweight (n=180)	Obese (n=105)
Parental recognition of child’s overweight	NA	11.1 (4.0 to 18.3)*	23.5 (12.7 to 34.3)*
Parental understanding overweight health risk	NA	7.0 (1.4 to 12.6)*	5.0 (−6.9 to 16.9) ns
Child with healthy diet	−0.7 (−3.4 to 2.0) ns	−4.3 (−12.7 to 4.0) ns	0 (−10.6 to 10.6) ns
Child with adequate physical activity	1.0 (−1.6 to 3.6) ns	0.6 (−6.1 to 7.3) ns	12.6 (2.5 to 22.8)*
Child with appropriate screen time	−4.0 (−6.6 to −1.4)*	−6.3 (−14.2 to 17.3) ns	−9.9 (−20.6 to 0.8) ns
Weight-related teasing	NA	6.4 (−2.7 to 15.5) ns	4.8 (−25.6 to 16.0) ns
Low self esteem	NA	No data	5.0 (−26.8 to 16.8) ns

Parental perceptions and behaviours for overweight/obese children in Reception (age 4-5 specifically)

Outcome	Difference in proportion (%, 95% CI)
Parental recognition of child’s overweight	16.9 (9.3 to 24.5)*
Parental understanding overweight health risk	8.1 (1.2 to 15.1)*
Child with healthy diet	−10.5 (−18.9 to −2.1) (negative effect)

	Child with adequate physical activity | 5.9 (−1.5 to 13.4) ns Proactive feedback for obese children had no effect on any outcome compared with letter only. 84.4% preferred feedback by letter, only 3.0% by phone. More than a third informed their child was overweight or obese sought further feedback, mostly from friends/family (14.4%) and internet (9.9%) followed by GP (8.9%) or nurse (8.4%) 21% of parents of overweight and 24.1% of obese children felt upset at feedback vs. 0.5% of healthy weight Weight-related teasing and low self-esteem were more prevalent in obese children at all time points, with no effect of giving feedback. Overall shows improved parental understanding but limited effect on behaviours with the exception of physical activity in obese children.
Comments	Large UK population-based sample relevant to NCMP. However, not evaluating the effects of treatment specifically, and limited evaluation of potential harms of feedback to teasing, self-esteem and parental feelings. Potential for bias: low response rate and high drop-out, with weight and socioeconomic differences between those who participated and did not Self-reported lifestyle habits may also be inaccurate.

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