UK National Screening Committee

Screening for obesity in children of 7-11 years

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

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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
ASHFS	Australian Schools Health Fitness Survey
BAI	Body adiposity index
BIA	Bioelectrical impedance analysis
BMI	Body Mass Index
CDAH	Child Determinants of Adult Health
CDC	Center for Disease Control
CHD	Coronary heart disease
CI	Confidence interval
CVD	Cardiovascular disease
D_2O	Deuterium dilution method
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
NCDS	National Child Development Study
NC	Neck circumference
NCMP	National Child Measurement Programme
NGHS/PFS	National Growth and Health study/ Princeton Follow-up Study
NIR	Near-infrared interactance
NPV	Negative predictive value
PICO	Population, intervention, comparator, outcome
PPV	Positive predictive value

RCT	Randomised controlled trial
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 aged 7 to 11 can achieve this.

The UK National Screening Committee recommends that the NHS should not screen children 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 aged 7 to 11 years are about 4-5 times more likely to become overweight or obese as adults. .

Some long running studies suggest that 7 to 11 year olds with higher body may be more likely to develop diabetes. It's less clear whether there could be any links with other health problems like heart disease or high blood pressure. 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 it difficult to know if the results are reliable. They also looked at children born over 60 years ago when obesity was much less common.

The main test for obesity is measurement of body mass index (BMI) which uses height and weight. If a BMI measure indicates overweight or obesity this is likely to be correct. But the test would miss some children with excess body fat. There was a lack of information on why this might be.

Some studies suggest that other tests may be better than BMI but there were only a small number of studies. More research would help to confirm this finding, including looking at the feasibility of undertaking such measurements.

Interventions are available for overweight and obese children. These usually aim to increase physical activity and change diet. Sometimes they involve parents as well as children. These have resulted in small reductions in weight over a short period of time. But most studies have not followed children up beyond 12 months. 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.

Most studies that looked for harms from weight loss interventions did not find any. But neither did they find that treatment improved the child's health or quality of life.

Because of these reasons the conclusion of the review is that screening for obesity in children aged 7 to 11 should not be recommended.

Executive Summary

Purpose/aim of the review

This review aims to examine evidence for obesity screening in primary school children aged around 7 to 11 years. 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 of children at 5 years or younger. Six years was a bridging age between the two reviews. Children of 6 years were mostly considered alongside under-fives; though some studies have looked at children of 6 years alongside older children so have been covered by this 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 roughly from 7-11 years (including studies that went up to age 12). It aimed to clarify evidence on the natural history of obesity, 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 adolescents. A separate review looks at younger children.

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 uncertainties about obesity screening in this age group:

- There is consistent evidence from large prospective cohorts that child obesity aged 7-11 years increases risk of obesity in early adulthood by about 4-5 times. However, while child obesity may be a clear risk factor for adult obesity, the majority of obese adults will not have been obese children. It's estimated about 30% of obese adults would have been obese as children.
- Questions remain over prediction of adolescent or adult morbidity. Several large prospective cohorts found a moderate association between higher BMI at age 7-11 years and development of T2DM or metabolic syndrome in adulthood. There was no evidence for a link with hypertension, and that for coronary heart disease was weak. However, there are limitations to this evidence, including variable timing and method of assessment of both child adiposity and adult outcomes, and high risk of bias from attrition and confounding. Cohorts also commenced 30-90 years ago and may have limited relevance to child populations today.
- Meta-analysis has assessed the performance of overweight to obese BMI thresholds against a validated reference standard of adiposity in non-selected samples representative of the UK child population aged 7-11years. This data suggests that there would be few false positives from an overweight/obese BMI, but the negative likelihood ratio of the test is quite poor. Thus a BMI measure may not be sensitive enough as a reliable screen test and may miss some children with excess adiposity.
- There is limited evidence for the performance of non-BMI screening tests in this age group, but results generally suggest that, like BMI, specificity is better than sensitivity.
- No studies have directly assessed interventions in screen-detected populations. A large number of trials provide evidence that multicomponent behavioural interventions for overweight to obese children aged 7-11 and their families can give small but statistically significant improvements in BMI, though it's not clear if the changes were clinically meaningful. The optimal format or duration of these interventions is also unclear. There is some evidence that interventions with total contact time lasting over 26 hours are

beneficial (for example, one hour a week for 6 months), though results are inconsistent and conflicting across studies. There is also limited follow-up available beyond 12 months. It is unclear whether interventions would reduce risk of obesity and morbidity into adolescence or adulthood, or whether ongoing maintenance would be needed to sustain effects.

- There is no evidence that behavioural interventions are harmful, but neither any evidence that they improve health-related quality of life or self-esteem, or parent-child relationships. One small English study did report feelings of guilt and anger in parents receiving BMI test results. This was difficult to interpret in the context of the full range of reported outcomes and given the size of the study.
- No studies were available to inform whether child height influences the likelihood of child obesity persisting into 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
Based on the evidence included in this review the current UK NSC recommendation not to screen for obesity in childhood should be retained..

Further high quality studies need to address the uncertainties identified. Diagnostic studies would benefit from evaluating alternative non-BMI screening tests in this age group, for example the waist-to-height measure.

Randomised controlled trials or comparative studies need to establish the specific components of multicomponent interventions, intensity and duration of sessions, that are most effective.

They also need to follow children and their families to see whether treatment is associated with harms, and whether anthropomorphic effects are sustained and reduce the risk of health problems.

This external review has several limitations. It was a rapid review process 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) 2014 / 15 data reported that around a third of all children and adolescents aged 2 to 15 are overweight or obese.[1] The National Child Measurement Programme (NCMP) reported that, in the same period, almost 1 in 10 children aged 4 to 5 and almost 1 in 5 children aged 10 to 11 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 become obese adults, 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 7-11 age group.

Basis for current recommendation

The UK National Screening Committee (NSC) currently 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 11-year-old to be obese in early adulthood?)	1 SR, 1 primary study
	b) Does obesity in childhood predict the development of morbidity in adulthood, for example, hypertension and type 2 diabetes?	1 SR, 2 primary studies
	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?	1 SR
	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	3 SRs, 2 RCTs, plus 1 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 address obesity screening in children aged 7-11 years, though we allowed evidence in children up to age 12. A companion review assesses screening in children 6 years and under.

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 7-12 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, 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 7-12 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 studies.	Non-systematic reviews, papers only in non-English language, editorials and communications, grey literature and conference abstracts.

	characteristics.						
3) Treatment	Age 7-12 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 105 relevant to children aged 7-11 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 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 10-11 year-old to be obese in later adolescence 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 that followed primary school children aged 7-11 years with obesity (diagnosed by any measure) into later adolescence or adulthood and which tracked obesity or assessed morbidity outcomes. We would also look at systematic reviews of these studies. 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.

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. Twenty-eight 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] (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 obesity (by any measure) predicts obesity in later adolescence or adulthood. They analysed children by age band, and meta-analysed four cohorts assessing whether obesity in those aged 7 to 11 predicts obesity in adulthood. They also narratively report five additional studies that assessed the diagnostic accuracy of obesity aged 7-11 years for adolescent or adult obesity. This HTA provides the main source of evidence for this question.

We subsequently searched for relevant studies published after the 2013 search date of the Simmonds HTA. One prospective cohort met the inclusion criteria. Brann et al.[4] (2015) (Appendix 2) assess whether a BMI measure of obesity age 10 years (assessed by three different reference curves) is associated with obese BMI age 18 years.

Therefore one systematic review and one additional prospective cohort 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 analyse how child obesity tracked to obesity in later 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] (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 analysed studies by age band, and the predictive ability of the 7-11 year obesity measure is relevant to this review. They meta-analysed 5 cohorts assessing whether increased BMI age 7-11 predicts coronary heart disease (CHD) in adulthood, 3 cohorts looking at the association with stroke, and 2 cohorts looking at the association with each of type 2 diabetes, hypertension and breast cancer.

Simmonds also narratively discussed a selection of cohorts with variable characteristics that could not be meta-analysed and which look at associations between obesity (by BMI or other measure) and morbidity outcomes.

Two additional prospective cohorts were identified after the 2013 search date of the Simmonds HTA. Schmidt et al.[5] (2016) (Appendix 3) assess whether high waist circumference aged 7-15 was associated with risk of metabolic syndrome aged 30. Graves et al.[6] (2013) (Appendix 4) assess whether high waist-to-height ratio (WHtR) or overweight/obese BMI at mean age 7 was associated with cardiometabolic risk factors in later adolescence (age 15 years).

Therefore one systematic review and two prospective cohorts were included for this question. The analyses are presented in Table 4.

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

We did not identify any studies assessing 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[7]) 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[8]) 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 <7 years or ≥13 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
- Studies 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 in later adolescence or adulthood
- Studies purely reviewing the current prevalence of type 2 diabetes or metabolic syndrome in children
- 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 children aged 7-11 years predicts obesity in adolescence or adulthood

Study	Design	Setting	Participants in meta-analysis or study	Child assessment	Adolescent/adult follow-up	Child measure to predict later obesity
Simmonds et al. 2012[3] (Appendix 1)	Systematic review Search date 2013	4 prospective cohorts: Bogalusa study (1973 to 1996), US school measure NCDS study (1958 to 1991), UK community measure NGHS/PFS study (1986 1997), US school measure ASHFS study (1985 to 2005), Australia school measure	Bogalusa n=2392 NCDS n=11,407 NGHS/PFS n=1669 ASHFS n=4571	Obesity aged 7 to 11 years BMI ≥95th centile	Obesity aged ≥18 years (age range of 4 cohorts: 21-34) BMI ≥95th centile or >30 kg/m^2	Meta-analysis risk of being obese as an adult if obese at 7-11 years: • RR 4.86 (95% CI 4.29 to 5.51) Individual cohorts: • Bogalusa: RR 4.17 (95% CI 3.61 to 4.82) • NCDS: RR 4.93 (95% CI 4.37 to 5.57) • NGHS/PFS: RR 5.62 (95% CI 4.82 to 6.55) • ASHFS: RR 4.86 (95% CI 3.87 to 6.09) Studies looking at accuracy of an obesity measure age 7-11 obesity to predict adult obesity: • Sn 30%, Sp 98%
Brann et al. 2015[4] (Appendix 2)	Prospective birth cohort (Grow Up 1990)	Sweden, school measurements	n=4,235	Obese BMI at age 10 According to IOTF 2012, WHO 2007 or Swedish 2001 reference curves	Obese BMI (≥30) at age 18	Risk of obesity at 18 if obese at age 10 defined by 3 reference curves: • IOTF: RR 19.3 (95% CI 14.1 to 26.3) • WHO: RR 26.1 (95% CI 18.7 to 36.4) • Swedish: RR 26.5 (95% CI 18.6 to 37.8) Accuracy of child obesity to predict adult obesity according to 3 reference curves: • IOTF: Sn 29.0, Sp 99.8 • WHO: Sn 63.4, Sp 95.6 • Swedish: Sn 69.5, Sp 94.1

Abbreviations: ASHFS, Australian Schools Health Fitness Survey; BMI, body mass index; CI, confidence interval; IOTF, international obesity task force; NCDS, National Child Development; NGHS/PFS National Growth and Health study/ Princeton follow-up study; Sn, sensitivity; Sp, specificity; WHO, World Health Organisation

The four cohorts identified by the Simmonds et al. HTA[3] provide consistent evidence that obesity age 7-11 years is associated with increased risk of adult obesity. The meta-analysis, and each of the four individual cohorts, gave a statistically significant risk increase of around the same magnitude, suggesting that obese children have 4-5-fold risk of being obese adults. When Simmonds examined studies that had reported the accuracy of child obesity to predict adult obesity, they found that child obesity has very high specificity. This means that nearly all normal weight adults would also have been normal weight children (very few would have been obese children). However, sensitivity is very poor. Only 30% of obese adults will have been obese children. This suggests that while obese children are at clear risk of adult obesity, identifying obese children may only address a small proportion of obese adults. .

These prospective cohorts were all of good size including >1000 participants and from Western countries, which should be relevant to the UK. All data is applicable to the 7-11 year age group of interest. However, there are several limitations to the quality and applicability of the evidence.

High attrition rate is a common limitation. Despite the large sample size of the four cohorts, the participants included in the analysis represent in some cases only between a quarter and a half of the cohort who entered the study. There may be differences, including BMI, lifestyle and socioeconomic status, between those who completed all assessments and those unavailable for follow-up. As such, the prevalence of obesity among those not measured could be different, which may have altered analyses of the persistence of obesity had these measures been available. There is also the possibility that the risk associations are being influenced by health and lifestyle factors that have not been adjusted for in the analysis.

Additionally the cohorts commenced many decades ago. There are differences in terms of environmental and lifestyle factors between children today and those born 30 to 60 years ago. The prevalence of obesity differs today, as may the likelihood of child obesity persisting to older ages.

The Brann et al.[4] cohort which followed the Simmonds[3] review gives slightly different results. It still finds an increased risk association, but the magnitude of the risk increase is far greater with child obesity increasing risk of adult obesity by 19-27 times compared with 4-5 times risk in the Simmonds[3] meta-analysis. However, the timeframe is shorter looking at obesity age 10 to predict obesity age 18, rather than 7-11 years to 21-34 as in the review cohorts. Obesity may be more likely to persist over fewer years.

Despite the large cohort size, the number of obese 10-year-olds was also small, ranging from 88 using the IOTF definition to 335 using the more inclusive Swedish reference curve. Therefore the small numbers with obesity may reduce the reliability of these associations, as suggested by the wide confidence intervals. Looking instead at overweight (including obesity) to predict overweight (including obesity) at age 18 gave much larger sample size, and the risk associations were more conservative and reliable at around 6-fold risk increase (see Appendix 2).

Similar to the findings of the Simmonds[3] review, the low sensitivity suggests that identifying obese 10-year-olds identifies only a fraction of those who will be obese aged 18, particularly for the IOTF reference curve which defines fewer children as obese.

We did not identify any evidence tracking the persistence of obesity when using alternative non-BMI measures of adiposity.

Question 2: Child obesity predicting adult morbidity

Table 4: Prospective studies assessing whether obesity in children age 7-11 years predicts morbidity in later 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	Prospective cohorts in school or community setting: 5 for CHD (UK, Denmark and Finland) 3 for stroke (UK, Denmark and Finland) 2 for T2DM (UK and US) 2 for hypertension (UK and China) 2 for breast cancer (UK and Finland)	CHD, n=295,080 Stroke, n=130,333 T2DM, n=13,996 Hypertension, n=13,511 Breast cancer, n=9,273 NB: Estimates from individual study details; exact number in MA uncertain	Obesity aged 7 to 11 years BMI ≥95th centile	CHD, stroke, T2DM, breast cancer in adulthood (age range 27 to 73 years) Method of diagnostic confirmation not reported.	Meta-analysis of odds of adult morbidity with each standard deviation increase in child BMI: • CHD: OR 1.14 (95% CI 1.08 to 1.21) • T2DM: OR 1.78 (95% CI 1.51 to 2.10) • Stroke: OR 1.02 (95% CI 0.94 to 1.10) *ns* • Hypertension: OR 1.67 (95% CI 0.89 to 3.13) *ns* • Breast cancer: OR 0.90 (95% CI 0.77 to 1.05) *ns* (See Appendix 1 for individual cohort results) Summary of studies in this age group not included in meta-analyses: • CHD: 1 found a weak link • T2DM: 2 found weak links • Hypertension: 3 studies found increased odds with obese BMI and 2 studies with high WC • Metabolic syndrome: 3 studies found increased odds with overweight/obese BMI, and 1 study with high SFT, WC and WHR (See Appendix 1 for full details of these studies) Child obesity to predict adult morbidity: • Researchers report at best overweight/obese BMI has sensitivity of 40% for adult diabetes and 20% for CHD; prediction of these outcomes from obesity, specifically, rather than the combined BMI category, is said to be no better than chance
Schmidt et al. 2016[5] (Appendix 3)	Prospective cohort (CDAH) 1985-2004/06	Australia, clinic assessments	n=1792	Waist circumference age 7-15 years divided into highest, middle and lowest thirds of measurement	Metabolic syndrome at mean 31 years	Risk of adult metabolic syndrome compared to those in the lowest third of WC: Adjusted for age, gender, smoking, alcohol and socioeconomic status: • Middle third: RR 2.00 (95% CI 1.19 to 3.37) • Highest third: RR 3.32 (95% CI 2.05 to 5.37) Additionally adjusted for level of child fitness: • Middle third: RR 1.96 (95% CI 1.16 to 3.31) • Highest third: RR 3.00 (95% CI 1.85 to 4.89)

Graves et al. 2013[6] (Appendix 4)	Prospective birth cohort (ALSPAC) 1991/2	UK, clinic assessments	n=2710	Overweight/obese BMI (IOTF) and WHtR ≥0.5 at 7-9 years (median 7.4)	≥3 cardiometabolic risk factors at 15 years	Risk of adolescent cardiometabolic risk factors according to child measure: • Males WHtR ≥0.5: OR 4.6 (95% CI 2.6 to 8.1) • Males overweight/obese BMI: OR 3.6 (95% CI 2.2 to 5.8) • Females: both *ns* (ORs not given) Accuracy of WHtR ≥0.5 to predict adolescent cardiometabolic risk: • Males: Sn 21.1, Sp 94.7 • Females: Sn 17.0, Sp 91.4

Abbreviations: ALSPAC, Avon Longitudinal Study of Parents and Children; BMI, body mass index; CDAH, Childhood Determinants of Adult Health; CHD, coronary heart disease; CI, confidence interval; IOTF, international obesity task force; ns, non-significant; OR, odds ratio; RR, relative risk; SFT, skin fold thickness; Sn, sensitivity; Sp, specificity; T2DM, type 2 diabetes mellitus; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio

The Simmonds[3] systematic review identified a number of prospective cohorts assessing the association between obesity aged 7 to 11 years and adult morbidity. These meta-analyses find that high child BMI is associated with statistically significant increased risks of adult CHD and type 2 diabetes. However, the link with CHD was weak and suggests no meaningful association. There was no statistically significant association with stroke, hypertension or breast cancer.

However, with the exception of CHD, which was informed by 5 cohorts, the meta-analyses are based on the pooled results of 2 or 3 cohorts. Across all analyses, the results of the individual cohorts were inconsistent. For CHD only 2 of the 5 individual cohorts found a significant association. For diabetes, one cohort found a clearly significant link, while the other cohort was non-significant with very wide confidence intervals. For hypertension, the two individual cohorts had in fact both found significant associations but their results were so different that the confidence intervals did not overlap. This produced a pooled result with very wide confidence intervals which bridged 1.0. Overall this suggests uncertainty of effect.

A number of individual cohorts that could not be included in the meta-analyses also found links of variable magnitude between different measures of child obesity and CHD, diabetes, hypertension and metabolic syndrome.

There are several limitations to the body of evidence identified by Simmonds[3] which may account for the variability in findings.

The cohorts are large and on the whole relevant to Western countries. However, the inception of most was 60-90 years ago. As with obesity tracking, the definitions of child BMI, prevalence of child obesity and associated environmental, socioeconomic, health and lifestyle factors are likely to be different from children today. The attrition rate of these long-term cohorts is also high and there may be differences between those who do and do not attend later follow-up.

The age range of adult follow-up is also very wide, ranging from 27 to 73 years. The method of diagnostic confirmation of health outcomes is unclear. Self-reported diagnoses of CHD, stroke and T2DM may be less accurate than confirmation by medical records. There are also likely to be other health and lifestyle factors influencing the association with later morbidity and which the analysis was not adjusted for.

Overall these factors make it difficult to give a definite answer to whether child obesity directly increases risk of later morbidity.

Two cohorts identified after the Simmonds[3] review look at non-BMI measures of excess adiposity. Schmidt et al[5] provide evidence that high waist circumference at age 7-15 increases risk of metabolic syndrome at age 31 by about 2-3 times. This link was consistent even with additional adjustment for child cardiorespiratory fitness.

This is a good quality study of a relatively recent Australian cohort. It has strengths in that analyses were adjusted for several potential confounding factors, and also used a valid definition of metabolic syndrome. They study analysed thirds of waist circumference, rather than specific definitions of obesity, but this did allow large numbers of children in each group for comparison. The narrow confidence intervals suggest a clear association. However, attrition from the full potential cohort (n=8498) was very high, and those who could be contacted and attended all follow-up clinic assessments may have a different demographic to non-attenders.

The UK cohort by Graves et al.[6] has less applicability to the study question in that it is looking at a short time frame and prediction of cardiometabolic risk factors in adolescence from anthropomorphic measures at median 7.4 years. It also does not look at a specific definition of

obesity but primarily aims to assess the predictive ability of waist-to-height ratio of ≥0.5, a cut-off that was informed by prior studies suggesting this was linked with high cardiometabolic risk. It does though additionally include analysis of overweight/obese BMI.

It finds that both WHtR ≥0.5 and overweight/obese BMI at age 7.5 increased the risk of males having cardiometabolic risk factors in adolescence, though no link was found in females. There was a relatively high childhood prevalence of overweight/obese BMI (n=375) and high WHtR (n=185). However, only 104 male and 64 female adolescents had 3 or more cardiometabolic risk factors. The smaller number may possibly explain why a significant link was found in males but not females.

No studies were identified directly assessing whether child height has on influence on the likelihood of obesity persisting or predicting morbidity outcomes.

Addendum: Evidence available at the July 2017 update search

KQ1: Obesity tracking into adolescence and adulthood

No further studies identified.

KQ2: Obesity predicting morbidity in later childhood and adulthood

Potentially relevant studies are listed below, which further support the link between raised BMI at 7-11 years and adult type 2 diabetes and metabolic syndrome. Links with cardiovascular disease outcomes were very weak with no clear link with hypertension or blood pressure.

Study	Population	Exposure	Outcomes
Koskinen et al. 2017[9] 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 8-10 years: RR 2.49 (1.97 to 3.13) • High BMI at 11-13 years: RR 2.89 (2.38 to 3.51) Adult type 2 diabetes: • High BMI at 8-10 years: RR 3.52 (1.67 to 7.46) • High BMI at 11-13 years: RR 2.46 (1.35 to 4.50)
Ajala et al. 2017[10] Systematic review with meta-analysis of cohort studies assessing link between child obesity and adult CVD and impaired glucose control	N=18 studies, n=13 in MA	BMI measure at mean age 10 years	Child BMI tor predict adult: • Stroke or heart disease events: OR 1.04 (1.02 to 1.07) • Hypertension: OR 1.17 (95% CI 1.06 to 1.27): weakly predicted diastolic BP but not systolic
Umer et al. 2017[11] Systematic review with meta-analysis of cohort studies assessing link between child obesity	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

and adult blood pressure and cholesterol			

Summary: Criterion 2 Met for KQ1, Not met for KQ 2 & 3.

KQ1. Several large prospective cohorts provide consistent evidence that child obesity at age 7-11 years increases risk of obesity in early adulthood by about 4-5 times. Another study suggested that obesity at age 10 increases risk of obesity at age 18 to a much greater extent, though confidence in this risk association is limited by the small numbers meeting obesity criteria. Therefore most children who are obese between these ages will be obese adults. However, only 30% of obese adults will have been obese children. This means that treatment/preventative interventions targeted at obese children may have limited impact in tackling adult obesity.

KQ2. Considering adult morbidity, large prospective cohorts provide some evidence that higher BMI (though not specifically obesity) in 7-11 year-olds may increase risk of type 2 diabetes and metabolic syndrome. There was no association for hypertension or stroke, and links with CHD only just reached statistical significance. However, the individual cohorts assessing later obesity and morbidity outcomes are inconsistent in terms of their findings, age of child assessments and method of diagnosing adiposity, timing of adult assessments and outcome definitions, and carry risk of bias from attrition and confounding. This makes it difficult to have confidence in these findings.

Most cohorts assessing obesity tracking or prediction of morbidity, though representative of UK or Western countries, also commenced between 30 and 90 years ago and may have limited applicability to children today.

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 to direct future interventions. 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 NSC question therefore aimed to address these uncertainties and see whether new studies have been published since the Fayter et al[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 7-11 years.

We would also review any identified studies assessing the performance of possible alternative non-BMI screening tests, such as waist 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 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-seven were reviewed at full text.

The Simmonds et al.[3] 2015 HTA review (Appendix 5) 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] identified a total of 30 studies assessing the diagnostic accuracy of a BMI measure. 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.

An additional systematic review with meta-analysis on the diagnostic performance of BMI was identified (Javed et al. 2015[12]), but this was excluded for several reasons. The search date was early 2013, the same as the Simmonds [3] HTA review, 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 covered a range of reference standards including skinfold thickness (SFT) 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.

We reviewed any studies assessing BMI accuracy published after the Simmonds[3] 2013 search date. One potentially relevant study (Kim et al. 2014[13]) had assessed the performance of BMI (along with neck circumference) against a valid reference standard in the target age group. However, this was conducted as an ancillary study in 92 children (66% male) taking part in a research project to validate different accelerometers. Therefore this was excluded as it could be a small selective sample not representative of the general UK child population.

Therefore despite the lack of performance data specific to the diagnosis of obesity, the Simmonds[3] meta-analysis provided the best pooled evidence to date on the reliability of the BMI measure in children. The results of this meta-analysis are presented in Table 5.

Alternative non-BMI screen tests

The Simmonds et al.[3] review also identified studies assessing the performance of non-BMI screening tests for obesity. It did not pool these studies, but gave a narrative summary of their results. In the target age group of children aged 7-11 years Simmonds[3] analysed three studies assessing skinfold thickness, three assessing waist circumference, and one analysing waist-to-height ratio. These studies are summarised in Table 6.

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 bioelectrical impedance analysis (BIA). The first study of neck circumference (Kim et al. 2014[13]) was excluded for the reasons above. The second was a US study (Kabiri et al. 2015[14]) including 55 children (mean age 8) which aimed to assess the validity, test-retest reliability and diagnostic value of a potential new BIA scale (Tanita BF-689). This was excluded as this was an initial validity study in a small sample with uncertain applicability.

Therefore no additional studies of non-BMI screening tests met 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 excluded studies:

- Conducted exclusively in children <7 or ≥13 years, including mean age
- 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 or regions

Results

Table 5: Performance accuracy of a BMI measure to detect obesity

Study	Design	Included studies	Index test	Reference standard	Meta-analysis population	Sensitivity of BMI overweight/obesity threshold (95% CI)	Specificity of BMI overweight/obesity threshold (95% CI)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)
Simmonds et al. 2015[3] (Appendix 5)	Systematic review Search date 2013	N=30 studies assessing BMI. 11 using accepted BMI threshold and applicable to UK population pooled in meta-analysis	BMI cut-off ≥85% for overweight and ≥95% for obesity 2 studies each used UK90, CDC, IOTF, 1 WHO curve, remainder regional or unspecified	Multicomponent method, DEXA, deuterium dilution or densitometry. Of pooled studies: 9 used DEXA, 2 densitometry	Boys (8 studies)	77.8 (69.6 to 84.2)	93.4 (91.2 to 95.1)	11.8 (9.05 to 15.5)	0.238 (0.172 to 0.329)
					Girls (8 studies)	73.5 (61.4 to 82.8)	96.1 (92.8 to 97.9)	18.7 (11.07 to 31.5)	0.276 (0.186 to 0.408)
					Boys and girls* (10 studies)	75.5 (68.7 to 81.3)	94.7 (92.9 to 96.1)	14.4 (11.01 to 18.74)	0.258 (0.201 to 0.331)
					All children* (9 studies)	73.9 (64.2 to 81.8)	94.7 (92.2 to 96.4)	13.9 (10.02 to 19.24)	0.275 (0.199 to 0.381)

*Simmonds et al. conducted two analyses for boys and girls combined. The "boys and girls" analysis includes the separate data for boy and girl subgroups available from 9 studies, in addition to one study that assessed all children combined. The "all children" analysis excludes one of the studies that provided data for boys only, with no data for girls.

Table 6: Individual studies of performance accuracy of non-BMI measures to detect obesity including children aged 7-11 years

Study	Design	Individual studies	Population	Index test	Reference standard	Sensitivity (95% CI)	Specificity (95% CI)
Simmonds et al. 2015[3] (Appendix 5)	Systematic review Search date 2013	Himes (1989) (high quality)	n=159 boys, n=157 girls Age 8.4 to 19 (uncertain mean)	SFT >85th centile	underwater hydrostatic weighing >90th centile	Triceps SFT: boys 24 (8 to 45), girls 23 (10 to 40)	100 (99 to 100), girls 97 (93 to 99)
						Subscapular SFT: boys 38 (18 to 61), girls 30 (15 to 48)	boys 99 (97 to 100), girls 99 (96 to 100)
						Sum SFT: boys Sn 57 (35 to 78), girls Sn 80 (63 to 92)	boys 85 (78 to 90), girls 82 (75 to 88)
		Marshall (1991) (high quality)	n=540 age 7-14 (mean 10.9)	SFT >85th centile	hydrostatic weighing 20% body fat boys, 25% girls	Triceps SFT: 65.8 (NR)	94 (NR)
						Sum SFT: 86.8 (NR)	90.1 (NR)
		Mei (2006)	n=1196 age 5-18 (mean 12)	SFT >95th centile	DEXA >95th centile	Triceps SFT: 89.6 (NR)	93.2 (NR)
						Subscapular SFT: 89.6 (NR)	94 (NR)
		Reilly (2010)	n=7722 mean age 9.9	WC UK 1988 reference >95th centile	DEXA >90th centile	98 (96 to 99)	81 (80 to 82)
		Wickramasinghe (2009) (high quality)	n=282 age 5-15 (mean 9.8)	WC >98th centile	D_20 25% body fat boys, 30% girls	37 (30 to 45)	99 (95 to 100)
		Fujita (2011)	n=226 boys, n=196 girls mean age 10 years	WC cut-off 76.5 boys, 73 girls	DEXA >95th centile	100 (NR) both genders	97(NR) boys and 96 (NR) girls
				WHtR cut-off 0.519 boys and 0.499 girls	DEXA >95th centile	100 (NR) both genders	95 (NR) both genders

Abbreviations: CI, confidence interval; D_20, Deuterium dilution method; DEXA, Dual-energy X-ray absorptiometry; NR, not reported SFT, skin fold thickness; WC, waist circumference; WHtR, waist-to-height ratio

BMI measure

The Simmonds[3] meta-analysis suggests that BMI thresholds for overweight or obesity have good specificity, ranging from 89 to 100% across studies. The very high positive likelihood ratio indicates that a positive screening test result would reliably indicate overweight or obesity.

However, BMI has low sensitivity at around 75%, with values across the individual studies ranging from 23 to 96%. The negative likelihood ratios of around 0.25 to 0.275 indicate that a negative test (normal BMI) only decreases the likelihood of excess adiposity by a small amount. There may be a high false negative rate and some children with excess adiposity would be missed by the BMI test.

In terms of quantity and quality of this evidence, the Simmonds[3] HTA was a high quality review. It only included prospective population-based cohorts that had assessed BMI against a validated reference standard for diagnosing excess adiposity. However, of the 30 studies identified, only 11 had used the accepted BMI test thresholds (cut-off ≥85th centile for overweight and ≥95th for obesity) and were applicable to a UK population who would be eligible for screening. Therefore only these 11 studies could be pooled in meta-analysis.

The small subset of 11 studies had high heterogeneity. All studies had used a validated reference standard for diagnosing excess adiposity, but none had used the gold standard multicomponent method. DEXA was most commonly used and is considered to be less preferable as a reference standard. It's possible that an imperfect reference standard may lead to overestimation of both sensitivity and specificity. The details around its use, for example, the diagnostic threshold used and whether or not there was adjustment for age were also variably reported across the studies.

Only one of the pooled studies, and 8 of all studies identified by the review, were assessed to be high quality.

In terms of applicability to the key question, an important limitation is that the evidence does not specifically inform on the accuracy of an obese BMI measure at the ≥95th centile. All performance data refers to the lower threshold encompassing both overweight and obesity.

The meta-analysis also includes children and adolescents in general rather than specific to age. Eight of the 11 pooled studies encompassed the 7-11 age range, and therefore the studies should be generally applicable to the target age range. However, it is not certain how specific test performance results would be to a BMI measure at specific ages.

No studies were identified that directly evaluated the effect of height on BMI test performance.

Non-BMI screen tests

The Simmonds[3] review included six studies that assessed the diagnostic performance of non-BMI screening tests and encompassed the target population aged 7-11 years.

However, they provide a varied body of evidence and quite inconsistent results from which it is difficult to draw clear conclusions on test reliability.

The three studies that assessed skinfold thickness suggest that this measure, like BMI, has fairly poor sensitivity for identifying excess body fat but this varies from 23% to 89.6% across the studies. Specificity is generally good and varies from 90% to 100%. However, these studies are highly diverse in their sample size, specific child age, SFT measurement and threshold used (85th

or 95th centile), and reference standard and threshold used. These inconsistencies make it difficult to give an overall summary answer on the accuracy of SFT.

The three remaining studies all assessed waist circumference (WC). These studies again give contrasting results. Two suggest sensitivity of 98% and 100%, but the third was an outlying result at 37%. This latter study, however, had specificity of 99% which was similar to another study at 97%, while the third study had specificity of 81%. Again, these studies differed in sample size, WC cut-off used, reference standard and threshold used, making it difficult to be sure of the reliability of the measure.

One of these studies had also assessed waist to height ratio (WHtR) and found good very good sensitivity and specificity of WHtR cut-off of around 0.5 in 10-year olds. However, as this is only a single study, further evidence would be needed in this age group to confirm these findings.

Addendum: Evidence available at the July 2017 update search

No further primary studies were identified that assessed the performance of BMI or a non-BMI test against a validated reference standard of excess adiposity.

An additional systematic review publication by Simmonds et al. (2016)[15] was identified. This review is reported to form part of the 2013 HTA[3] and has the same search date and study inclusion criteria. For reasons unclear from the publication, it includes a different number of studies in meta-analysis from the HTA publication, and also gives separate and slightly different results for overweight and obese thresholds. These indicate obese BMI thresholds to have slightly improved sensitivity compared with those for overweight. Performance was similar for waist circumference but poorer for skinfold thickness.

Test performance reported by Simmonds et al. (2016):[15]

Index test	Studies in MA	Threshold	Sensitivity (95% CI)	Specificity (95% CI)
Body mass Index	N=22	Obese	81.9 (70.0 to 93.8)	96.0 (93.8 to 98.1)
		Overweight	76.3 (70.2 to 82.4)	92.1 (90.0 to 94.3)
Waist circumference	N=7	Obese	83.8 (61.2 to 100)	96.5 (92.1 to 100)
		Overweight	73.4 (58.6 to 88.1)	94.7 (91.1 to 98.4)
Skinfold thickness	N=7	Obese	72.5 (58.7 to 86.3)	93.7 (90.2 to 97.2)
		Overweight	78.0 (69.2 to 86.9)	90.3 (88.0 to 92.5)

Summary: Criterion 5 not met.

Meta-analysis has assessed the performance of overweight to obese BMI thresholds against a validated reference standard in non-selected samples representative of the UK child population.

The included studies predominantly cover the target 7-11 age range. They suggest that the BMI measure has good specificity so there would be few false positives from an overweight/obese BMI measure. However, the lower sensitivity would mean some children with excess adiposity would be missed.

Individual cohorts have assessed the performance of non-BMI screening tests in the target population. Three studies have each assessed skinfold thickness and waist circumference against a validated reference standard. However, these studies gave highly inconsistent results, and varied in the index test cut-off used, and reference standard and threshold used. Overall this makes it difficult to give clear summary conclusions of the reliability of these measures, but generally they suggest that, similar to BMI, specificity is better than sensitivity. A single study suggests that waist-to-height ratio has good accuracy in this age group. However, further study would be needed to confirm these findings.

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] 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..

The current review aimed to see whether there is evidence that interventions for obese children aged 7-11 years are safe and effective.

We looked 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 looked 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 the need for 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 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 (with or without family involvement) relevant to children aged 7-11. As individual children with obesity would be identified through a screening programme, we focused on individually-targeted treatments for 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 50 systematic reviews were acquired in full text.

The initial 2016 search did not retrieve any systematic reviews that were an exact match to the question of effectiveness of multicomponent interventions as recommended by NICE (combining dietary, activity and behavioural components) in obese children aged 7-11 years and/or their parents. Instead a total of 10 systematic reviews were selected that gave an overview of the evidence on the effectiveness of different interventions for overweight to obese children and which included those aged 7-11 years (though evidence was not specific to this age group).

The 2017 update search, however, identified a 2017 Cochrane review (Mead et al 2017[17], Appendix 6) that was an exact match to PICO assessing multicomponent behavioural interventions in overweight or obese children aged 6 to 11 years. This superseded the previous systematic reviews that had been selected for this key question, and now forms the core evidence base for this criterion. The findings of the Cochrane review are summarised in Table 7. The 10 systematic reviews published prior to July 2016 and retrieved from the initial search are now summarised in Appendix 12 of this report.

A USPSTF[18] evidence review was also identified. This review found no direct evidence available on the benefits and harms of screening children and adolescents for excess weight. It looked at trials examining the effect of behavioural interventions and medical treatment for overweight and obese children and adolescents aged 2-18. The Cochrane review was prioritised for the overall assessment of effect of behavioural interventions on weight outcomes as it focuses on the target age group. However, data from the USPSTF review was also relevant as it looked specifically at weight loss by number of contact hours.

One additional systematic review[19] also 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 benefit. This review is included for comparison, and both are also summarised in Table 7.

Two further systematic reviews were identified but were not selected for evidence extraction. Steele et al.[20] assessed quality of life change in the context of any intervention (behavioural, pharmacological or surgical) for obesity in children (age range 7-17 years). All relevant trials that reported QoL outcomes following behavioural interventions in the target 7-11 age group were included by the Cochrane review,[17] so this review was not prioritised for inclusion. A second review (Murray et al.[21]) analysed the effect of multicomponent interventions on self-esteem in adolescents aged 10-19 years, so was predominantly above the target age range. Trials of relevance in children up to the age of 12 years were again covered by the Cochrane review.[17]

The update search was reviewed for any relevant trials published after the Cochrane[17] review that had either assessed multicomponent obesity interventions in the target age group or had evaluated screen-detected populations.

No trials of screening programmes were identified. However, two additional RCTs of relevance were selected. Robertson et al. (2017)[22] evaluated the clinical effectiveness of a family-based intervention for obese children aged 6-11 years in the UK. Wilfley et al. (2017)[23] was a multicentre US study evaluating a maintenance intervention following completion of family-based treatment. These studies are also summarised in Table 7.

Reasons for exclusion of other trials included very specific interventions (for example, local North American programmes comparing different dietary content) or targeted populations (e.g. US low income/minority ethnic groups or rural populations) that were thought to have minimal relevance to the UK setting.

One UK prospective cohort[24] evaluated the effect of providing weight feedback through the NCMP, including the psychological effects on parents and children. Though not investigating the effect of obesity screening and intervention, this study was included given its applicability to the UK population. This study is summarised in Table 8 and Appendix 10.

Other reasons for exclusion were studies:

- Included only children aged <7 or >13, or with the majority age group in this bracket
- Excluding obese children
- Drug treatment (not licensed in <12s)
- 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
- 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
- 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 7: Multicomponent interventions for the treatment of overweight or obese children aged 7-11 years

Study	Design	Population/studies	Intervention	Comparator	Outcome (all mean difference, 95% CI)
Mead et al. 2017[17] (Appendix 6)	Systematic review of RCTs with meta-analysis Search July 2016	70 RCTs (n=8461), 55 pooled in MA Inclusion: Children age ≥6yrs and <12 years (mean 10) with overweight or obesity (variably defined) 38 trials included overweight to obese children, 27 obese only, 5 overweight only Trials mostly high income countries (6 UK)	64 trials multicomponent lifestyle intervention – with 49 including all elements of dietary physical activity, and/or behavioural (e.g. motivational interviewing) Intervention duration 10 days to 2 years. Duration of follow-up: ≥6 months	No intervention, usual care or concomitant therapy (given to both arms)	Multicomponent vs. control at 6-36 month follow-up • BMI: mean difference [MD] -0.53 kg/m^2 (95% CI -0.82 to -0.24) (24 trials, n=2785) • BMI z score: MD -0.06 units (95% CI -0.10 to -0.02) (37 trials, n=4019) • Body weight: MD -1.45 kg (95% CI -1.88 to -1.02) (17 trials, n=1774) • Serious adverse events: 2 per 1000 vs. 4 per 1000 (RR 0.57, 95% CI 0.17 to 1.93; 31 trials, n=4096) (no AEs reported by 28 trials, 16 unclear, 6 with events) No difference on secondary outcomes: • Caregiver-reported QoL (PedsQL): SMD +0.13 units (95% CI -0.06 to +0.32) (5 trials, n=718) • Child-reported QoL (PedsQL): SMD +0.15 units (95% CI -0.34 to +0.64) (3 trials, n=164) • Self-esteem (Harter global score): MD +0.19 (95% CI -0.04 to +0.42) (2 trials, n=144)
USPSTF evidence review 2017[18] (Appendix 7)	Systematic review of RCTs with meta-analysis Search Jan 2016 with surveillance to Dec 2016	42 RCTs (n=6956) of behavioural interventions Inclusion: trials relevant to healthcare settings and assessing benefits/harms of weight-loss interventions in overweight or obese children aged 2-18 years from middle-high income countries. Most relevant to primary school children or adolecents.	Behavioural interventions. Contact hours ranged from 0.25 to 122 hours delivered over 2.25 to 24 months. All included trials had assessed an outcome at ≥6 months follow-up	Usual care, no intervention, waitlist, attention control, or minimal intervention.	Effect on BMI by estimated contact hours (standardised mean difference in change from baseline): • ≥52 hours: -1.10 (95% CI -1.30 to -0.89), n=6 trials, I^2=43% • 26-51 hours: -0.34 (95% CI -0.52 to -0.16), n=9 trials, I^2=24% • 6-25 hours: -0.02 (95% CI -0.25 to +0.21), n=7 trials, I^2=37% • 0-5 hours: -0.17 (95% CI -0.25 to -0.08), n=14 trials, I^2=0%
Heerman et al. 2017[19] (Appendix 8)	Systematic review of RCTs with meta-regression	258 RCTs, 133 included in meta-regression. All trials including overweight to obese children aged 2-18	Behavioural change interventions, 82% including parent/family members.	NA	• Median Hedges' g effect size -0.25 (small decrease in weight outcome) with significant heterogeneity (I^2 97%) • 56% of studies demonstrated decrease in

	Search data June 2017	years (39% 2-11). 46% in clinic/university settings, 22% school/community, 32% other combination.	Mean intended contact time 27.7 hours. Mean intervention duration 26 weeks.		standardised weight outcome, 40% no significant change, 4% increase in weight outcome • No relationship between standardised effect size and total contact hours (p=0.79), duration of intervention (p=0.44) or their interaction
Robertson et al. 2017[22] (Appendix 9)	Randomised controlled trial conducted in 3 UK sites, March 2012 to Feb 2014	N=115 families including 128 overweight (≥91st centile) or obese (≥98th centile) children aged 6-11 years. Mean age 9.4 years, 83% obese.	'Families for Health' child-parent behavioural intervention promoting lifestyle change, parenting skills, child emotional and social development. 12 sessions over 12 months	Usual care which differed across the 3 sites and centred on family-based interventions.	No effect of intervention on BMI z score at 12 months: • Between group difference: +0.114 (95% CI -0.001 to +0.229, p=0.053 • Within groups significant reduction in the usual care arm (-0.118, 95% CI -0.203 to -0.034, p=0.007) vs. no change with intervention (-0.005, 95% CI -0.085 to +0.078, p=0.907). • No effect on secondary outcomes including WC, % body fat, lifestyle, child or parent-reported QoL, parent mental health or parent-child relationship – with exception of improved parental activity in usual care group only • Greater attendance ≥1 session in the intervention than usual care arm (75% vs. 41%, p=0.001)
Wilfley et al. 2017[23] (Appendix 10)	Randomised controlled trial conducted in 2 US academic sites, Dec 2009 to March 2013 Investigating effect of enhanced maintenance after family-based intervention	N=172 randomised to maintenance following 4 month intervention (n=241 in primary study) Children aged 7-11 years with overweight or obesity (BMI ≥85th centile) and at least one overweight parent. Mean age 9.4 years, 90% obese or severely obese.	Enhanced social facilitation maintenance plus (SFM+): High dose: 32 weekly sessions + more intervention contact; or Low dose: 16 alternate weekly sessions	Education-only control: 16 alternate weekly sessions but without SFM+ content	Change from end of intervention (month 4) to end of maintenance (12 months). Between-group difference in % above the overweight threshold on CDC curve: • High vs Control: -6.71 (95% CI -9.57 to -3.84), p<0.001 • Low vs Control: -3.34 (95% CI -6.21 to -0.47), p=0.02 • High vs Low: -3.37 (95% CI -6.15 to -0.59), p=0.02

Table 8: NCMP weight feedback evaluation

Study	Population	Intervention	Comparator	Results
Falconer et al. 2014[24] (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 recognition increase by 23.5% after feedback, overweight recognition increased by 11.1% • parental recognition of health risks: obese no significant effect, overweight +7% • children with recommended physical activity: obese +12.6%, overweight no significant effect • no effect on healthy diet or screen time • no effect on weight-related teasing or self-esteem Children age 10-11 specifically (overweight and obese groups combined) : • parental recognition of child's weight: +14.6% • parental recognition of health risks: no significant effect • no effect on child physical activity, healthy diet or screen time • no effect on weight-related teasing or self-esteem 21% of parents of overweight and 24% of parents of obese children reported feeling upset about feedback. 15% of parents of overweight/obese children reported guilt at feedback and 15% reported anger.

The Cochrane[17] review is high quality and incorporates a large body of evidence specific to the target age group of interest. Few trials are UK-based but most are applicable to Western populations. It shows that multicomponent interventions incorporating dietary, physical activity and behavioural components can achieve small but statistically significant reductions in BMI, BMI z score (which shows how many standard deviations a child's BMI deviates from the norm for their age and gender) and weight loss in overweight to obese children. They also show that these can be maintained in the short to medium-term from six months to up to three years follow-up. Though it's difficult to know whether this was following cessation of the intervention (intervention duration varied widely across studies from 10 days to 2 years).

There are a number of other limitations to set this in context. Despite the large number of trials, the review categorised the overall quality of evidence as low to very low across outcomes and most studies had high risk of bias related to blinding and incomplete or selective outcome reporting.

There was no evidence specific to the treatment of children identified through screening programmes. Settings vary widely from primary and secondary care to community and academic settings which may have limited applicability to identification through a screening programme.

The trials also vary widely in their methods. The interventions, their specific components and their duration differ, making it difficult to assess the most effective dose or delivery format. The growth charts used to define weight status varied and the included populations ranged from overweight to severely obese. All analyses include overweight to obese so there is no data specific to the effect of interventions in obese children.

The BMI reduction compared with control is statistically significant but whether the difference would have meaningful clinical effect is unclear and was not reported by the studies. There is no evidence that effects would be sustained in the long term or whether regular maintenance would be needed. Whether interventions could reduce risk of cardiometabolic morbidity such as type 2 diabetes or hypertension is also unclear.

Mead et al.[17] carried out subgroup analyses to try and explain the heterogeneity in results across studies and found no effect of intervention type or duration, or baseline BMI. Nevertheless, children with obesity may be harder to treat or face more challenges than those who are overweight, and may benefit from different approaches. Approaches may also need to differ depending on sociodemographic, ethnic or cultural differences. It is not possible to assess these possibilities from this evidence.

The USPSTF[18] and Heerman et al.[19] reviews assessing the effect of duration or contact time of behavioural interventions (children of any age) have inconsistent findings. The USPSTF review found the greatest effect for behavioural interventions lasting in total ≥52 hours. All 6 of these trials showed a benefit with BMI z score reduction of around 0.2 in the intervention group with minimal change in controls. As an indication of what this means, a BMI z score of +1 would be the difference between normal and overweight reference ranges; +2 between normal and obese ranged. However, most trials assessed interventions of lower contact time, with wide ranging results. In general the review found that interventions lasting >26 hours in total (for example, an hour a week for six months) were effective, but the findings were inconsistent as 0-5 hours was also associated with a small effect.

Heerman et al. also found that behavioural interventions have a small effect on reducing weight outcomes, but by contrast they found no relationship between the effect size and intervention duration/contact time.

Both reviews caution that their estimates of contact hours may be inaccurate as most published trials lack adequate information on the received compared with prescribed dose or the contact time for certain modalities (e.g. calls, emails or web information). They also note the highly variable intervention format and settings and wide ranging effect sizes across trials. It may be that characteristics and circumstances of the individual child may influence the effect, where some children benefit from different approaches or treatment intensity from others. It is difficult to identify the moderating factors and be sure of an optimal format or duration with which to guide future behavioural interventions after screening detection.

The individual trials identified raise other questions. Robertson et al.[22] is a recent trial conducted across three UK sites, so should be applicable. This study found no evidence that 12 sessions of a multicomponent family-based intervention had any effect on child BMI over the course of 12 months. Notably, however, there was improvement in BMI the usual care arm. It is not possible to determine exactly what constituted usual care for obesity as it varied across UK centres. However, care provided to the control arm was noted to evolve throughout the course of the study, which may be because it was changing to address local population or even individual family needs. A more targeted approach could possibly explain the greater effect with usual care.

Wilfley et al.[23] look at the effect of maintenance following family-based interventions. However, though maintenance was effective compared with control, it is difficult to conclude that this single study provides evidence that maintenance helps to sustain effects. The intervention period only lasted for 4 months, with multicomponent maintenance extending to 12 months from baseline. It is hard to know how different this format could be from other multicomponent interventions where the whole intervention lasts for 12 months, such as the Robertson et al. trial.

Like many trials included by the systematic reviews there is little follow-up available beyond 12 months and so it is unknown whether interventions would reduce risk of obesity and morbidity into adolescence and adulthood. Overall much more remains to be understood about the optimal delivery format of multicomponent interventions for obese children and how to sustain effects.

Harms and quality of life effects

There is no evidence from the available studies that multicomponent interventions affect quality of life, in either a positive or negative way. The Cochrane[17] review finds no evidence that lifestyle interventions are associated with harms in this age group. A few studies reported on child quality of life or self-esteem. These found a suggestion that interventions may improve this, but the changes were not statistically significant. They were far from that required for a clinically meaningful change, for example improvement of over 4 points on the PedsQL.

The USPSTF[18] also concluded that only one of the seven trials assessing quality of life outcomes found an improvement. Of the two non-prioritised reviews (for reasons outlined in the above evidence description), Murray et al.[21] also found no evidence that multicomponent interventions improve self-esteem. Steele et al.[20] found that the effects on quality of life were related to the extent of BMI change, such that pharmacological or surgical interventions which yielded greater BMI change had stronger effects than behavioural interventions.

The Falconer et al.[24] analysis of the effect of obesity/overweight feedback to parents as part of the NCMP programme suggests that this has no effect on the child's self-esteem or teasing. The study also reported an improvement in parental recognition of their child's overweight and

obesity and one third of parents sought further information. However, the study reported a minimal effect on behaviour change amongst obese children and no change in overweight children. Feedback of results was associated with parents of overweight and obese children reporting feeling upset, guilty or angry, though this finding is difficult to interpret and further studies would be needed before conclusions could be drawn.

The UK-based trial,[22], found no evidence that the family-based intervention had any effect on child quality of life, parent-child relationships or parental wellbeing.

Summary: Criterion 10 not met.

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

A large number of trials provide evidence that multicomponent behavioural interventions for overweight to obese children aged 7-11 can give small but statistically significant improvements in BMI. The studies did not evaluate whether the level of weight loss was clinically meaningful.

The optimal format or duration of these interventions is less clear. One review finds that behavioural interventions with total contact time lasting over 26 hours are beneficial, though results are inconsistent across studies. Another review found no effect of contact time. Both reviews highlight difficulty in accurately quantifying the intervention format and contact time from the published literature. As such it is difficult to know what would be the best form of multicomponent treatment to deliver to obese children, particularly when children are identified through a screening programme.

There is also limited follow-up available beyond 12 months. It is unclear whether interventions would reduce risk of obesity and morbidity into adolescence or adulthood, or whether ongoing maintenance would be needed to sustain effects.

There is no evidence that interventions are harmful, but neither any evidence that they improve health-related quality of life or self-esteem, or parent-child relationships.

There was a lack of evidence on whether any particular child characteristics, such as height, have an influence on the effectiveness and harms of treatment.

Conclusions

Implications for policy

This review primarily aimed to assess obesity screening for children 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. This review considers screening for obesity in children aged 7-11 years. A separate review considers younger children aged less than 6 years.

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

- There is consistent evidence from several large prospective cohorts that child obesity at aged 7-11 years increases risk of obesity in early adulthood by about 4-5 times. Most obese children in these studies became obese adults. However, only a small proportion of obese adults will have been obese children. Therefore identifying and treating obese children may be of limited value for identifying all those who may be at risk in adulthood and reducing the overall prevalence of obesity.
- Questions remain over child obesity as a predictor of adolescent or adult morbidity. Several large prospective cohorts found a moderate association between higher BMI at age 7-11 years and development of T2DM or metabolic syndrome in adulthood. There was no evidence for a link with hypertension or stroke, and that for CHD only just reached statistical significance. However, there are limitations to this evidence, including variable timing and method of assessment of both child adiposity and adult outcomes, and high risk of bias from attrition and confounding. Cohorts also commenced 30-90 years ago and may have limited relevance to child populations today. This reduces confidence in the findings.
- Meta-analysis has assessed the performance of overweight to obese BMI thresholds against a validated reference standard of adiposity in non-selected samples representative of the UK child population aged 7-11 years. This data suggests that there would be few false positives from an overweight/obese BMI, but the negative likelihood ratio of the test is quite poor. Thus a BMI measure may not be sensitive enough as a reliable screening test and may miss some children with excess adiposity who may be at risk.
- There is limited evidence for the performance of non-BMI screening tests in this age group, but results generally suggest that, like BMI, specificity is better than sensitivity. A single study suggests that waist-to-height ratio has good accuracy in this age group, but this would need validating.
- No studies have directly assessed interventions in screen-detected populations. A large number of trials provide evidence that multicomponent behavioural interventions for overweight to obese children aged 7-11 and their families can give small but statistically significant improvements in BMI, though it's not clear if the changes were clinically

meaningful. The optimal format or duration of these interventions is also unclear. There is some evidence that interventions with total contact time lasting over 26 hours are beneficial (for example, one hour a week for 6 months), though results are inconsistent and conflicting across studies. There is also limited follow-up available beyond 12 months. It is unclear whether interventions would reduce risk of obesity and morbidity into adolescence or adulthood, or whether ongoing maintenance would be needed to sustain effects.

- There is no evidence that behavioural interventions are harmful, but neither any evidence that they improve health-related quality of life or self-esteem, or parent-child relationships.. One small UK study did report feelings of guilt and anger in parents receiving test results. This was difficult to interpret in the context of the full range of reported outcomes and given the size of the study.
- No studies are available to inform whether child height influences the likelihood of obesity persisting into 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 7-11 years. A separate review has assessed obesity screening in younger children <6 years.

Searching was limited to four bibliographic databases and did not include grey literature sources. 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 evidence team of the National Screening Committee secretariat. The search results were passed to Bazian Ltd. Wwo 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.

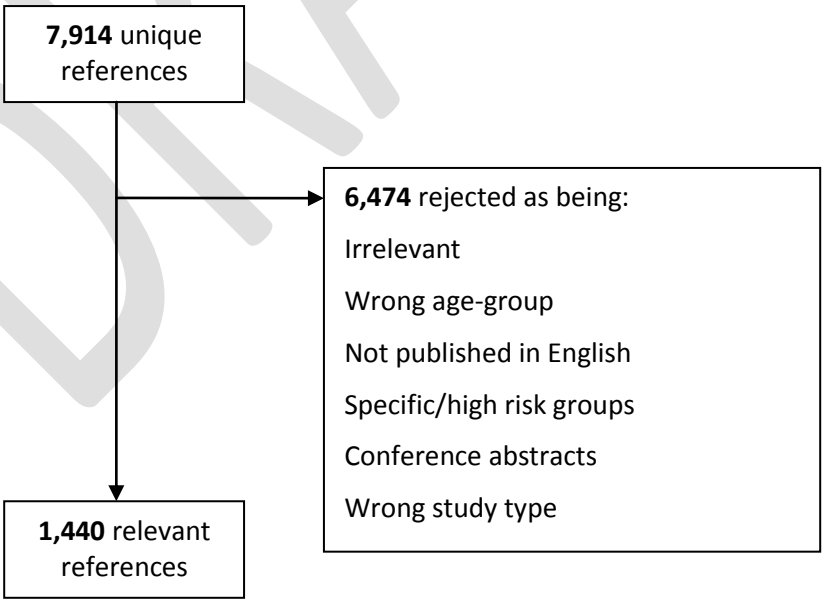
Inclusions and exclusions

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 (surgery/pharmacotherapy) (26) • Screening (18) • QoL/harms after interventions (35)	**556**
Total	**1440**

2017 Update search

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

DATES OF SEARCH: June 2016 – November 2017

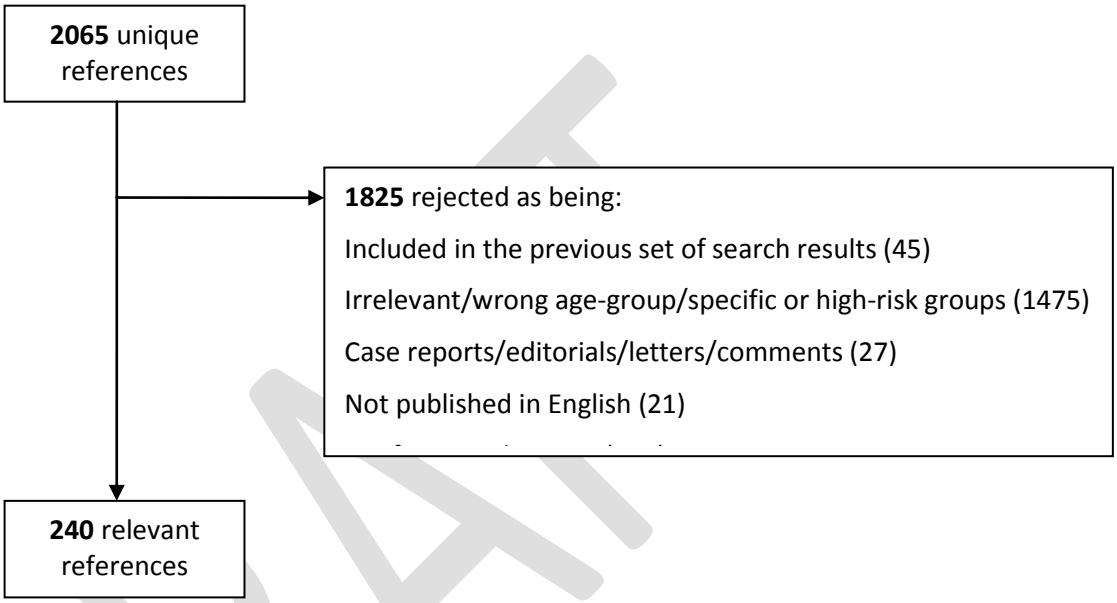
All searches carried out on 28 November 2017

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, D_2O, 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 June 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 systematic reviews including Singh (2008) and Brisbois (2012) reviews for (Q1), and the reviews by Park (2012), Reilly (2011), Lloyd (2010 and 2012), and Owen (2009) for adult morbidity (Q2). For Q1 on obesity tracking, database searching was restricted to between 2007 and 2013 only, as the Singh (2008) review formed the starting base for the review.
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 >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) <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.
Population	<u>Question 1</u> N=23 studies tracking child/adolescent obesity into adulthood. All studies assessed BMI, only 1 reviewed another measure. Studies that provided full diagnostic data were included in meta-analysis. Four studies included in the meta-analysis of childhood obesity (age 7-11) to predict adult obesity (>18 years): • Freedman (2005): Bogalusa study, USA, 1973 to 1996, school measure, n=2392 (recruited 11,411), assessed age 5-14, reassessed age 27 years, low risk of bias. • Power (1997): NCDS (National Child Development) 1958 UK birth cohort, 1958 to 1991, community measure, n=11,407 (recruited 17,733), assessed age 7-16, tracked to 33 years, moderate/uncertain risk attrition bias, otherwise low risk of bias. • Thompson (2007): NGHS/PFS (National Growth and Health study/ Princeton follow-up study cohort), USA, 1986 to 1997, school measure, n=1669 (recruited 1963), assessed 10-16 years, tracked to 21-23 years, moderate/uncertain risk attrition and outcome bias. • Venn (2007): ASHFS (Australian Schools Health Fitness Survey), Australia,

	1985 to 2005, school measure, n=4571(recruited 8498), assessed age 7-15, tracked to 24-34 years, moderate/uncertain risk attrition, prognostic factor and outcome bias and confounding. Three studies were reported to track child (7-11) to adolescent (12-18) obesity, but risk associations were not given in meta-analyses. <u>Question 2</u> N=37 studies assessing the association with adult morbidities All studies assessed BMI, 3 also assessed WC and one also looked at SFT and waist-to-hip ratio. 23 studies in total covered age 7-11. Those studies that could be converted into the risk association per 1 standard deviation increase in BMI were meta-analysed. Other individual studies were discussed narratively. Meta-analysed studies: • 5 cohorts included in meta-analysis for association with adult CHD (Boyd Orr, Copenhagen boys and girls, Helsinki 1924 and 1934) • 3 cohorts included in meta-analysis for association with adult stroke (Boyd Orr, Copenhagen girls, Helsinki 1934) • 2 cohorts included in meta-analysis for T2DM (NCDS 1958 UK birth cohort and NGHS/PFS) • 2 cohorts included in meta-analysis for hypertension (NCDS 1958 UK birth cohort and BCAMSS) • 2 cohorts included in meta-analysis for breast cancer (Helsinki 1924 and MRC NSHD) Characteristics of morbidity studies: • Gunnell 1998 (Boyd Orr study, 1937 to 1995), England and Scotland 1937 to 1995, n=2399 with follow-up (recruited not reported), age range 2-14, 49% male, unknown measurement setting, follow-up to 73 years of age. High risk of attrition bias, otherwise low risk of bias. • Jeffreys 2004 (Boyd Orr study, 1937 to 1995). England and Scotland 1937 to 1995, n=2347 (recruited 2997), age range 2-14, 49% male, unknown measurement setting, follow-up to 66 years of age. Unclear risk of selection and reporting bias. • Ahlgren 2004 (Copenhagen girls only), Denmark, 1930 to 2011, n=117,415 females (recruited 161,063), age 7-14, years school measurement setting, follow-up to unknown age. Unclear risk of attrition bias.

	• Baker 2007 (Copenhagen including boys), Denmark, 1930 to 2011, n=276,835 (recruited; follow-up not reported) age 7-13 years, 51% male, school measurement setting, follow-up to over 25 years. Low risk of bias. • Forsen 2000 (Helsinki 1924 study), Finland 1924 to 1997, n=7086 (recruited; follow-up not reported), age range 6-16, 51% male, school/outpatient setting, follow-up to age 31-73. Low risk of bias. • Barker 2002 (Helsinki 1934 study), Finland 1934 to 2003, n=8760 (recruited 10,519), age range 1-12, 53% male, school/outpatient setting, follow-up to age 27-63. Unclear risk of attrition and outcome bias. • Cheung 2004 (NCDS) 1958 UK birth cohort, 1958 to 2000, n=12,327 (recruited 17,000), assessed at 7, 11 and 16, 52% male, setting not reported, follow-up to 42 years. High risk of attrition, outcome bias and confounding. • Cheng 2011 (BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study), China 2004 to 2010, n=1184 (recruited 2189), age 6-16, 54% male, school setting, follow-up to 16 years. High risk of attrition, unclear risk of confounding. • De Stavola 2004 (MRC NSHD, Medical Research Council National Survey of Health and Development), UK 1946 to 1999, n=2187 females (recruited 2547), age range 2-15, school/community setting, follow-up to age 47-53. High risk of outcome bias.

Results	<u>Question 1</u>
	Individual cohort results for obesity age 7-11 (≥95th centile of BMI) to predict adult (>18 years) obesity (≥95th centile or >30 kg/m2):
	• **Meta-analysis: RR 4.86 (95% CI 4.29 to 5.51)**
	  ○ Freedman (2005): RR 4.17 (95% CI 3.61 to 4.82)
	  ○ Power (1997): RR 4.93 (95% CI 4.37 to 5.57)
	  ○ Thompson (2007): RR 5.62 (95% CI 4.82 to 6.55)
	  ○ Venn (2007): RR 4.86 (95% CI 3.87 to 6.09)
	A figure is given tracking child obesity with sensitivity plotted against specificity but quantitative figures are only given in the discussion. There is generally high specificity and low sensitivity. Specificity of 95% for adolescence and 98% for adulthood mean that nearly all non-obese adolescents or adults were also non-obese children. However, sensitivity was low and 70% of obese adults were not obese children.
	The figure includes three studies tracking child (7-11) to adolescent (12-18)

obesity, but no risk meta-analyses are given. The researchers report that childhood obesity tracks reasonably well to adolescent obesity but with lower sensitivity - 62% of obese adolescents being obese childhood. A high specificity of 95% indicates that nearly all non-obese adolescents were non-obese children.

Other studies not included in meta-analyses:

- One study (part of the NSCD UK birth cohort) was reported to find sensitivity of obesity age 11 for adult obesity (age 33) was low (21.9% in boys and 20.2% in girls), as was its sensitivity for adult overweight (23.3% in boys and 28.8% in girls). PPV for child obesity for adult overweight/obesity was 42-56%; NPV was 90%. AUC 0.78 for boys and 0.80 for girls
- Another study found obesity across all ages (3–18) had very low sensitivity (15.8%) but high specificity (97.9%) for adult (age 30–45 years) obesity.

<u>Question 2</u>

Meta-analyses of odds of adult morbidity with each standard deviation increase in BMI at age 7-11 years:

- **CHD: OR 1.14, 95% CI 1.08 to 1.21** (5 studies)
    - Boyd Orr: 1.27 (0.79 to 2.11)
    - Copenhagen boys : 1.19 (1.15 to 1.22)
    - Helsinki 1934: 1.02 (0.90 to 1.16)
    - Copenhagen girls: 1.12 (1.07 to 1.17)
    - Helsinki 1924: 1.26 (0.95 to 1.65)
- **Stroke: OR 1.02, 95% CI 0.94 to 1.10** (3 studies)
    - Boyd Orr: 1.00 (0.43 to 2.75)
    - Helsinki 1934: 1.95 (0.85 to 1.05)
    - Copenhagen girls: 1.05 (1.01 to 1.09)
- **Type 2 diabetes: OR 1.78 (95% CI 1.51 to 2.10)** (2 studies)
    - British birth cohort 1958: 1.78 (1.50 to 2.10)
    - NGHS/PFS: 1.86 (0.64 to 7.74)
- **Hypertension: OR 1.67 (95% CI 0.89 to 3.13)** (2 studies)
    - British birth cohort 1958: 1.22 (1.15 to 1.28)
    - BCAMSS: 2.32 (1.92 to 2.77)
- **Breast cancer: OR 0.90, 95% CI 0.77 to 1.05** (2 studies)

	○ Helsinki 1924: 0.91 (0.73 to 1.05) ○ MRC NSHD: 0.87 (0.64 to 1.18) Overall findings of additional studies with variable characteristics not included in meta-analyses and discussed narratively: • T2DM: one study found a trend for higher BMI at 11 years to be linked with T2DM in adulthood; another found a weak link with BMI <10 years. • CHD: one study found a weak between high BMI age 11 and CHD risk (per 1 standard deviation increase in BMI: HR 1.14, 95% CI 1.00 to 1.31 for boys and 1.35, 95% CI 1.02 to 1.78 for girls). • Hypertension: one study found higher odds of adult hypertension in children with obese BMI (OR 4.9, 95% CI 3.4 to 7.0) and waist circumference (OR of 3.9, 95% CI 2.8 to 5.3) age 11, another with obese BMI age 5-14 years (OR 4.39, 95% CI 1.83 to 9.72), one study with 10cm increase in waist circumference age 7-15 (RR 1.6, 95% CI 1.2 to 2.1 for girls and RR 1.2, 95% CI 1.0 to 1.4 in boys), and one study found significant link between BMI age 8-12 and hypertensive drug use in adulthood. • Metabolic syndrome: one study found a significant link between BMI at age 8 (OR 1.36, 95% CI 1.21 to 1.53) and 11 (OR 1.63, 95% CI 1.43 to 1.85) and metabolic syndrome at 26-33 years. One study found a link with three non-BMI measures at age 7-15: SFT in girls (RR 11.2, 95% CI 1.4 to 91.3), WC in boys (RR 4.8, 95% CI 2.5 to 9.2) and waist-hip ratio in girls (RR 4.6, 95% CI 1.5 to 14.1) and boys (RR 2.1, 95% CI 1.3 to 3.6). One study found a link with obese BMI age 5-14 and metabolic syndrome in adulthood (OR 4.62, 95% CI 2.81 to 7.45). Another study found a significant link for overweight BMI at ages 3-9 years (OR 3.0, 95% CI 2.0 to 4.7). ROC curve given for predicting future morbidity from BMI at age 7 to 11 which overall shows poor predictive power of BMI to predict morbidity (quantitative values not given). Researchers report that at best, 40% of adults with diabetes and 20% of those with CHD were overweight or obese children (≥85th centile of BMI). For obesity only (≥95th centile) the results are said to be no better than chance.
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. Majority representative of Western countries, and school setting. Average child age within 7-11 years, but specific

	ages varied so difficult to know how closely applies to the 10-11 year age group. Reference curves for BMI also differed. Clear association with obesity tracking, weaker associations with morbidity. With the exception of CHD there were few studies informing each meta-analysis for morbidity, some with considerable heterogeneity. Analyses for morbidity are also per SD increase rather than the association with obese BMI. The majority of cohorts for morbidity are inception prior to 1958 and so may have limited representation to children today in terms of sociodemographics, health and lifestyle. Adult follow-up times and ages varied, though most do not provide data above 40 years of age. Adult morbidity outcomes are unclear in terms of assessment and definition and may include self-reported morbidity rather than medical confirmation. High drop-out rate and outcome/reporting bias in some studies and unclear adjustment for confounders. Few studies used alternative non-BMI measures to provide reliable information on links with morbidity.

Appendix number	2
Relevant criteria	2
Publication details	Brann E, Sjoberg A, Chaplin JE, et al. Evaluating the predictive ability of childhood body mass index classification systems for overweight and obesity at 18 years. Scandinavian Journal of Public Health. 2015;43(8):802-9.[4]
Study details	Prospective birth cohort (Grow Up 1990), Gothenburg, Sweden. Follow-up collected 2008-09 when participants were 18 years
Study objectives	To demonstrate how the IOTF 2012, the WHO 2007 and the Swedish 2001 BMI classification systems, when applied to a population at age 10, predicted overweight and obesity at 18 years according to the adult BMI classification.
Inclusions	Final year school (12th grade) students with height and weight measurements between age 17.8 to 20.2 years (referred to as 18 years) who were also measured at 9-11 years (referred to as 10 years).
Exclusions	None reported
Analysis	At 10 years children were classified as overweight including obese (OwOb) or obese according to the IOTF 2012, the WHO 2007 and the Swedish 2001 BMI. At 18 students were classified as OwOb (BMI ≥25) or obese (BMI ≥30).

<table>
<tr><td>Population</td><td>n=4235 (n=2066 female) (original cohort size 5314)

At age 10: prevalence OwOb ranged from 17% (IOTF) to 27% (Swedish) across the 3 reference curves, and obese ranged from 2 to 8%.

At age 18: 17% were OwOb and 3% were obese according to BMI.</td></tr>
<tr><td>Results</td><td>Obese or OwOb at 10 years to predict obese or OwOb at 18 years (all children):

<table>
<tr><td></td><td colspan="3">Obese at 18 years (BMI)</td></tr>
<tr><td></td><td>IOTF 2012</td><td>WHO 2007</td><td>Swedish 2001</td></tr>
<tr><td>Obese at 10 years (n)</td><td>88</td><td>263</td><td>335</td></tr>
<tr><td>RR (95% CI)</td><td>19.3 (14.1 to 26.3)</td><td>26.1 (18.7 to 36.4)</td><td>26.5 (18.6 to 37.8)</td></tr>
<tr><td>Sensitivity (95% CI)</td><td>29.0 (21.1 to 36.8)</td><td>63.4 (55.1 to 71.6)</td><td>69.5 (61.6 to 77.4)</td></tr>
<tr><td>Specificity (95% CI)</td><td>99.8 (98.4 to 99.1)</td><td>95.6 (95.0 to 96.2)</td><td>94.1 (93.3 to 94.8)</td></tr>
<tr><td>+ Likelihood ratio</td><td>23.81</td><td>14.45</td><td>11.68</td></tr>
<tr><td>- Likelihood ratio</td><td>0.72</td><td>0.38</td><td>0.32</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">OwOb at 18 years (BMI)</td></tr>
<tr><td></td><td>IOTF 2012</td><td>WHO 2007</td><td>Swedish 2001</td></tr>
<tr><td>OwOb at 10 years (n)</td><td>709</td><td>1072</td><td>1150</td></tr>
<tr><td>RR (95% CI)</td><td>5.6 (5.0 to 6.4)</td><td>6.2 (5.4 to 7.2)</td><td>6.5 (5.6 to 7.5)</td></tr>
<tr><td>Sensitivity (95% CI)</td><td>53.1 (49.4 to 56.7)</td><td>67.9 (64.5 to 71.4)</td><td>70.6 (67.3 to 74)</td></tr>
<tr><td>Specificity (95% CI)</td><td>90.5 (89.5 to 91.5)</td><td>83.2 (82.0 to 84.4)</td><td>81.5 (80.2 to 82.8)</td></tr>
<tr><td>+ Likelihood ratio</td><td>5.59</td><td>4.04</td><td>3.82</td></tr>
<tr><td>- Likelihood ratio</td><td>0.52</td><td>0.39</td><td>0.36</td></tr>
</table>
</td></tr>
<tr><td>Comments</td><td>Prospective study with large sample size. Reduced confidence in prediction of obese-to-obese prediction due to smaller sample.

Relatively recent birth cohort and should be applicable to UK setting. Standardised school measurement at 18 years, but variable measurements at 10 years. Short duration of adolescent/adult follow-up to 18 years only.

However, primary aim of the study was to identify which reference curve to use when screening to detect high-risk children. Variability in results across reference curves highlight that BMI may be an imperfect measure of excess adiposity. IOTF has higher specificity and would give few false positives, but lower sensitivity to detect those with adiposity.</td></tr>
</table>

Appendix number	3
Relevant criteria	2
Publication details	Schmidt MD, Magnussen CG, Rees E, et al. Childhood fitness reduces the long-term cardiometabolic risks associated with childhood obesity. International Journal of Obesity. 2016;17:17.[5]
Study details	Prospective cohort (Childhood Determinants of Adult Health, CDAH), Australia.

	Child measurements 1985, follow-up May 2004-06.
Study objectives	To examine whether childhood cardiorespiratory fitness attenuates or modifies the long-term cardiometabolic risks associated with childhood obesity.
Inclusions	Children aged 7 to 15 years who participated in the Australian Schools Health and Fitness Survey (ASHFS) in 1985 and attended follow-up in May 2004-06 at age 26 to 36 years. Mean follow-up 19.9 years and mean age at follow-up 31.0 years
Exclusions	None reported
Population	N=1792 (938 male and 854 female) Original cohort of 8498, n=6840 (81%) could be located at follow-up and 5170 (61%) enrolled and provided follow-up data. 2410 attended one of 34 assessments clinics, and analysis restricted to 1792 who provided a fasting blood sample at the follow-up clinic and had waist circumference and cardiorespiratory fitness measured at both time points.
Analysis	Height and waist circumference measured at both time-points to the nearest 0.1cm and weight to nearest 0.5kg at baseline and the nearest 0.1kg at follow-up. Cardiorespiratory fitness in childhood was estimated by a 1.6 km (1 mile) run. At adult follow-up blood pressure, fasting glucose and insulin, high-density lipoprotein cholesterol and triglycerides were determined. Metabolic syndrome was determined using the 2009 consensus definition proposed by the International Diabetes Federation, National Heart, Lung and Blood Institute, and other international organisations as three or more of: • waist circumference ≥102 cm (men) or ≥88 cm (women); • raised blood pressure (systolic ≥130 mmHg or diastolic ≥85 mmHg or treatment of diagnosed hypertension); • high-density lipoprotein cholesterol <1.0 mmol/l (<40 mg/dl) in men or <1.29 mmol/l (<50 mg/dl) in women, or lipid treatment; • triglycerides ≥1.70 mmol/l (≥150 mg/dl) or drug treatment for elevated triglycerides; • fasting plasma glucose ≥5.6 mmol/l (≥100 mg/dl) or diabetes medication. Smoking, alcohol and socioeconomic status (determined by residence) were included as covariates.
Results	10.1% of males (n=95, reviewer calculated) and 4.0 % (n=34, reviewer calculated) of females with metabolic syndrome at follow-up. Childhood waist circumference: n=591 in lowest third, n=594 middle third, n=607

	highest third.
	
	Compared to lowest third of WC, higher WC increased risk of metabolic syndrome:
	• Adjusted for age and gender:
	  ○ Middle third: RR 2.00 (95% CI 1.19 to 3.37)
	  ○ Highest third: RR 3.32 (95% CI 2.05 to 5.37)
	• Additionally adjusted for level of child fitness:
	  ○ Middle third: RR 1.96 (95% CI 1.16 to 3.31)
	  ○ Highest third: RR 3.00 (95% CI 1.85 to 4.89)
	
	(Associations between fitness and metabolic syndrome not presented).

Comments	Primary aim to assess child fitness as a modifier of the association with metabolic syndrome. Small number of young adults with metabolic syndrome decreases confidence in associations. High attrition rate; those with full data may not be representative. Assesses association with high, middle, low waist circumference, rather than obesity. Australian birth cohort should be applicable to UK, but based on child assessments in 1985 which may not be representative of today.

Appendix number	4
Relevant criteria	2
Publication details	Graves L, Garnett SP, Cowell CT, et al. Waist-to-height ratio and cardiometabolic risk factors in adolescence: findings from a prospective birth cohort. Pediatric Obesity. 2014;9(5):327-38.[6]
Study details	Prospective birth cohort (Avon Longitudinal Study of Parents and Children, ALSPAC), UK. Recruitment of pregnant women 1991-92; child follow-up at 7-13 years then 2 years thereafter.
Study objectives	To examine the prospective association between WHtR assessed in childhood and cardiometabolic risk factors assessed in adolescence and also examine these associations in relevance to the respective associations with BMI. (Additional aim to look at the cross sectional association between WHtR and cardiometabolic risk factors in adolescents – not assessed here).
Inclusions	Children with waist circumference, height and serum lipid levels measured at the 15 year clinic. Those children with anthropomorphic also available at 7-9 years

	were included in the prospective analysis.
Exclusions	None reported.
Population	N=2710 children (median age 7.4 years) with full data for the prospective association with adolescence (age 15 years). (N=2858 included in the cross sectional adolescent association).
Analysis	Weight measured to the nearest 0.1kg and height to the nearest 1mm. Waist circumference was measured at the mid-point between the lower rib and the iliac crest to the nearest 1mm. At-risk WHtR was set at ≥0.5 which has been previously established to be linked with cardiometabolic risk. Overweight or obese BMI was based on IOTF criteria. Cardiometabolic risk at 15 defined as having three or more of: • triglycerides ≥1.7 mmol/l • HDL cholesterol <1.03 mmol/l • LDL cholesterol ≥2.79 mmol/l • plasma glucose ≥5.6 mmol/l • insulin ≥16.95 IU/l • blood pressure ≥130 mmHg systolic and ≥85 mmHg diastolic
Results	BMI and WHtR were significantly correlated but BMI identified more children as overweight/obese than WHtR: • Prevalence overweight and obese BMI was 13.8% in childhood (n=375) and 17.2% in adolescence (n=490). • Prevalence of WHtR ≥0.5 was 6.8% (n=185) in childhood and 17.2% in adolescence (n=492). • 91.9% of children with high WHtR also had overweight/obese BMI. • 45.1% with overweight/obese BMI also had high WHtR. • 69.2% of children with high WHtR in childhood also had high WHtR in adolescence. Prevalence of individual cardiometabolic risk factors in adolescents varied from 2.2% (n=62) for high diastolic blood pressure to 29.0% (n=806) for high systolic. Prevalence of co-occurrence (≥3 risk factors): 5.9% (n=168) overall, males 7.6% (n=104) and females 4.3% (n=64). Male children with WHtR ≥0.5 and overweight/obese BMI had increased risk of co-occurrence of risk factors in adolescence: • WHtR ≥0.5: OR 4.6 (95% CI 2.6 to 8.1) • Overweight/obese BMI: OR 3.6 (95% CI 2.2 to 5.8) Female children: both non-significant associations (ORs not given). Accuracy of WHtR ≥0.5:

	• Males: Sn 21.1 (95% CI 13.4 to 30.6), Sp 94.7 (95% CI 93.3 to 95.9) • Females: Sn 17.0 (95% CI 8.1 to 29.8), Sp 91.4 (95% CI 89.8 to 92.9) The optimal WHtR cut point for identifying co-occurrence of risk factors: • Males: 0.47 (Sn 37.9 [28.1 to 48.4], Sp 83.3 [81.0 to 85.3]) • Females: 0.44 (Sn 71.7 [57.7 to 83.2], Sp 54.4 [51.7 to 57.1])
Comments	Applicable to UK setting and reportedly the first to look at the prospective association between high WHtR in childhood and later cardiometabolic risk factors. 5% of the adolescent cohort lacked childhood data, and these children represent only half of the full ALSPAC cohort. May be greater drop-out among those at higher risk. Low numbers with overweight/obesity and high WHtR in childhood. Low numbers with ≥3 risk factors in adolescence. Low numbers of females may explain why CI did not reach statistical significance. WHtR was not specific definition of obesity. 0.5 was informed by previous studies to show increased cardiometabolic risk, but the most appropriate cut-off is not clear. This study suggests good specificity but very poor sensitivity.

Appendix number	5
Relevant criteria	5
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 Health Technology Assessment programme.
Study objectives	To investigate how accurately simple measures of obesity reflect actual adiposity in children.
Inclusions	Any diagnostic accuracy studies of obesity measurement in children that used one of the following validated reference standards to assess adiposity: • a multicomponent model measuring four or five components (considered the gold standard)

	• dual-energy X-ray absorptiometry (DEXA) • deuterium dilution (D_20), or • densitometry (underwater hydrostatic weighing or ADP) Additional inclusion criteria: • Studies including a population-based sample of overweight or obese children/adolescents ≤18 years • Child obesity measures could include any simple measures of BMI, NC, WC, WHR, WHtR, BAI, Ponderal Index, Benn's Index, FMI, SFT, BIA and NIR • Prospective diagnostic cohort studies that evaluated any of the tests against the reference standards • Outcomes giving summary estimates of diagnostic accuracy or sufficient data for this to be calculated Extensive databases searched including MEDLINE, EMBASE, PsycINFO and Cumulative Index to Nursing and Allied Health Literature (CINAHL) searched 2008 to 2013, supplemented by reference checking and citation searching. Searches used terms encompassing the key concepts of "obesity/adiposity", "children", "simple anthropometric measures" (index tests, specifically "BMI"), and "reference standards".
Exclusions	• Studies only carried out in children not overweight or obese • Studies not comparing against a validated reference standard
Population	Total 34 studies identified, 30 assessed BMI, 10 SFT, 7 WC, 4 WHR, 2 WHtR, 6 other. 11 studies using the accepted BMI threshold and representative of the UK population (regardless of reference standard) were pooled in meta-analysis. Age ranges covered by the individual studies: one study 3-18yrs; two 5-18yrs; two 8-19yrs; one 7-17yrs; one 13-18yrs; one mean 9; one mean 10; one mean 16; one study unclear age range.
Test	BMI cut-off ≥85 centile for overweight and ≥95 centile for obesity. Index tests included UK90 reference curves (2 studies), CDC (2 studies), IOTF (2 studies), WHO (1 study), AVENA (1 study), Goteborg, Sweden (1 study), not reported (2 studies) Alternative screen tests in this age group: 3 studies assessed SFT, 3 WC and 1 waist-to-height ratio

<table>
<tr><td>Comparator</td><td>A multicomponent model, dual-energy X-ray absorptiometry (DEXA), deuterium dilution or densitometry.

Of the meta-analysed studies all used DEXA (variably adjusted for age and ethnicity) and 2 used densitometry (air and water displacement, respectively). Thresholds varied depending on test.</td></tr>
<tr><td>Results</td><td>Of the 11 studies, sensitivity of BMI varied from 23% to 96% for diagnosing obesity and 19% to 94% for diagnosing overweight. Specificity ranged from 89.4% to 100% for diagnosing obesity and 82% to 100% for diagnosing overweight.

Data were given as 2 × 2 contingency tables for 8 overweight studies, 6 obesity studies, and not available for 2 studies. Pooled performance data was gathered from contingency tables.

8 studies separately analysed both gender subgroups, 1 study analysed boys only, and 1 study analysed all children (not separated by gender). The “boys and girls” analysis includes combined data from all studies. The “all children” analysis excluded data from the one study that reported results for boys only.

BMI threshold ≥85 centile cut-offs (overweight or obese) in non-selected populations to indicate adiposity:

<table>
<tr><th>Population</th><th>Studies (data set)</th><th>Sensitivity (95% CI)</th><th>Specificity (95% CI)</th><th>Positive LR (95% CI)</th><th>Negative LR (95% CI)</th></tr>
<tr><td>Boys</td><td>8 (19)</td><td>77.8 (69.6 to 84.2)</td><td>93.4 (91.2 to 95.1)</td><td>11.8 (9.05 to 15.5)</td><td>0.238 (0.172 to 0.329)</td></tr>
<tr><td>Girls</td><td>8 (18)</td><td>73.5 (61.4 to 82.8)</td><td>96.1 (92.8 to 97.9)</td><td>18.7 (11.07 to 31.5)</td><td>0.276 (0.186 to 0.408)</td></tr>
<tr><td>Boys and Girls</td><td>10 (38)</td><td>75.5 (68.7 to 81.3)</td><td>94.7 (92.9 to 96.1)</td><td>14.4 (11.01 to 18.74)</td><td>0.258 (0.201 to 0.331)</td></tr>
<tr><td>All children</td><td>9 (19)</td><td>73.9 (64.2 to 81.8)</td><td>94.7 (92.2 to 96.4)</td><td>13.9 (10.02 to 19.24)</td><td>0.275 (0.199 to 0.381)</td></tr>
</table>

Few false positives due to high specificity, but low sensitivity means that some with adiposity would be missed by BMI measure. Hence BMI is better at ruling out excess adiposity (better positive LR) than detecting it (poorer negative LR).

<u>Non-BMI screen test</u>

No meta-analysis provided for alternative screen tests. Results for individual studies that cover the target age group (≤12 years) and look at the accuracy for diagnosing obesity described below. Pooled data for all presented in preference; separate data by gender presented only when there is no combined data available.

Skinfold thickness</td></tr>
</table>

	• Himes et al. (1989) (high quality study), n=159 boys and n=157 girls, age 8.4 to 19, SFT >85th centile vs. underwater hydrostatic weighing 90th centile:
	  ○ Triceps SFT: boys sensitivity 24% (95% CI 8 to 45) specificity 100% (95% CI 99 to 100); girls Sn 23 (10 to 40) Sp 97 (93 to 99)
	  ○ Subscapular SFT: boys Sn 38 (18 to 61), Sp 99 (97 to 100); girls Sn 30 (15 to 48), Sp 99 (96 to 100)
	  ○ Sum SFT: boys Sn 57 (35 to 78), Sp 85 (78 to 90); girls Sn 80 (63 to 92), Sp 82 (75 to 88)
	• Marshall (1991) (high quality study), n=540, age 7-14 (mean 10.9), SFT >85th centile vs. hydrostatic weighing 20% body fat boys, 25% girls:
	  ○ Triceps SFT: Sn 65.8 (NR), Sp 94 (NR)
	  ○ Sum SFT: Sn 86.8 (NR), Sp 90.1 (NR)
	• Mei (2006), n=1196, age 5-18 (mean 12), SFT >95th centile vs. DEXA 95th centile:
	  ○ Triceps SFT: Sn 89.6 (NR), Sp 93.2 (NR)
	  ○ Subscapular SFT: Sn 89.6 (NR), Sp 94 (NR)
	Waist circumference
	• Reilly (2010), n=7722, mean age 9.9, WC UK 1988 reference 95th centile vs. DEXA 90th centile, Sn 98 (96 to 99), Sp 81 (80 to 82)
	• Wickramasinghe (2009) (high quality study), n=282, age 5-15 (mean 9.8), WC smallest between ribs and iliac crest 98th centile vs. D_20 25% body fat boys, 30% girls: Sn 37 (30 to 45), Sp 99 (95 to 100)
	• Fujita (2011), n=226 boys, n=196 girls, mean age 10 years, WC umbilical (cut-off 76.5 boys and 73 girls) vs. DEXA 95th centile: Sn 100 (NR) both genders, Sp 97(NR) boys and 96 (NR) girls
	Waist-to-height ratio
	• Fujita (2011), n=226 boys, n=196 girls, mean age 10 years, WC umbilical (cut-off 0.519 boys and 0.499 girls) vs. DEXA 95th centile: Sn 100 (NR), Sp 95(NR) both genders

Comments This was a high quality review with appropriate inclusion criteria to investigate whether a BMI measure in a nationally-representative child population is an appropriate indicator of overweight or obesity as measured against a validated reference standard. However, there were quality limitations of the	

included studies.

Despite larger number of studies only 11 assessing BMI were representative of the UK population and could be pooled in meta-analysis. The small subset of studies had high heterogeneity. Wide confidence intervals indicate the uncertainty. Covers the accuracy of BMI measures indicating overweight/obesity rather than obesity specifically. They pooled all ages, though most cover the 7-12 age group so should be generally applicable.

Simmonds et al. assessed each individual diagnostic accuracy study according to the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2). A summary of these findings is as follows:

Most studies assessed a single index test – BMI in 30 studies – which was adequately described.

However, threshold varied and many may not have been representative of the UK population. Only 11 studies using the standard threshold were pooled – but only one of these was assessed as high quality. The reference charts included IOTF, WHO, CDC and UK90 reference charts.

Only 2/34 studies used the gold standard multicomponent model. Most studies (24) used the least preferable reference standard of DEXA. The details of the reference standard were also quite poor making reproducibility difficult.

Only 8 of the studies overall were assessed to be of high quality – none that used DEXA as a reference standard and only 1 of the 11 pooled studies of BMI.

Time lag between index test and reference standard not thought to be of concern, with exception for 2 longitudinal studies where timing was unclear.

18/34 studies recruited consecutive or randomly selected children representative of the UK population and who would be eligible for the test in clinical practice. 13 studies didn't include representative populations, either of the UK or country of study; 1 was only representative of the study country; and 2 were unclear. However, all those in the meta-analysis were representative to country.

Withdrawals reported not to be a source of bias across studies.

Alternative non-BMI screen tests varied in index test and reference standard. Variable quality. Uncertainty whether the Himes study (8.4 to 19) has a mean age of the target age group.

Appendix number	6
Relevant criteria	10
Publication details	Mead E, Brown T, Rees K et al. Diet, physical activity and behavioural interventions for the treatment of overweight or obese children from the age of 6 to 11 years. Cochrane Database of Systematic Reviews 2017, Issue 6. Art. No.: CD012651. DOI: 10.1002/14651858.CD012651.[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 obese children aged 6-11 years.
Inclusions	RCTs including overweight or obese children with a mean trial age of ≥6 years and <12 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. Interventions may involve parents but parent-only interventions were excluded. Comparators could be no intervention, usual care or an alternative/concomitant therapy that was also delivered to the intervention arm. There was no minimum duration of intervention, but there had to be at least 6 months follow-up. Search on 14th July 2016 with no language restriction: Cochrane, Medline, Embase, PsycINFO, CINAHL, LILACS, WHO International Clinical Trials Registry, ClinicalTrials.gov.
Exclusions	Studies in children eating disorders, type 2 diabetes, or a secondary or syndromic cause of obesity.
Population	110 trials were identified, 20 of which are ongoing and 20 awaiting further assessment. 70 completed trials (n=8461) were included in qualitative synthesis and 55 in meta-analysis. Sample size ranged from 16 to 686. A total 38 studies included overweight or obese children, 27 only obese children, and 5 only overweight. Weight status was defined using the CDC 2000 growth charts in 31 studies, IOTF in 12, UK90 growth charts in 4, WHO in one study, with others using country-specific reference ranges. Median child age was 10 years and BMI z score 2.2. Nearly all studies were from higher income countries. 30 studies came from the US, 6 the UK, 5 Germany, 4 Australia, 3 each from Sweden, New Zealand and Spain, 2 each from Israel and Italy. Individual studies in Austria, Brazil, Canada, Denmark, Finland, Greece, Hong Kong, Iceland, Japan, Malaysia, Mexico and the Netherlands. Trials were published 1984 to 2016.
Intervention	Dietary, physical activity and/or behavioural. 64 trials were multicomponent and 49 included all three components, 4 assessed physical activity only and 2 diet only. Nearly all (65) included both the child and parent/caregiver. Duration of intervention varied from 10 days to 2 years. 25 were conducted in secondary care, 11 primary care, 7 university settings, 7 community, 4 in homes, 4 in schools, 10 mixed settings and 2 unclear.
Comparator	No intervention (21 studies), usual/standard care as defined by the authors (34 studies), or an alternative/concomitant therapy that was also delivered to the intervention arm (15 studies).

Results/outcomes	Primary outcomes: change in BMI/weight and adverse effects (both measured at baseline to at least 6 months) Mean difference in BMI (kg/m^2) at 6 to 36 months: • 0.53 lower (95% CI -0.82 to -0.24) with behavioural intervention than control (p=0.0004, I^2 =65%); low quality evidence from 24 studies (n=2785) Mean change in BMI z score at 6 to 36 months: • 0.06 units lower (95% CI -0.10 to -0.02) with behavioural intervention (p=0.001, I^2 =56%); low quality evidence from 37 studies (n=4019) Weight change (kg) at 6 to 36 months: • 1.45kg lower (95% CI -1.88 to -1.02) with behavioural intervention (p<0.00001, I^2=0%); low quality evidence from 17 studies (n=1774) Adverse effects at 0 to 36 months: • Poorly reported and had to be reviewed by contacting study authors: confirmed none reported in 28 trials, unclear in 16 and adverse events reported in 6. Two of 31 trials with data reported serious adverse events • No significant difference in serious adverse events reported across 31 trials (n=4096): 2 per 1000 with intervention vs. 4 per 1000 with control (RR 0.57, 95% CI 0.17 to 1.93, low quality evidence) • Adverse effects were various and did not seem related to the study intervention Secondary outcomes: • Low to very-low quality evidence that interventions had no effect on parent- or child-reported health-related quality of life: o Caregiver Pediatric Quality of Life Inventory (PedsQL) SMD 0.13 units higher with intervention (95% CI -0.06 to +0.32) where higher scores indicate improvement and 4.5 is a clinically important change (5 studies, n=718) o Child PedsQL SMD 0.15 units higher with intervention (95% CI -0.34 to +0.64) where 4.36 is a clinically important change (3 studies, n=164) o Self-esteem (Harter global score): MD 0.19 (95% CI -0.04 to +0.42) • There were no deaths and no trials reported on morbidity or socioeconomic effects, and few reported participant views of treatment Subgroup analyses to assess heterogeneity found no significant effect of

	intervention or comparator type, setting, parental involvement, baseline BMI, duration of follow-up or loss to follow-up.
Comments	High quality systematic review, with large population size, applicable age and of sufficient duration (>6 months) to assess the study question. Not exclusively in obese populations, and definitions varied. Wide variation of interventions, though most have included all components. High or unclear risk of bias across most trials related to lack of participant/assessor blinding and incomplete or selective outcomes reported. Small effects and low quality evidence for all outcomes. Unclear whether effects are maintained in the longer term without the intervention. Can't be sure on benefits in specific population group, for example by weight status, socioeconomic status or ethnicity.

Appendix number	7
Relevant criteria	10
Publication details	O'Connor EA, Evans CV, Burda BU, et al. Screening for Obesity and Intervention for Weight Management in Children and Adolescents: Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA. 2017;317(23):2427-44.[18]
Study details	Systematic review with meta-analysis
Study objectives	To systematically review the benefits and harms of screening and treatment or obesity and overweight in children and adolescents to inform the US Preventive Services Task Force recommendation.
Inclusions	Randomised controlled trials and non-randomised controlled trials that examined the benefits or harms of screening or weight management interventions (counselling, metformin, orlistat, and health care system-level approaches) in children and adolescents aged 2 to 18 years and which reported ≥1 weight outcome ≥6 months after randomisation. Included trials had to be conducted in economically developed countries, conducted in or recruited from healthcare settings and have a primary aim of reducing excess weight or maintaining previous reductions in excess weight. Weight management interventions could take place by telephone, virtual, community, or research settings as long as there was a connection to a health setting (e.g. recruitment from a health care setting). Trials were required to target individuals meeting the CDC or similar reference curve for overweight or obesity, those with previous excess weight or engaged in

	weight maintenance, or high-risk populations with a high proportion of youth with excess weight. This included studies where at least half the sample met the criteria for overweight or obesity and the study targeted a population with elevated risk of obesity. MEDLINE/PubMed, PsycINFO, Cochrane Central Register of Controlled Trials, PsycINFO and the Education Resources Information Center were searched to January 2016 with ongoing surveillance to December 2016.
Exclusions	Studies conducted in settings that were not generalisable to primary care (e.g. school classrooms or residential treatment facilities); with components that would not be feasible for an outpatient health care setting (e.g. interventions that provided most or all of the participants' food); studies limited to youth with an eating disorder, who were pregnant or postpartum, or had obesity secondary to a medical condition; those with an intellectual or developmental disability; non-English language studies.
Population	59 trials were eligible of which 42 (n=6956) examined relevant behavioural interventions (the remainder assessed orlistat and metformin which aren't reviewed here). 8 trials were good quality, the remainder fair. The majority of trials targeted primary school or adolescent children.
Intervention	Behavioural interventions that used counselling on diet, physical activity, or behaviour change management with the aim of reducing excess weight. Most were conducted in primary care (43%) or other healthcare settings (43%). Number of sessions ranged from 1 to 122, and contact hours ranged from 0.25 to 122 hours delivered over 2.25 to 24 months.
Comparator	Usual care, no intervention, waitlist, attention control, or minimal intervention (e.g. pamphlets or 1 to 2 brief sessions with no more than 60 minutes of total estimated direct contact).
Results/outcomes	Effect on BMI by estimated contact hours (standardised mean difference in change from baseline): • ≥52 hours: -1.10 (95% CI -1.30 to -0.89), n=6 trials, I^2=43% • 26-51 hours: -0.34 (95% CI -0.52 to -0.16), n=9 trials, I^2=24% • 6-25 hours: -0.02 (95% CI -0.25 to +0.21), n=7 trials, I^2=37% • 0-5 hours: -0.17 (95% CI -0.25 to -0.08), n=14 trials, I^2=0% Effect on cardiometabolic outcomes from trials with ≥52 hours (mean difference): • Systolic BP: -6.4 mmHg (95% CI -8.6 to -4.2), n=6 trials, I^2=51%

	• Diastolic BP: -4.0 (95% CI -5.6 to -2.5), n=6 trials, I^2=17% • No effect on lipids or blood glucose (n=4 trials) Only one of the seven trials assessing QoL outcomes found a significant effect (in favour of intervention). Five trials reported no differences in adverse effects between groups.
Comments	Largest effect seems to be trials ≥52 hours where all 6 trials showed a benefit with BMI z score reduction about >0.2 in the intervention group with minimal change in controls. Otherwise there was inconsistency across studies with a wide range of effects. Finds >26 hours in general effective though 0-5 hours also found to have small effect. Authors note imperfect estimate of contact hours with many studies lacking detail on planned and provided contact. Minimal follow-up of outcomes >12 months and little evidence on health outcomes.

Appendix number	8
Relevant criteria	10
Publication details	Heerman WJ, JaKa MM, Berge JM, et al. The dose of behavioral interventions to prevent and treat childhood obesity: a systematic review and meta-regression. The International Journal of Behavioral Nutrition and Physical Activity. 2017;14(1):157.[19]
Study details	Systematic review with meta-regression
Study objectives	To review the existing literature on behavioural interventions to prevent and treat childhood obesity and use quantitative methods to better understand how dose was related to outcome. It aimed to describe the distribution of dose in existing behavioural trials for childhood obesity in varied settings and use this to help guide those implementing future interventions as to the minimum dose necessary to achieve meaningful and sustainable improvements in childhood obesity.
Inclusions	RCTs of behavioural change interventions to treat or prevent obesity that included children aged 2-18 years and had sufficient data to calculate the main analytic variables of dose and a weight-related outcome (e.g. BMI z score). PubMed, Cumulative Index to Nursing and Allied Health Literature, PsycINFO and EMBASE databases searched for studies published from 1990 to June 2017. Data collected on age band (2-5, 6-11, 12-14, 15-18), intervention type (e.g. in-person, with additional materials), format (e.g. individual, group), settings (e.g.

	clinics, schools) and whether there was parental involvement.
Exclusions	Interventions targeted at pregnant women; children who were underweight; children hospitalised, in residential overnight camps, or in assisted living; pharmacologic or surgical interventions; prescribed diet or exercise interventions without a behaviour change component; interventions delivered only during the school day or community-wide interventions (where individual dose was not measured).
Population	258 studies met PICO inclusion criteria and 133 had sufficient data on dose and a calculable effect size to be included in meta-regression. Study characteristics: • 39% included 2-11 year-olds (n=52), 17% 12-18 years, and 44% other combination • 79% included overweight to obese (n=105), 21% normal and overweight or obese, none included normal weight only • 82% interventions included parents/other family members • 80% followed group format, remainder individual only • 57% in-person plus other format, the remainder in-person only • 46% were clinic/university settings, 22% school/community and 32% other combinations • Mean intended contact time 27.7 hours with median 18 hours • Mean intervention duration 26 weeks and median 17.3 weeks • Intervention duration 37% <3 months, 41% 3-6 months, 5% 6-9 months, 17% >9 months • 23% were low intensity (<10 hours), 49% medium (10-36 hours) and 28% high intensity (>36 hours)
Analysis	The primary effect was derived from pre- to post-treatment weight-related change in the intervention group only. SMD for each study were calculated to allow comparison across studies assessing different outcome measures. Data from the first follow-up with complete data was used. Random effects meta-regression was conducted to look at the relationship between total in-person contact hours, total duration and intervention group effect size. Covariates adjusted for: study year; intention-to-treat analysis; age group (2-11 vs. 12-18 years); intervention mode (multi-modality vs. in-person only); setting (school/community vs. multi-location vs. clinic/university); intervention format (group vs. individual/group or individual only); participants (parent or parent/child vs. child only); baseline weight status of child (normal + overweight or obese vs. overweight or obese only).
Results	• Median Hedges' g effect size -0.25 (small decrease in weight outcome) with significant heterogeneity (I^2 97%) • 56% of studies demonstrated decrease in standardised weight outcome, 40% no significant change, 4% increase in weight outcome

	No relationship between standardized effect size and: • total contact hours (coefficient 0.000, 95% CI -0.003 to 0.002, p=0.79) • duration of intervention (coefficient 0.001, 95% CI -0.002 to 0.003, p=0.44) • their interaction (coefficient 0.000, 95% CI 0.000 to 0.000, p=0.29) Additionally no effect of age, mode of treatment (in-person or plus other), format (individual or group), participants (child or parent/child), setting or publication date. The only factor of significance was that studies involving overweight and obese children only were more effective than preventative studies including normal weight (coefficient -0.277, 95% CI -0.425 to -0.130, p<0.001). Researchers conclude "This systematic review identified wide variation in the dose of behavioural interventions to prevent and treat paediatric obesity, but was unable to detect a clear relationship between dose and weight-related outcomes. There is insufficient evidence to provide quantitative guidance for future intervention development."
Comments	Large body of evidence and majority applicable to management of overweight/obese rather than prevention. Large variation in effect size. Likely that different intensity of treatment is required for different people which the study is not able to explore further. Wide variation in dose across trials making it difficult to unify doses across trials. Data available to quantify the extent of certain elements (e.g. calls, emails, web material). Also dose actually received was often unclear. Allocation concealment and participant and assessor blinding were the most likely sources of bias.

Appendix number	9
Relevant criteria	10
Publication details	Robertson W, Fleming J, Kamal A, et al. Randomised controlled trial evaluating the effectiveness and cost-effectiveness of 'families for health', a family-based childhood obesity treatment intervention delivered in a community setting for ages 6 to 11 years. Health technology assessment2017. p. i, 179.[22]
Study details	Randomised controlled trial conducted in three trial sites within primary care in West Midlands, UK. March 2012 to February 2014.
Study objectives	To assess the effectiveness and cost-effectiveness at 12 months of Families for Health: a family-based group intervention for the treatment of children aged 6-11

	years who are overweight or obese. This included effects on BMI z scores, as well as investigating parent and child views of the programme.
Inclusions	Families with at least one child aged 6–11 years who was overweight (≥91st centile BMI) or obese (≥98th centile BMI), where the child and at least one parent or guardian were willing to take part. Active child recruitment included those identified through the NCMP or referred from healthcare professionals, as well as community recruitment through advertising etc. and participant self-referral.
Exclusions	Metabolic or other recognised medical cause of obesity; child with severe learning difficulties and/or behavioural problems who would find it difficult to participate in a group-based programme; language barriers.
Population	N=115 families including 128 children (63 boys and 65 girls). 82.8% were obese and 17.2% overweight. Mean BMI z score 2.71 and BMI 25.9. Mean age 9.4 years. 61.7% white ethnicity. Higher socioeconomic status in the intervention arm (43% professional vs. 25%), otherwise baseline characteristics similar. 80% study retention at 3 months and 72% by 12 months with lower retention in the usual care arm (66% vs. 79% in intervention).
Intervention	N=56 families. The programme was run in a community venue by two facilitators with parallel groups for parents and children addressing lifestyle change, parenting skills, relationship skills, and emotional and social development. The programme followed the Medical Research Council's framework for complex interventions and followed a pre-post-test study in 27 children that showed improvement in BMI z score at 9 months. Total 10 sessions of 2.5 hours. Attendance of ≥5 intervention sessions was defined as completion. There were 2 follow-up sessions at 1 and 3 months after the intervention.
Comparator	N=59 families. The usual support for the treatment of childhood obesity provided within each NHS locality. This varied by site with site A group-based (family-based intervention), one-to-one support in site B (Change4Life), and either group-based or one-to-one support in site C (including a weight management programme, Weight Watchers or referral to the school nurse). Usual care was said to evolve from virtually nothing to reasonably high-level provision in the time between the pilot and the implementation of the trial.
Results/outcomes	Primary outcome change in child BMI z-score at 12 months: • No difference between groups: +0.114 (95% CI -0.001 to +0.229, p=0.053) • Within groups significant reduction in the usual care arm (z score -0.118, 95% CI -0.203 to -0.034, p=0.007) vs. no change in the intervention arm (-

	0.005, 95% CI -0.085 to +0.078, p=0.907). No effect on any secondary outcomes with the exception of parental activity in the usual care arm only. These outcomes included waist circumference; % body fat; physical activity; fruit and vegetable consumption; child health-related quality of life; parental BMI, mental well-being, diet (and activity), parent-child relationships and parenting style. Child-related QoL at 12 months: • change on child-reported PedsQL (total score): intervention group +2.131 (95% CI -1.830 to +6.092) vs. control +0.254 (95% CI -3.712 to +4.220), p=0.502 • change on parent-reported PedsQL (total score): intervention group +3.375 (95% CI -1.764 to +8.514) vs. control +3.997 (95% CI -1.536 to +9.530), p=0.868 • change on child-reported EQ-5D-Y: intervention -0.017 vs. control -0.040, p=0.667 • change on parent-reported EQ-5D-Y: intervention +0.012 vs. control +0.047, p=0.332 Parents' mental well-being change at 12 months (Warwick–Edinburgh Mental Well-Being scale): • +2.409 intervention vs. -2.167 control, p=0.06 Greater attendance in at least one session in the intervention than usual care arm (75% vs. 41%, p=0.001). Challenges of parents waiting >3 months to receive a session in the intervention arm. (Neither was the intervention cost effective).
Comments	Recent trial and highly relevant to the UK setting. Sufficient sample size with ITT analysis. Significant difference in sociodemographic between groups at baseline. Usual care had highly variable content across locations and may have evolved to meet local population needs or even individual family needs hence greater effect (even though low completion of usual care). These alone could be viewed as multicomponent interventions though hard to evaluate format and contact time. Could also suggest simply informing parents of child weight status may be effective component. Logistic difficulties in delivery of intervention.

Appendix number	10
Relevant criteria	10
Publication details	Wilfley DE, Saelens BE, Stein RI, et al. Dose, Content, and Mediators of Family-Based Treatment for Childhood Obesity: A Multisite Randomized Clinical Trial. JAMA pediatrics. 2017.[23]
Study details	Randomised controlled trial, maintenance following family-based treatment, 2 US centres December 2009 to March 2013.
Study objectives	To evaluate optimal dosing of maintenance following a 4 month family-based behavioural intervention. Trial compares a high or low intensity weight control intervention (enhanced social facilitation maintenance) with control on child body measures.
Inclusions	Children aged 7-11 years with overweight or obesity (BMI ≥85th centile) and at least 1 parent with overweight or obesity (BMI ≥25) recruited through media, advertisements, and physician referrals.
Exclusions	Use of other weight-loss treatment or weight-affecting medications or medical or mental health conditions affecting participation.
Population	N=241 entered family-based intervention trial (month 0) N=172 randomised to maintenance (month 4) N=160 (93%) completed 12 month assessment Baseline characteristics: mean age 9.4 years, 62% female, 63% white ethnicity, 10% overweight, 40% obese, 50% severely obese
Intervention	Enhanced social facilitation maintenance (SFM+): • high dose: 32 weekly sessions with educational materials in addition to the opportunity for more intervention contact to practice skills (n=59) • low dose: 16 sessions on alternative weeks. Same educational materials but no additional intervention contact (n=56) Both were delivered to in 30 minute family sessions with 45 minute separate parent/child sessions. Parents and children were also weighed at each session. The focus was on helping families establish a social and physical environment across all contexts of their lives to promote healthy behaviours and weight-control success. The original family-based intervention followed the same 30/45 min format delivered over 16 weekly sessions.
Comparator	Education-only control: 16 sessions on alternative weeks as low dose, and with total 75 minutes each session, but all of that was delivered in the group format with no weighing (n=57)
Results/outcomes	Primary outcome: percentage that the child's BMI was above the overweight

	threshold on the CDC 2000 reference curve. Between-group difference in % overweight change from 4 to 12 months: • High vs Control: -6.71 (95% CI -9.57 to -3.84), p<0.001 • Low vs Control: -3.34 (95% CI -6.21 to -0.47), p=0.02 • High vs Low: -3.37 (95% CI -6.15 to -0.59), p=0.02 Between-group difference in % achieving clinically meaningful weight loss (≥ 9 unit reduction in % overweight from 0 to 12 months): • High vs Control: 34% (95% CI 16 to 51), p<0.001 • Low vs Control: 16% (95% CI -3 to 35), p=0.10 • High vs Low: 18% (95% CI 1 to 34), p=0.03 Mediation analysis suggested that the benefits from SFM+ were due to continued monitoring and goal setting.
Comments	Adequately powered to detect differences at maintenance follow-up and ITT analysis. Shows that, following family-based intervention, an ongoing multicomponent weight control intervention with specialised content improves outcomes compared with an educational control. However, the 4 month intervention/8 month high intensity maintenance may be equivalent to a 12 month intervention. Difficulty in knowing how outcomes would change in the longer term. Hard to place compatibility with other interventions. Academic US setting may not be applicable.

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.[24]
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.

<table>
<tr><td>Exclusions</td><td>None reported</td></tr>
<tr><td>Population</td><td>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).</td></tr>
<tr><td>Intervention/test</td><td>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.</td></tr>
<tr><td>Comparator</td><td>NA</td></tr>
<tr><td>Results/outcomes</td><td>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:

<table>
<tr><td>Outcome</td><td>Healthy and underweight (n=1574)</td><td>Overweight (n=180)</td><td>Obese (n=105)</td></tr>
<tr><td>Parental recognition of child's overweight</td><td>NA</td><td>11.1 (4.0 to 18.3)*</td><td>23.5 (12.7 to 34.3)*</td></tr>
<tr><td>Parental understanding</td><td>NA</td><td>7.0 (1.4 to 12.6)*</td><td>5.0 (−6.9 to 16.9) ns</td></tr>
</table>
</td></tr>
</table>

	overweight health risk			
	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 Year 6 (age 10-11)

Outcome	Difference in proportion (%, 95% CI)
Parental recognition of child's overweight	14.6 (6.3 to 22.9)*
Parental understanding overweight health risk	4.4 (−3.3 to 12.1) ns
Child with healthy diet	4.6 (−4.0 to 13.2) ns
Child with adequate physical activity	4.3 (−3.2 to 11.8) 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. 15.4% of parents of overweight/obese children reported guilt and 14.8% anger.

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.

Appendix 12: Summary of systematic reviews published prior to July 2016 evaluating different interventions for the treatment of obesity and including children aged 7-11 years

Systematic review	Population	Intervention	Comparator	Outcome	Total RCTs	Results (95% CI)
Behavioural or lifestyle focus (individual or parent/family)						
Peirson et al. (2015)[25] Search 2008 to Aug 2013 (search date from last US Preventative Task Force search: relevant studies included)	Children aged 2-18 years with overweight or obesity (BMI >85th centile)	Behavioural (diet, exercise, lifestyle), drug or combined treatments (drug treatment not analysed here). All treatments had to be relevant for use in, or referral from, primary care in Canada. Specific eligible components of behaviour al interventions not specified.	No intervention, usual care, placebo or minimal intervention	BMI or z-score Adverse effects (Secondary cardio-metabolic outcomes not presented as unclear if the analysis includes drug studies).	N=28 (minus 2 orlistat studies) Mean age range 5-16 years Sample range 40-445 Duration 3-24 months	Behavioural treatment (listed as lifestyle +/- diet +/- exercise in any combination) **BMI or BMI z score** Overall: SMD -0.54 (–0.73 to –0.36) (28 studies; n=3346; I^2 85%; low quality evidence) Aged 2-12 years only: SMD -0.54 (–0.76 to –0.32) (22 studies; n=2612; I2 86%; low quality) <u>By study duration</u> ≤12 months: SMD –0.54 (–0.73 to –0.35) (25 studies; n=3056; I^2 84%; low quality) >12 months: SMD –0.53 (–1.31 to 0.26) *ns* (3 studies; n=290; I^2 90%; low quality) <u>By focus</u> Individual: SMD -0.90 (-1.27 to -0.53) (11 studies; n=1347; I^2 89%; moderate quality) Family-based: SMD -0.34 (-0.52 to -0.16) (17 studies; n=1999; I^2 73%; moderate quality) <u>Weight loss maintenance</u> End of intervention to 6-12 month follow-up: SMD 0.08 (-0.07 to 0.23) *ns* (4 studies; n=686; I^2 0%; low quality) **BMI change in kg/m^2** Overall: –1.15kg/m^2 (–1.59 to –0.72) (19 studies; n=2538; I^2 93%; moderate quality) **Adverse effects for behavioural** Any: Not estimable Serious: RR 0.51 (0.09 to 2.73) *ns* in favour of

						intervention (1 study, n=322, moderate quality)
Janicke et al. (2014)[26] Search to April 2013	Children aged ≤19 years with overweight or obesity (however defined)	Comprehensive behavioural family lifestyle interventions (including diet activity and behavioural components) conducted in community settings and focused on weight-loss	No intervention, usual care, waiting list, education control or treatment as usual	Change in BMI, z score, overweight or adiposity allowing calculation of effect size	N=20 studies N=1671 participants Age range 3-17 years Sample range 22-108 Duration 1-24 months	BMI z score: ES 0.47 (0.36 to 0.58) (small effect of intervention in reducing z score) (20 studies; n=1671; moderate quality evidence; significant heterogeneity)
Loveman et al. (2015)[27] Cochrane review Search March 2015	Children with mean age 5-11 years with overweight or obesity (any diagnosis)	Parent-only lifestyle intervention (single or multi-component diet, physical activity or behavioural intervention) aimed at child weight-loss	Parent-child, child only, usual care or alternative therapy also delivered in intervention arm	Change in BMI or body weight Adverse effects	N=20 studies N=3057 participants Sample range 15-645 Duration 6-24 months	BMI z score change <u>Parent-only vs. parent-child</u> At 10-24 months: MD -0.04 (-0.15 to 0.08) *ns* (3 studies; n=267; low quality evidence) <u>Parent-only vs. waiting list</u> At 10-12 months: MD -0.10 (-0.19 to -0.01) (2 studies; n=136; low quality) <u>Parent-only vs. minimal contact</u> At 9-12 months: MD 0.01 (-0.07 to 0.09) *ns* (1 study; n=165; low quality) Adverse effects: not reported
Education focus						
Sbruzzi et al. (2013)[28] Search to May 2012	Children aged 6-12 years with normal weight, overweight or obesity (only treatment interventions considered here)	Education interventions with duration ≥6 months for prevention or treatment of obesity (all treatment studies	Usual care or no treatment	Change in BMI or z score, weight, waist circumference or cardio-metabolic measures	N=8 treatment studies in overweight or obese children and/or their parents Sample range 70-192 Duration 6-12 months (N=26 studies overall,	Treatment studies only: BMI kg/m^2: MD -0.86 (-1.59 to -0.14) (5 studies; n=507; I^2 51; low quality) BMI z score: MD -0.06 (-0.16 to 0.03) *ns* (6 studies; n=546; I^2 37; very low quality) WC: MD -3.21 (-6.34 to -0.07)

		multicomponent family-based)			18 prevention)	(3 studies; n=380; I^2 72; very low quality) SBP: MD -3.74 (-8.04 to 0.56) *ns* (2 studies; n=308; I^2 74; very low quality) DBP: MD -3.68 (-5.48 to -1.88) (2 studies; n=308; I^2 0; moderate quality)
Focus on diet						
Ho et al. (2012)[29] Search Sept 2010	Children aged ≤18 years with overweight or obesity (not defined)	Lifestyle interventions including a dietary/nutrition component (including family-based) with duration ≥8 weeks	No treatment, usual care, waiting list, minimal advice or written diet and physical activity education materials.	BMI Cardio-metabolic measures	N=33 studies Sample range 22 to 259 participants Age range 3-18 years (studies sub-grouped by ≤12 and >12 years) Duration 8 weeks to 24 months	Meta-analyses in children aged ≤12 years <u>Lifestyle vs. no treatment/waiting list</u> BMI kg/m^2 (last follow-up): -1.00 (-1.91 to -0.08) (6 studies; n=699; I^2 96) BMI z score (<6 month): -0.31 (-0.39 to -0.22) (2 studies; n=148; I^2 0) BMI z score (>6 month): -0.09 (-0.17 to -0.02) (4 studies; n=279; I^2 0) <u>Lifestyle vs. usual care/minimal contact</u> BMI kg/m^2 (end treatment): -0.91 (-1.29 to -0.52) (3 studies; n=284; I^2 0) BMI kg/m^2 (last follow-up): -0.67 (-1.31 to -0.20) (2 studies; n=261; I^2 0) <u>Cardio-metabolic measures (all ages)</u> Triglycerides (mmol/l): -0.15 (-0.24 to -0.07) (5 studies; n=440; I^2 74) LDL cholesterol (mmol/l): -0.30 (-0.45 to -0.15) (4 studies; n=372; I^2 59) HDL cholesterol (mmol/l): 0.10 (-0.06 to 0.27) *ns* (4 studies; n=372; I^2 94) Fasting insulin (pmol/l): -55.14 (-71.23 to -39.05) (6 studies; n=410; I^2 0) SBP (mmHg): -3.40 (-5.19 to -1.61) (7 studies; n=554; I^2 80)

						DBP (mmHg): -1.78 (-2.88 to -0.67) (7 studies; n=554; I^2 62)
Ho et al. (2013)[30] Search 2010	Children aged ≤18 years with overweight or obesity (not defined)	Dietary intervention alone	Diet plus exercise or exercise only	BMI change	N=15 studies Age range 6-18 (10 studies in children ≤12) Sample range 20-165 participants Duration 6-24 weeks 9/15 studies used calorie restriction approach	Change in BMI: Diet + exercise (any) vs. diet only: MD 0.06 (-0.14 to 0.26) *ns* (9 studies; n=519; I^2 44) Diet + aerobic exercise vs. diet only: MD -0.24 (-0.62 to 0.14) *ns* (4 studies; n=109; I^2 52) Diet + resistance training vs. diet only: MD 0.40 (0.08 to 0.71) (favours diet only) (3 studies; n=178; I^2 0) Diet + resistance and aerobic training vs. diet only: MD -0.10 (-0.45 to 0.26) *ns* (3 studies; n=232; I^2 0)
Exercise-only interventions						
Kelley et al. (2015)[31] Search 1990 to Nov 2014	Children age 2-18 with overweight or obesity (however defined by authors)	Exercise as an isolated intervention lasting ≥4 weeks (aerobic, strength training or both)	No intervention, usual care, waiting list or attention control	Change in BMI in kg/m^2	N=20 studies N= 971 participants Mean age 12 (range 8-17), mean BMI 29 Sample range 15-204 Duration range 6-24 weeks, frequency 1-5 times a week. Mean 46 mins, 3 times per week, for 16 weeks	Mean change in BMI (kg/m^2): -1.08 (-1.64 to -0.52) (20 studies; n=971; I^2 91) Number needed to treat: 5
Kelley et al. (2014)[32] Search to Dec 2012	Children age 2-18 with overweight or obesity (however defined by authors)	Exercise as an isolated intervention lasting ≥4 weeks (aerobic, strength training or both)	No intervention, usual care, waiting list or attention control	Change in BMI z score (effect size)	N=10 studies N= 835 participants Mean age 11 (range 9-16), mean BMI 29	Change in BMI z score -0.06 (-0.09 to -0.03) (equivalent to 3% change in BMI z score) (10 studies; n=835; I^2 59.8)

					Sample range 20-322 Duration range 6-24 weeks, frequency 1-5 times a week Mean 43 mins, 4 times per week, for 16 weeks	Number needed to treat: 107
Garcia-Hermoso et al. (2013)[33] Search April 2013	Obese children ≤14 years (obesity not defined)	Exercise in isolation (aerobic or otherwise) with intervention ≥8 weeks	No exercise, diet, education or other intervention	Blood pressure or hypertension	N=9 studies N=410 participants Age range 7-15 years Duration 8-24 weeks, frequency 2-6 sessions per week	SBP:ES -0.4 (-0.66 to -0.24) (9 studies; I^2 27) DBP:ES -0.28 (-0.55 to 0.00) *ns* (7 studies; I^2 78)
Garcia-Hermoso et al. (2013)[34] Search Sept 2013	Obese children 6-18 years (obesity not defined)	Aerobic exercise in isolation	No exercise, diet, education or other intervention	Markers of insulin resistance	N=9 studies N=367 participants Age range 9-17 years Duration 6-36 weeks, frequency 3-6 sessions per week	<u>Studies in children 6-12 only</u> Fasting glucose: ES -0.25 (NR) *ns (p=0.2)* (2 studies; n=105; I^2 0) Insulin: ES -0.19 (NR) *ns (p=0.3)* (2 studies; n=117; I^2 0) <u>Overall MA</u> Fasting glucose: ES -0.39 (-0.68 to -0.14) (7 studies; I^2 19) Insulin: ES -0.40 (-0.63 to -0.17) (7 studies; I^2 0)

Abbreviations: CI, confidence interval; ES, effect size; MA, meta-analysis; MD, mean difference; NR, not reported; ns, non-significant; RR, relative risk; SMD, standardised mean difference; SBP, systolic blood pressure; WC, waist circumference

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