

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

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**National Institute for
Health Research**

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Abstract

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

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Background: It is uncertain which simple measures of childhood obesity are best for predicting future obesity-related health problems and the persistence of obesity into adolescence and adulthood.

Objectives: To investigate the ability of simple measures, such as body mass index (BMI), to predict the persistence of obesity from childhood into adulthood and to predict obesity-related adult morbidities. To investigate how accurately simple measures diagnose obesity in children, and how acceptable these measures are to children, carers and health professionals.

Data sources: Multiple sources including MEDLINE, EMBASE and The Cochrane Library were searched from 2008 to 2013.

Methods: Systematic reviews and a meta-analysis were carried out of large cohort studies on the association between childhood obesity and adult obesity; the association between childhood obesity and obesity-related morbidities in adulthood; and the diagnostic accuracy of simple childhood obesity measures. Study quality was assessed using Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) and a modified version of the Quality in Prognosis Studies (QUIPS) tool. A systematic review and an elicitation exercise were conducted on the acceptability of the simple measures.

Results: Thirty-seven studies (22 cohorts) were included in the review of prediction of adult morbidities. Twenty-three studies (16 cohorts) were included in the tracking review. All studies included BMI. There were very few studies of other measures. There was a strong positive association between high childhood BMI and adult obesity [odds ratio 5.21, 95% confidence interval (CI) 4.50 to 6.02]. A positive association was found between high childhood BMI and adult coronary heart disease, diabetes and a range of cancers, but not stroke or breast cancer. The predictive accuracy of childhood BMI to predict any adult morbidity was very low, with most morbidities occurring in adults who were of healthy weight in childhood. Predictive accuracy of childhood obesity was moderate for predicting adult obesity, with a sensitivity of 30% and a specificity of 98%. Persistence of obesity from adolescence to adulthood was high. Thirty-four studies were included in the diagnostic accuracy review. Most of the studies used the least reliable reference standard (dual-energy X-ray absorptiometry); only 24% of studies were of high quality. The sensitivity of BMI for diagnosing obesity and overweight varied considerably; specificity was less variable. Pooled sensitivity of BMI was 74% (95% CI 64.2% to 81.8%) and pooled specificity was

95% (95% CI 92.2% to 96.4%). The acceptability to children and their carers of BMI or other common simple measures was generally good.

Limitations: Little evidence was available regarding childhood measures other than BMI. No individual-level analysis could be performed.

Conclusions: Childhood BMI is not a good predictor of adult obesity or adult disease; the majority of obese adults were not obese as children and most obesity-related adult morbidity occurs in adults who had a healthy childhood weight. However, obesity (as measured using BMI) was found to persist from childhood to adulthood, with most obese adolescents also being obese in adulthood. BMI was found to be reasonably good for diagnosing obesity during childhood. There is no convincing evidence suggesting that any simple measure is better than BMI for diagnosing obesity in childhood or predicting adult obesity and morbidity. Further research on obesity measures other than BMI is needed to determine which is the best tool for diagnosing childhood obesity, and new cohort studies are needed to investigate the impact of contemporary childhood obesity on adult obesity and obesity-related morbidities.

Study registration: This study is registered as PROSPERO CRD42013005711.

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Glossary

D₂O Deuterium dilution method.

Sum SFT The sum of skinfold thickness measurements at more than one site.

UK90 The British 1990 growth reference.

List of abbreviations

4-C	four-component	FMI	fat mass index
ADP	air displacement plethysmography	HC	hip circumference
AUC	area under the curve	HDL	high-density lipoprotein
BAI	body adiposity index	HR	hazard ratio
BIA	bioelectrical impedance analysis	HSROC	hierarchical summary receiver operating characteristic
BMI	body mass index	HTA	Health Technology Assessment
CDC	Centers for Disease Control and Prevention	IDF	International Diabetes Federation
CDSR	Cochrane Database of Systematic Reviews	IOTF	International Obesity Taskforce
CEDAR	Centre for Diet and Activity Research	LDL	low-density lipoprotein
CENTRAL	Cochrane Central Register of Controlled Trials	LR–	negative likelihood ratio
CHD	coronary heart disease	LR+	positive likelihood ratio
CI	confidence interval	MeSH	medical subject heading
CINAHL	Cumulative Index to Nursing and Allied Health Literature	MRI	magnetic resonance imaging
CPCI-S	Conference Proceedings Citation Index – Science	MUSP	Mater-University Study of Pregnancy
CRD	Centre for Reviews and Dissemination	NC	neck circumference
CVD	cardiovascular disease	NCDS	National Child Development Study
DARE	Database of Abstracts of Reviews of Effects	NCMP	National Child Measurement Programme
DEXA	dual-energy X-ray absorptiometry	NHANES	National Health and Nutrition Evaluation Surveys
DoPHER	Database of Promoting Health Effectiveness Reviews	NHS EED	NHS Economic Evaluation Database
DOR	diagnostic odds ratio	NICE	National Institute for Health and Care Excellence
EASO	European Association for the Study of Obesity	NIR	near-infrared interactance
ECOG	European Childhood Obesity Group	NLSAH	National Longitudinal Study of Adolescent Health
EPPI-Centre	Evidence for Policy and Practice Information and Co-ordinating Centre	NLSY79	National Longitudinal Survey of Youth
		NPV	negative predictive value
		OR	odds ratio
		PPV	positive predictive value

LIST OF ABBREVIATIONS

PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses	SES	socioeconomic status
		SFT	skinfold thickness
PSID	Population Study of Income Dynamics	WC	waist circumference
		WHO	World Health Organization
ROC	receiver operating characteristic	WHR	waist-to-hip ratio
RR	relative risk	WHtR	waist-to-height ratio
SCI	Science Citation Index	WoS	Web of Science
SD	standard deviation		

Plain English summary

Obesity in adults increases the risk of health problems such as diabetes, heart disease and cancer. It is unclear whether or not being obese as a child is also linked to these adult diseases. It is also unclear if body mass index (BMI) is the best way of assessing whether or not a child is a healthy weight.

Our research investigated how useful it is to assess whether or not a child is obese. We also investigated if there was any evidence that using other measures, such as waist-to-hip ratio or waist circumference, might be better than BMI. We also assessed how accurate BMI and other measures are in children.

We performed systematically conducted reviews of the medical literature to find all the best research evidence to address these questions.

Our research found that obesity frequently persists from childhood to adulthood and that BMI is a reasonably accurate measure of obesity in children, which can help identify children who are likely to be obese in adulthood and who may benefit from losing weight. However, it does not identify the many healthy-weight children who will become obese or develop obesity-related diseases in adulthood. Most obesity-related diseases occur in adults who were of healthy weight in childhood.

There is a lack of evidence to help determine whether or not any other measure is better or worse than BMI for assessing childhood weight status. Children, parents and nurses found BMI was generally acceptable and easy to use.

Scientific summary

Background

It is generally accepted that adult obesity is associated with an increased risk of morbidity and premature mortality in adults. However, the nature of the link between childhood obesity and adult morbidity and obesity is less clear. Recent systematic reviews have indicated that childhood obesity is positively associated with adult obesity and that childhood overweight and obesity are positively associated with an increased risk of morbidity in adulthood. However, none has investigated the link between childhood weight status and adult morbidity in terms of predictive accuracy. In addition, these reviews have primarily considered body mass index (BMI) to determine the presence and level of obesity. The question remains of whether or not another simple measure would be better for gauging the association between childhood obesity and adult obesity and (separately) adult morbidity.

The decision problem addressed in this review is, 'What is the best simple measure, or combination of simple measures, of obesity in children for predicting the development of obesity-related health problems such as type 2 diabetes, cardiovascular disease (CVD) and cancer in adolescence and/or adulthood?' The abilities of these simple measures to correctly identify weight status in childhood, and to predict the persistence of obesity from childhood into adolescence and adulthood, were also investigated. Acceptability and ease of use of the measures were also addressed within the review.

Objectives

This research addressed, through systematic reviews, the questions raised in the decision problem.

1. Is obesity in children and adolescents a risk factor for CVD, type 2 diabetes and/or cancer in adults, and do the results vary according to the simple measure of obesity employed?
2. To what degree do simple measures of obesity in childhood accurately predict the tracking of obesity into adolescence and adulthood?
3. How accurately do simple measures of obesity reflect actual adiposity in children?
4. How acceptable are these simple measures of adiposity to children, their carers and health professionals, and how easy is it for parents and health professionals to implement and understand them?

Methods

The systematic reviews were conducted following the general principles recommended in the Centre for Reviews and Dissemination guidance for undertaking reviews in health care and the reporting guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

Literature search

Separate literature searches were undertaken to identify studies for each of the review questions. The searches were limited to the date range 2008–13. A variety of sources was searched including MEDLINE, EMBASE, PsycINFO and Cumulative Index to Nursing and Allied Health Literature (CINAHL), supplemented with reference checking and citation searching.

Inclusion criteria

For all review question studies, a range of simple obesity measures were considered, including BMI, waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and skinfold thickness (SFT).

For review question 1, prospective, large ($n \geq 1000$) longitudinal studies which measured obesity in childhood were eligible. Adult outcomes considered were CVD, type 2 diabetes and cancer.

For review question 2, large ($n \geq 1000$) longitudinal studies recruiting children and/or adolescents (aged 2–18 years) which measured obesity in childhood and at a later time (at least 5 years later) were eligible.

For review question 3, diagnostic accuracy studies of obesity measurement in children were eligible for inclusion, provided they used one of the following reference standards: a multicomponent model, dual-energy X-ray absorptiometry (DEXA), deuterium dilution or densitometry.

For review question 4, on the acceptability and ease of use of childhood obesity measures, BMI, SFT, WHR and WHtR were eligible for inclusion. Studies on the acceptability and ease of use of these measures, from the perspective of the child, parent or health professional, were eligible. A simple survey was conducted to obtain some indication of the attitudes of children, school nurses and parents to these four measures.

Quality assessment and statistical analysis

The quality of included studies was assessed using Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) for studies of diagnostic accuracy and Quality in Prognosis Studies (QUIPS) for studies of predictive value. A critical summary of recent relevant systematic reviews was undertaken.

For the review questions evaluating test accuracy, studies with sufficient data were included in meta-analyses generating pooled odds ratios (ORs), and pooled estimates of diagnostic accuracy where possible. Otherwise, results were synthesised narratively.

For the review and elicitation exercise on the acceptability and ease of use of childhood measures, results were tabulated and summarised narratively.

Results

Review of prediction of adult morbidities

Thirty-seven studies (22 cohorts) met the inclusion criteria. Of these, 26 studies (13 cohorts) were included in meta-analyses. All studies included BMI. Three measured WC, and one used WHR and the sum of SFT measurements (sum SFT). No evidence was found for other simple childhood measures.

Elevated childhood BMI was modestly associated with an increased risk of adult morbidities. The association between a 1-standard deviation (SD) increase in BMI and adult diabetes had an OR of 1.7 [95% confidence interval (CI) 1.30 to 2.22], approximately equivalent to a 24% increase in risk per BMI unit in an adolescent. The association between a 1-SD increase in BMI and adult coronary heart disease (CHD) had an OR of 1.2 (95% CI 1.20 to 1.31), approximately equivalent to an 8% increase in risk per BMI unit in an adolescent. There was no convincing evidence of an association between childhood obesity and stroke. Across a range of cancers, there was evidence that childhood obesity was associated with a higher risk of cancer in adulthood. Increases in odds were generally around 20% per SD of BMI. There was no evidence of an association between childhood BMI and breast cancer. These analyses were not adjusted for adult BMI, in order to investigate whether or not childhood obesity alone can predict adult morbidities.

Despite the positive association between childhood BMI and morbidities, childhood BMI was not found to be a good predictor of adult disease. Only 40% of adult diabetes and 20% of CHD and cancers would occur in overweight or obese children. Hence, the majority of adult morbidity occurs in people who were of healthy weight as children.

In the narrative review, childhood obesity was found to be associated with adult metabolic syndrome, and there was some very limited evidence that BMI had poor sensitivity to predict this disorder. Evidence on the association between childhood BMI and hypertension and hypercholesterolaemia was very limited. Evidence was too limited to draw any firm conclusions on other childhood measures of obesity.

Review of tracking of obesity into adulthood

Twenty-three studies from 16 cohorts met the inclusion criteria for this review. All studies relied on BMI as the measure of obesity, except one which used triceps SFT. The association between childhood obesity (≥ 95 th centile) and obesity in adults (age ≥ 20 years) was strong, with obese children being more than five times more likely to be obese as adults than non-obese children [pooled relative risk (RR) 5.21, 95% CI 4.50 to 6.02]. There was no apparent difference in this RR between younger and older age groups.

Obesity tracked moderately well from childhood into adolescence; around half of obese children were still obese in adolescence. It tracked well from adolescence to adulthood; about 80% of obese adolescents were still obese in adulthood and 70% were still obese after age 30 years. No data were available for tracking beyond age 40 years.

Body mass index was less effective at identifying who would be obese in adulthood; 70% of obese adults were not obese as children or in adolescence, and 80% of obese people aged over 30 years were not obese in adolescence, so childhood BMI has poor sensitivity to detect adult obesity. Analyses of the tracking of childhood overweight (≥ 85 th centile) to adult obesity or overweight gave broadly similar results.

Review of diagnostic accuracy of childhood measures of obesity

Thirty-four studies were included in the review of diagnostic accuracy. Thirty assessed BMI, 10 SFT, seven WC, four WHR, two WHtR and six looked at other childhood measures of obesity. Most of the studies used DEXA as the reference standard, which is the least reliable of the eligible reference standards. Of the 34 studies, only eight were considered to be high quality.

Overall, the sensitivity of BMI for diagnosing both obesity and overweight varied considerably; specificity was less variable. Meta-analyses showed that, of those who were obese according to the reference standard, 74% were classified as obese using BMI, and of those who were not obese according to the reference standard, 95% were not classified as obese.

Data on other measures of obesity were more limited. The most commonly evaluated non-BMI test was SFT.

Most of the simple measures had high specificities. When fat mass index was evaluated alongside BMI (one study), it looked like a promising alternative, but this would require further research. Sum SFT also showed potential. Of the measures that incorporate a waist measurement, it seems that WHtR was more accurate than WC alone or WHR, although WHtR was evaluated in fewer studies.

Review of acceptability and ease of use of childhood measures of obesity

Five studies were identified for the review of acceptability and ease of use, all eliciting opinions about BMI. None of the studies elicited the opinions of children, three elicited the opinions of caregivers/guardians and two those of health professionals (school nurses in one study and family doctors and paediatricians in the other). The opinion of parents and nurses regarding the usefulness of BMI was generally positive. The usefulness of measuring BMI in preschool children was less well accepted among doctors.

In the elicitation exercise, although most children did not seem to have a problem with their height being measured, a large proportion were embarrassed, or had other adverse reactions, to being weighed. The 71 parents/caregivers questioned were generally unfamiliar with WHR, WHtR and SFT, and therefore with their potential accuracy and usefulness. Many felt that BMI was a more meaningful indicator of a child's weight status than height and weight alone; age- and sex-adjusted BMI were considered valuable.

Limitations and uncertainties

Despite there being a reasonable number of studies identified for the three main review questions, the number from which the necessary data could be obtained was small. Furthermore, across all reviews the limited reporting of most studies and their heterogeneity further reduced the number of studies that could be combined in meta-analyses, producing results with large uncertainty and wide CIs. There was limited scope to test for the impact of important confounders such as age and sex.

A number of assumptions had to be made in order to conduct the analyses. These assumptions, especially the assumption of normality for BMI, may not be accurate and this limits the reliability of the results.

Little evidence was available regarding childhood measures other than BMI. This greatly hampered the review's ability to address the project brief.

The cohort studies of the association between childhood obesity and adult morbidities were, of necessity, long-term studies, with recruitment often occurring in the 1960s or earlier. As this was before the rise in general obesity, it is unclear whether or not the findings from this part of the review apply to present-day children living in societies where obesity is more prevalent.

Conclusions

The review found that childhood obesity (measured using BMI) was associated with moderately increased risks of adult obesity-related morbidity. However, the increase in risk was not large enough for childhood BMI to be a good predictor of the incidence of adult morbidities; the majority of adult obesity-related morbidity occurs in adults who were of healthy weight in childhood.

The review of tracking studies found that childhood obesity (measured using BMI) is strongly associated with adult obesity. This strong association was matched by a strong persistence of childhood obesity into adulthood. Obese children, and particularly obese adolescents, are likely to still be obese in adulthood. However, childhood BMI is not a good predictor of the incidence of adult obesity or overweight; most obese adults were not obese in childhood, so overall adult obesity is not primarily determined by childhood obesity. No information was available on tracking of obesity into later adulthood, when most obesity-related morbidities are likely to occur.

The usefulness of BMI as a screening tool therefore depends upon the objectives of screening. It may be useful for identifying a group of obese or overweight children who may benefit from intervention, but does not identify all children who will go on to be obese or to develop obesity-related morbidities in adulthood.

Body mass index was found to be reasonably good at diagnosing obesity during childhood, with around 75% of genuinely adipose children being classified as obese using BMI, and around 95% of non-obese children also being correctly classified. This result was, however, based mostly on studies using DEXA, which is not generally regarded as a gold standard for diagnosing obesity. BMI therefore appears to be a reasonably good measure of obesity in children, as it effectively identifies childhood adiposity and children likely to be obese in adulthood.

There is a lack of evidence to help determine whether or not any simple measure is better or worse than BMI for assessing childhood weight status, either for diagnosing obesity in childhood or for predicting adult obesity or obesity-related morbidities.

The opinion of parents and nurses as to the usefulness of BMI was generally positive. However, its usefulness in preschool children was less well accepted among doctors, although it was considered useful for selected young children.

Recommendations for research

- Further investigation of individual-level data to avoid the limitations and assumptions made in this review and, potentially, to analyse measures other than BMI that have not been reported.
- A full assessment of diagnostic accuracy, including identifying studies using magnetic resonance imaging as the reference standard to assess abdominal obesity.
- Further primary studies of the diagnostic and predictive accuracy of measures other than BMI, should the research described above suggest that they are merited.
- Cohort studies to assess tracking of obesity and incidence of obesity-related morbidities to investigate the effect of contemporary childhood obesity on long-term obesity and morbidity. This could be achieved through appropriate maintenance and analysis of NHS records.

Study registration

This study is registered as PROSPERO CRD42013005711.

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Chapter 1 Background

Obesity

Adiposity, or obesity, is defined as an accumulation of excess body fat to the extent that it may have an adverse effect on health.¹ Adult obesity prevalence in England has increased from approximately 16% in 1995 to approximately 26% in 2010, with the increase seemingly continuing.¹ Obesity in adults has been linked to increased mortality and morbidity.¹ A meta-analysis of 26 cohort studies reported 60,374 deaths, 17,708 deaths from coronary heart disease (CHD) and 27,099 deaths from cardiovascular disease (CVD) among 388,622 adults recruited in the studies.² When the normal-weight people were compared with those who were obese [using body mass index (BMI)], the risk of mortality was significantly increased for the obese group. The pooled relative risks (RRs) reported were as follows: for overall mortality, 1.20 [95% confidence interval (CI) 1.12 to 1.29] for men and 1.28 (95% CI 1.18 to 1.37) for women; for death from CHD, 1.51 (95% CI 1.36 to 1.67) for men and 1.62 (95% CI 1.46 to 1.81) for women; and for death from CVD, 1.45 (95% CI 1.33 to 1.59) for men and 1.53 (95% CI 1.38 to 1.69) for women.²

Childhood obesity

The Health Survey for England 2012 reported that 14% of both boys and girls between the ages of 2 and 15 years were obese and that 28% of both boys and girls were classed as either overweight or obese.³ Data for younger children have been provided by the National Child Measurement Programme (NCMP), which has been in progress for 6 years. The prevalence of obesity has been measured using BMI (using the 85th centile for overweight and 95th for obese) at two time points (aged 4/5 years and 10 years) using a cross-sectional study design. In England, in the 2012–13 school year the NCMP recorded 1,076,824 measurements in children (a participation rate of 93%). At reception (aged 4–5 years), 22.2% of children were either overweight or obese and 9.3% were obese. These figures increased in Year 6 (aged 10 years by 1 September, the start of the school year) to 33.3% of children being either overweight or obese and 18.9% being obese.⁴ Data from the Health Survey for England³ show that the proportion of children aged 11–15 years in England who were obese was similar to adults (aged 16 years and over) up to 2004. Just under 15% were obese in 1995, rising to just over 25% in 2004, but, unlike the figures for adults, there has been a decrease since, with the proportion categorised as obese plateauing in 2010 at approximately 18%. In children aged 2–10 years, the proportion who were obese was lower: 10% were obese in 1995, rising to a peak of approximately 17% in 2005, followed by a decrease to just under 15% in 2010.⁵ From these figures, it seems that the prevalence of overweight and obesity, and changes over time, vary for different age groups of children. It has been projected that, by 2050, the prevalence of obesity will increase in boys to over 35% of those aged 6–10 years and 23% of those aged 11–15 years, and in girls to 20% of those aged 6–10 years and 35% of those aged 11–15 years.⁶ The prevalence of childhood obesity varies depending upon ethnicity.^{4,7–9} It has been suggested that certain obesity metrics may misrepresent these ethnic differences.^{9,10} Data on childhood obesity incidence are more limited, although US evidence suggests that incident obesity between the ages of 5 and 14 years is more likely to occur at a younger age, primarily among overweight 5-year-old children.¹¹

The association between childhood obesity and adult obesity and morbidity

It is generally accepted that adult obesity increases the risk of some morbidities, particularly CVD, type 2 diabetes mellitus and some types of cancer,^{7,12–14} and leads to a higher risk of associated mortality.¹⁵ It may also be associated with other chronic conditions, such as rheumatological disorders, asthma, psychological

illness, sleep disorders and reduced fertility.⁷ However, the link between childhood obesity and adult morbidity is less clear. Recent systematic reviews have indicated that childhood obesity is associated with adult obesity^{16,17} and adult morbidities.^{18–22} However, none of these reviews evaluated this association in terms of predictive accuracy.

A recent systematic review of 25 studies stated that all the studies consistently reported that overweight and obese children were at an increased risk of becoming overweight or obese adults, with the risk of tracking into adulthood obesity increasing as the level of overweight/obesity in childhood increased.¹⁶ The findings from that review suggested a moderate likelihood of persistence of overweight into adulthood for children who were overweight or obese, but there were considerable variations in the predictive values across studies. Regarding the link between childhood obesity and adult morbidity, recent systematic reviews support the opinion that it is adult obesity, or the continued overweight/obesity from childhood into adulthood,^{1,18,20,23,24} that increases the risk of adult morbidity, rather than obesity in childhood being an independent risk factor for adult morbidities. However, there is some uncertainty and this may vary across the morbidities.

Measuring obesity

Simple measures of obesity

There are a range of simple, anthropometric, indirect measures of adiposity.^{25,26} The simplest measure is weight; however, on its own this provides little useful information, as confounding variables such as a person's height and body composition are not taken into consideration.

Body mass index is the most commonly used simple measure of obesity, and is also the only measure recommended for use in children in the UK. It is calculated by dividing weight in kilograms by height in metres squared (kg/m^2). BMI increases sharply in infancy, peaking at around 9 months, and then falls to its lowest at around 6 years.²⁷ BMI (adjusted for age and sex) is recommended by the National Institute for Health and Care Excellence (NICE) (CG43) as a practical estimate of overweight in children and young people, but the guidance warns that the result needs to be interpreted with caution because BMI is not a direct measure of adiposity.²⁸ The main limitation of BMI is that it measures excess weight, rather than excess fat, which is what determines whether someone is obese or not. Therefore, those with strong bones and/or well-developed muscularity, but little fat, will have a high BMI and could be categorised as obese, as bone and muscle are more dense than fat.²⁹ Additionally, BMI is not consistent across the normal height range, with shorter heights producing higher BMI values.³⁰ BMI also does not give any indication as to the distribution of fat in the body; in adults, central adiposity is more closely associated with health risks than general adiposity,^{31,32} and the use of BMI and waist circumference (WC) is recommended in adults in the UK.

Simple measures other than BMI include:

- *WC* A measure which gives an indication as to the distribution of excess body fat. However, in isolation it provides insufficient information regarding overall adiposity. Based on a UK reference population, 95th centile cut-off points range from 57.0 cm at age 5 years to 85.2 cm at age 16 years in boys, and from 57.2 cm at age 5 years to 75.1 cm at age 16 years in girls.³³
- *Neck circumference (NC)* The use of this measure has been investigated in children, and it is thought to be reliable for identifying children with high adiposity.^{34–36} Based on a US population, thresholds for obesity are suggested as 29 cm in prepubertal boys, 28 cm in prepubertal girls, 32.5 cm in pubertal boys and 31 cm in pubertal girls.³⁶
- *Rohrer's Ponderal Index (Rohrer's Index, Ponderal Index or Corpulence Index)* Similar to BMI, but calculated by dividing weight in kilograms by height in metres cubed (kg/m^3), rather than height in metres squared.²⁹ This has been compared with BMI in respect of its ability to predict percentage body fat in children and adolescents, and its long-term associations with adult obesity.^{37,38}

- Benn's Index** Calculated by dividing weight in kilograms by height^p (kg/m^p); p is a power index derived from the weight-to-height ratio ($p = \text{bHO/WO}$), making the index independent of height.^{29,39} Benn's Index is rarely used as p is neither constant nor necessarily a whole number, which means the calculations are complicated.²⁹ A study in boys from four countries showed that the power of p required to produce a correlation of zero between the index and height varied with age and ethnicity. For US, Japanese and Singaporean boys, the p value was < 2.8 at age 6 years, increased to < 3.5 at age 9–10 years and decreased to < 2.0 by age 16 years. For boys in the UK, p started at < 2.3, increased to < 2.6 then decreased to < 2.0.⁴⁰
- Waist-to-height ratio (WHtR)** As with the waist-to-hip ratio (WHR), WHtR is a measure of fat distribution, and primarily identifies those with abdominal obesity. A person is typically considered obese if their WC is over half their height (threshold of 0.5 across multiple countries and ethnicities).^{41,42}
- WHR** A measure of regional fat distribution used as a marker for intra-abdominal fat in adults. A WHR of ≥ 0.80 in females and ≥ 1.0 in males is considered to be indicative of a high risk of health problems.⁴³ One of the limitations with ratios using waist measurement is the potential for measurement error, as there is inconsistency in the actual site of the waist measurement.
- Body adiposity index (BAI)** This was suggested by Bergman *et al.* (2011)⁴⁴ as reflecting the percentage body fat in adults regardless of sex or ethnicity without numerical correction, and it was therefore considered an improvement on BMI. BAI is calculated by the equation $[\text{hip circumference}/(\text{height})^x] - 18$, with x being a unitless power term. The correlation between BAI and percentage adiposity was highest when x was between 1.47 and 1.5, and therefore the use of 1.5 as the power term in Mexican American adults was suggested.⁴⁴ The measure has not been validated in children, and a power term for children has not been specified.
- Skinfold thickness (SFT)** A direct anthropometric measure of adiposity. Skinfold measurements are considered as good indicators as they are a direct measure of the fat layer, but the measurements are site- and sex-specific.²⁷ The most common sites are the subscapular and the triceps;²⁵ other potential sites include the chest, axilla, abdomen, suprailium and thigh.²⁶ Scores can be presented adjusted for age and sex. There are also a large number of equations available that can be used to obtain an estimate of percentage subcutaneous fat from SFT measurements,^{25,26} although these may introduce biases and have not been standardised for children over the age of 6 years.⁴⁵ In adults, women with 30% or higher, and men with 25% or higher, body fat are classified as obese.⁴⁶ One of the limitations of SFT is that visceral fat (fat in the abdominal cavity) is not measured. As with waist measurements, measurement error is a particular limitation of this method. There can be considerable variability across practitioners, leading to the requirement for specific training.
- Bioelectrical impedance analysis (BIA)** This measures the opposition to the flow of an electric current applied to extremities of the body (usually the wrists or ankles; in children, foot-to-foot currents are used as this only requires the child to stand barefoot on scales), using a low-level (below the threshold of human perception; usually a single frequency of 50 kHz) alternating electrical current passing through the body. This is used to estimate total body water. As fat contains little water compared with other body tissues, impedance can be used as a proxy measure for fat-free body mass. Body fat can then be calculated from the difference between fat-free body mass and overall weight. BIA has several limitations. First, the body is a number of cylinders of different length and diameter (legs, torso, arms), rather than a single cylinder, and given that resistance decreases as the cross-section of a cylinder increases, the arms and legs contribute more to resistance than the torso. The limbs represent 50% of body weight but 90% of the body's impedance; this means that impedance is more closely related to changes in the muscle mass of the limbs. In addition, as there is an assumption that fat-free mass is 73% water,²⁶ factors such as dehydration, exercise, diuretics or a full bladder will affect the results.⁴⁷ Furthermore, equations based on height and weight are used to determine overall adiposity and these vary across manufacturers. The equations used by some instruments may be unknown, and results may vary across different instruments and populations.⁴⁸ Given these limitations, BIA is currently not recommended for use in the UK.

- *Fat mass index (FMI)* Calculated from fat mass as determined by BIA (kg) divided by height squared. FMI plus the fat-free mass index (fat-free mass/height squared) = BMI.^{49,50}
- *Near-infrared interactance (NIR)* A beam of infrared light is transmitted into the biceps; the light is reflected by underlying muscle and absorbed by fat, and therefore the proportion of reflected light will indicate the proportion of fat. The NIR light penetrates the tissues to a depth of 4 cm and is reflected back to the detector, which measures the optical density at wavelengths of 940 nm (optical density 1) and 950 nm (optical density 2). The underlying principle is that optical densities are linearly and inversely related to percentage body fat, and thus, the smaller the optical density, the greater the absorption of NIR light and the higher the fat composition.²⁶

More complex measures of obesity

Apart from SFT, the anthropometric measures listed above are indirect measures of adiposity. There are a number of more direct measures of adiposity available; these are not routinely available and need to be conducted by those who have been specifically trained, and therefore they are not useful as population measures. Such measures include:

- *Densitometry [hydrostatic weighing; underwater (hydrostatic) weighting]* This method measures underwater weight. It distinguishes fat mass and fat-free mass, assuming specific densities of these two tissues, and therefore requires measurement of total body density (body mass/body volume).⁵¹ Whereas the density of fat is relatively constant, that of fat-free mass varies according to its composition. This variability is partly explained by the process of chemical maturation that occurs before adulthood, but interindividual variability is also significant, even in healthy children.
- *Densitometry [air displacement plethysmography (ADP)]* A new system that uses the displacement of air rather than water. This is thought to have better precision than hydrodensitometry in children, and is acceptable in children as young as 4 years.⁵² An infant ADP has become available, allowing the measurement of body volume during the first 6 months of life. In general, densitometry is unsuitable for application as a two-component technique in patients in whom the composition of lean mass may be abnormal, such as those with excess fluid retention and undermineralisation, as these decrease the density of lean mass and lead to an overestimation of fatness.^{52,53}
- *Multicomponent models* These models combine the results of three, four or five different measures. The three-component model divides body weight into fat, water and fat-free dry tissue, and requires measurements of body weight, body water by hydrometry and body volume by densitometry. The four-component (4-C) model further divides fat-free dry tissue into protein and mineral, and requires the measurement of bone mineral by dual-energy X-ray absorptiometry (DEXA). Its advantage is that it is the most accurate approach, with all the component measurements being acceptable. It has the disadvantage of being expensive and thus generally limited to specialist research.⁵¹ Body volume index is a new multicomponent measure that uses BMI, WC and WHR along with other volumetric and body composition analyses. The method requires a three-dimensional full-body scanner.⁵⁴
- *DEXA* DEXA⁵¹ is a three-component model, as it measures bone mineral, bone-free lean mass and fat mass. For accurate estimation of body fat, the hydration of lean body mass needs to be established; often, a constant for hydration of lean body mass (0.73 ml/g) is assumed, which is based on non-elderly, healthy, adult measurements. The use of this assumption can lead to an error in the amount of lean tissue, particularly in children, the elderly and the sick; DEXA is likely to be more reliable in healthy adults with a constant tissue hydration.^{55,56} DEXA may therefore have difficulty accurately assessing body mass in infants, with increasing accuracy as body size increases. DEXA also has difficulty distinguishing between bone and non-bone lean mass in high bony areas (thorax, forearm).⁵⁵ In a review comparing DEXA with 4-C models, DEXA tended to underestimate body fat in most studies, with this underestimation usually being greater in leaner people.⁵⁷ Some studies did find DEXA overestimated body fat, and some no difference; there seemed to be differences in accuracy with different DEXA technology.⁵⁷

- *Deuterium dilution method (D₂O)* Deuterated water (²H₂O) is currently the most accurate way of measuring total body water. The difference in secreted markers (urine, saliva) between baseline and post ingestion is used in an algorithm to calculate total body water and fat-free mass. The difference between total body mass and fat-free mass gives fat mass, allowing body composition to be worked out, but the method is most effective for total body water when used in a multi-(four-)component model with body density [underwater (hydrostatic) weighting], BIA and DEXA. The method is safe and has been validated in a wide range of populations but does have disadvantages; it is expensive, time-consuming (requiring sample collections and analyses) and rather invasive because it requires participants to ingest a dose of deuterium-enriched water.⁵⁸

Challenges when measuring obesity in children

To monitor the trend in, and to reduce the prevalence of, overweight and obesity, several initiatives have been introduced in the UK. Programmes that target obesity in general include the Department of Health's 'Call to Action',⁵⁹ the National Obesity Observatory⁶⁰ and the International Obesity Taskforce (IOTF).⁶¹ Programmes aimed specifically at children include the NCMP, which measures the weight and height of children in reception class (aged 4–5 years) and Year 6 (aged 10–11 years) in order to assess overweight and obesity levels within primary schools.⁴ In order for such programmes to succeed, the measure of obesity needs to be accurate and simple to implement. It is therefore important to investigate whether or not BMI, the most commonly used simple measure, is the best measure for wide-ranging screening programmes, and, if not, which measure (or combination of measures) should replace it in order to ensure that children at risk of obesity-related morbidity are identified.

The assessment of childhood obesity using BMI and other anthropometric measures is more complicated than that of adults.⁶² The major limitation of anthropometric measures to determine obesity in children is that most are confounded by natural, age-related physiological variations in body composition.^{27,63} As a result, actual measurements are compared with reference data to determine if a child is overweight or obese. However, for BMI, the most commonly used anthropometric measure in children, there are several reference data sets available, including the centiles of the UK 1990 growth reference (UK90), IOTF thresholds and the World Health Organization (WHO) growth reference; the advantages and disadvantages of each have been summarised elsewhere.⁶⁴ This results in different thresholds being used for defining overweight and obesity across organisations and countries, which makes the comparability of data and the determination of the accuracy of these measures difficult.⁶⁵ In the UK, BMI is related to the UK90 BMI growth reference charts to determine whether or not a child is obese. For clinical purposes, overweight is defined as a BMI \geq 91st centile and obesity as a BMI \geq 98th centile; however, many of the data available have been collected within a research context, and for research and population monitoring purposes the 85th and 95th centiles are recommended for classifying overweight and obesity, respectively.¹ The associated standardised scores, based on UK90 reference data, are 1.04 for the 85th centile; 1.34 for the 91st centile; 1.64 for the 95th centile; and 2.0 for the 98th centile. Most of the anthropometric measures being investigated in this review will be affected by a child's age, sex and ethnicity, and will therefore require standardisation. NC, NIR and WHtR are measures not subjected to standardisation. The fact that they are not standardised may be attributable to the lack of appropriate reference data.

A lack of requirement for standardisation for age and sex for a measure would afford that measure some advantage over anthropometric measures that do require standardisation; whether or not this would be at the cost of accuracy would need to be established.

A further challenge arises when an association needs to be made between childhood obesity and adult morbidity, as very long-term studies are required. One study followed 1000 families from Newcastle upon Tyne (UK), involving 1142 children recruited at birth in 1947; 412 were followed to the age of 50 years.⁶⁶ The study concluded that there was little tracking of obesity from childhood to adulthood, that there was no excess adult health risk from childhood or teenage overweight, and that being thin as a child offered no protection against obesity in adulthood.⁶⁶ This contrasts with the results of other studies and reviews;^{21,23,67,68} although this may be related to population differences owing to the age of the cohort, it may also be a result of the study being underpowered. A comparison of two British birth cohorts, one of children born in 1946 and the other of children born in 1958, showed that girls in the 1958 cohort had a higher average BMI during 7 years in childhood, and that both boys and girls in the 1958 cohort had a greater rate of increase in BMI during adulthood.⁶⁹ These studies illustrate that potential determinants and levels of adiposity in childhood differ between these birth cohorts, and are likely to differ for the present-day child population. However, the long-term relationships between childhood obesity and adult morbidity may not change as a result of these differences, and standardisation of obesity scores is thought to mitigate some of the changes observed over time.

Aims and objectives of the review

It is generally accepted that adult obesity is associated with an increased risk of morbidity (type 2 diabetes, CVD and cancer) and premature mortality in adults. However, the link between childhood obesity and adult morbidity is less clear. Recent systematic reviews have indicated that childhood obesity is associated with adult obesity^{16,17} and a range of adult morbidities,¹⁸⁻²² but none has used formal methods to estimate the accuracy (in terms of sensitivity and specificity) of childhood obesity to predict adult obesity and morbidity. In addition, these reviews have primarily been based on studies that used BMI to determine the presence and level of obesity. BMI is the most commonly used measure, but there are concerns regarding its suitability in determining obesity in children, particularly in relation to the need for standardisation. The question remains of whether or not another simple childhood measure, used either alone or in combination with BMI or some other simple measure, would be better for predicting the risk of adult obesity and (separately) adult morbidity. It is therefore important to determine the predictive accuracy of the simple measures that are available in order to inform the decision as to which should be used for screening children to identify those at risk of developing obesity and serious obesity-related morbidities as adults.

The decision problem to be addressed was, 'What is the best simple measure, or combination of simple measures, of obesity in children for predicting the development of obesity-related health problems such as type 2 diabetes, CVD and cancer in adolescence and/or adulthood?' Given the relationship between adult obesity and morbidity, the ability of these simple measures to predict the persistence of obesity from childhood into adolescence and adulthood was investigated. Acceptability and ease of use of the measures are also important when considering whether or not any one of these measures should be introduced as the standard method for the assessment of childhood obesity; this will also be addressed within the review.

The objective of our research was to address, through systematic reviews, the questions raised in the decision problem.

1. Is obesity in children and adolescents a risk factor for CVD, type 2 diabetes and/or cancer in adults, and do the results vary according to the simple measure of obesity employed?
2. To what degree do simple measures of obesity in children accurately predict the tracking of obesity into adolescence and adulthood?

In order to fully evaluate the predictive value of the simple measures of obesity, and therefore the relationship between the measures and subsequent adult obesity and morbidity, the relationship between the measure and classifying weight status needs to be established. Therefore, a third question was addressed:

3. How accurately do simple measures of obesity reflect actual adiposity in children?

The review investigated how accurately the simple measures diagnosed a child's weight status (overweight or obese), rather than absolute adiposity, as this was the most relevant question.

Once the most promising measure(s) had been determined in terms of predictive accuracy, a fourth question was addressed for that measure(s):

4. How acceptable are these measures of adiposity to children and their carers, and how easy is it for health professionals to implement them?

This review has focused on differentiating between the association between childhood obesity and adult morbidity and obesity, and the ability of childhood obesity to predict adult morbidity or obesity. The analyses of association examine whether or not an increase in childhood obesity in the population as a whole will lead to increased incidence of adult morbidity and obesity. This is distinct from prediction, which examines whether or not childhood obesity could be used as a screening test for later morbidity or obesity. The focus is on whether or not individual adults who have a morbidity or are obese were obese in childhood, and, separately, whether or not obese children go on to become obese adults. This distinction is necessary because an association between childhood obesity and adult obesity or morbidity does not imply that childhood obesity is a good predictor of them.⁷⁰

In the original protocol, question 1 above was 'Is obesity in children and adolescents an *independent* risk factor for CVD, type 2 diabetes and/or cancer in adults, and do the results vary according to the simple measure of obesity employed?' The aim of this review was to assess the ability of childhood obesity specifically to predict adult morbidity such that appropriate action might be taken in childhood. Therefore, no adjustment for adult morbidity was considered. To avoid any ambiguities, the term 'independent' was therefore removed from the original question.

Chapter 2 Methods

The systematic reviews were conducted following the general principles recommended in Centre for Reviews and Dissemination (CRD) guidance for undertaking reviews in health care,⁷¹ and the reporting guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.⁷² The protocol for the systematic review is registered on PROSPERO (PROSPERO registration number: CRD42013005711).

Search strategy

Aim of the literature search

Three separate literature searches were undertaken to identify studies to answer the following questions:

1. How accurately do measures of childhood obesity predict CVD, diabetes and/or cancer in adulthood?
2. Which simple measure of obesity in children most accurately predicts the tracking of obesity into adolescence and adulthood?
3. How accurately do simple measures of obesity reflect actual adiposity in children (actual adiposity in terms of ability to correctly classify a child as normal weight, overweight or obese)?

The three search strategies were devised using a combination of indexed subject heading terms and free-text search terms appearing in the title and/or abstract of database records. Search terms were identified through discussion within the project team, by scanning background literature and 'key articles' already known to the project team and by browsing database thesauri. The search strategies were peer reviewed for accuracy by other information specialists based at CRD (Lisa Stirk and Melissa Harden). Once the MEDLINE search strategies were agreed and peer reviewed, they were adapted so that they could be used in the other databases. Bibliographic records were managed using EndNote XI bibliographic management software (Thomson Reuters, CA, USA).

Full details of the search strategies, dates of searches and results from all the databases and resources searched are given in *Appendix 1*.

Concepts of the search strategy

All three search strategies included a set of search terms for the following three concepts: 'obesity', 'children' and a collection of 'simple anthropometric measures' (index tests). The 'obesity' concept included search terms for 'adiposity'. As BMI is the most widely used and recognised simple anthropometric measure for obesity, using this as a search term inevitably increased the sensitivity of the search strategy and the volume of literature retrieved.

The database searches were supplemented with reference checking and citation searching, as well as additional targeted searches for any gaps in the literature identified after screening of the initial set of literature search results.

The search strategy for the question on the prediction of adult morbidities was structured using the following concepts:

(Obesity OR adiposity)

AND

(Children OR adolescents)

AND

(CVD OR diabetes OR cancer)

An initial search to identify only systematic reviews was conducted, and the searches were limited to the Database of Abstracts of Reviews of Effects (DARE), the Cochrane Database of Systematic Reviews (CDSR), the Database of Promoting Health Effectiveness Reviews (DoPHER) and MEDLINE (with a methodological search filter designed to retrieve systematic reviews).

Having assessed the systematic reviews of measures for predicting morbidity in adulthood, the team was able to identify gaps in the literature and decided on the limits for the searches for primary studies. Targeted searches were conducted for the combinations of measures and morbidities shown in *Table 1*.

For the review question on the tracking of obesity, the search strategy was structured using the following concepts:

(Obesity OR adiposity)

AND

IT

AND

(Tracking OR Cohort studies OR longitudinal studies OR follow-up studies)

AND

(Children OR adolescents)

AND

Adults

AND

Date limit (2007–2013)

TABLE 1 Specification for targeted searches

Measures	Morbidities	Update from
BMI	CVD, diabetes and cancer	2011
SFT	CVD and diabetes	2008
SFT	Cancer	All dates
WC	CVD and diabetes	2008
WC	Cancer	All dates
All other measures	CVD, diabetes and cancer	All dates

During the initial scoping searches, a systematic review about 'tracking' of childhood obesity into adulthood was identified [Singh *et al.* (2008)],¹⁶ and it was therefore decided to limit the searches to run from the date when the searches for this review were completed (2007). The final agreed search strategy was unable to identify one of the Singh review included studies, owing to the absence of any terms for 'tracking' or study design in the title or abstract and inadequate subject heading indexing.

The diagnostic accuracy literature searches were designed to identify studies that compared index tests with reference standards, so both concepts were combined alongside terms for 'obesity' and 'children'. The diagnostic accuracy search strategy was structured using the following concepts:

(Obesity OR adiposity)

AND

(Children OR adolescents)

AND

Index tests

AND

Reference standards

NOT

Animal studies

Initially, the search for studies on the acceptability of simple measures was to be conducted for those tests previously determined to be the most promising measures in terms of predictive accuracy. However, given the lack of non-BMI studies, searches were designed to retrieve qualitative studies about the accessibility and ease of use of the following simple measures of obesity: BMI, SFT, WHR and WHtR. The searches were limited to the following databases: MEDLINE, EMBASE, PsycINFO and Cumulative Index to Nursing and Allied Health Literature (CINAHL). They were also limited by date range (2008–13).

Resources searched

The literature searches involved searching a wide range of databases. The following databases and resources were searched:

- MEDLINE (OvidSP)
- MEDLINE In-Process & Other Non-Indexed Citations (OvidSP)
- PubMed (National Library of Medicine)
- EMBASE (OvidSP)
- PsycINFO (OvidSP)
- CINAHL (EBSCO)
- CDSR (Wiley Online Library)
- Cochrane Central Register of Controlled Trials (CENTRAL) (Wiley Online Library)
- DARE (CRD interface)
- Health Technology Assessment (HTA) Database (CRD interface)
- NHS Economic Evaluation Database (NHS EED) (CRD interface)
- Science Citation Index (SCI) [ISI Web of Science (WoS)]
- Conference Proceedings Citation Index – Science (CPCI-S) (ISI WoS)
- Health Management Information Consortium (OvidSP)

- Trials Register of Promoting Health Interventions [Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) interface]
- DoPHER (EPPI-Centre interface)
- Obesity and Sedentary Behaviour Database (EPPI-Centre interface)
- OAlster (<http://oaister.worldcat.org/>)
- OpenGrey (www.opengrey.eu/).

The following obesity-related organisation websites were searched:

- Public Health England – Obesity Knowledge and Intelligence (previously National Obesity Observatory) (www.noo.org.uk/)
- Association for the Study of Obesity (www.aso.org.uk/)
- Obesity Learning Centre (www.obesitylearningcentre.org.uk/)
- National Obesity Forum (www.nationalobesityforum.org.uk/)
- British Dietetic Association (www.bda.uk.com/index.html)
- Centre for Diet and Activity Research (CEDAR) (www.cedar.iph.cam.ac.uk/)
- The Nutrition Society (www.nutritionociety.org/)
- International Association for the Study of Obesity (www.iaso.org/)
- European Association for the Study of Obesity (EASO) (www.easoobesity.org/)
- European Congress on Obesity (www.easo.org/eco2013)
- European Childhood Obesity Group (ECOG) (www.ecog-obesity.eu/)
- Centers for Disease Control and Prevention (CDC) Division of Nutrition, Physical Activity, and Obesity (USA) (www.cdc.gov/nccdphp/dnpao/index.html)
- Weight-control Information Network (USA) (<http://win.niddk.nih.gov/>)
- The Obesity Society (USA) (www.obesity.org/)
- myhealthywaist.org (International Chair on Cardiometabolic Risk of Université Laval – QC, Canada) (www.myhealthywaist.org/).

Citation searches were conducted in SCI and Google Scholar. All sources proposed in the protocol are listed above.

Inclusion criteria

As systematic reviews had already been conducted for questions 1 and 2, good-quality systematic reviews that could be used as a basis for the current review were sought for these questions. Given the nature of the data required for meta-analysis, many studies included for these questions may be of cohorts recruited when influences in childhood were most likely different to those experienced by the present-day child population. However, reviews where such older cohorts are included were not excluded from the review.

Review of prediction of adult morbidities

- *Outcomes* The study had to report RRs, odds ratios (ORs), hazard ratios (HRs) or summary estimates of predictive accuracy, or sufficient data from which these could be derived, for the association between childhood obesity and adult CVD, type 2 diabetes or cancer. For the purposes of this review, CVD incorporated major cardiovascular events such as cardiovascular death, myocardial infarction, stroke, heart failure, hypertension, hypercholesterolaemia and metabolic syndrome.
- *Interventions* Data for the following simple measures were included: BMI, NC, WC, WHR, WHtR, BAI, Rohrer's Ponderal Index, Benn's Index, FMI, SFT, BIA and NIR. Studies were included for each of these measures, regardless of how the measurement was conducted (i.e. any level at which WC was measured was eligible).
- *Study design* Prospective, longitudinal studies that were sufficiently powered (1000 participants) and that evaluated any one of the interventions of interest used in childhood for the prediction of a morbidity of interest in adolescence or adulthood were eligible; case-control studies and retrospective studies were excluded.

There are many other types of morbidity where evidence of an association with obesity exists, including mental health problems, respiratory conditions and musculoskeletal conditions, among others. This review considered only cardiovascular conditions, diabetes, cancer and metabolic syndrome, in order to focus on those conditions most likely to lead to mortality, where the evidence of association with obesity was strongest, and where there was most likely to be long-term evidence in cohort studies of their association with childhood obesity.

Tracking of childhood obesity into adolescence/adulthood or adolescent obesity into adulthood

- *Population* Studies recruiting children and/or adolescents (up to the age of 18 years) were eligible for inclusion. Studies recruiting a mixture of adults and children/adolescents were included if the results for children/adolescents were reported separately. Studies had to recruit either population-based samples of children or overweight/obese children; studies conducted only in children who were not overweight or obese were excluded. We accepted the definition of obesity/adiposity used in the study.
- *Interventions* Data for the following simple measures were sought: BMI, NC, WC, WHR, WHtR, BAI, Ponderal Index, Benn's Index, FMI, SFT, BIA and NIR. Studies were included for each of these measures, regardless of how the measurement was conducted (i.e. any level at which WC was measured was eligible).
- *Outcomes* The study had to report estimates of test accuracy, or sufficient data from which these could be derived, for the association between the weight status in childhood and/or adolescence and the incidence of obesity/overweight in adulthood. This was a change from the protocol, required as data on the association between weight status in childhood and adulthood would be insufficient to assess the predictive accuracy of childhood obesity/overweight. Studies that reported only correlations between the childhood and adult measures were also excluded.
- *Study design* Prospective, longitudinal studies that evaluate any one of the interventions of interest were eligible; case-control studies and retrospective studies were excluded. Inclusion was initially restricted to studies that recruited at least 100 children; this was increased to 1000 children in studies of BMI given the volume of evidence available and so as to include only well-powered studies. As inclusion was restricted to those studies where predictive accuracy of the anthropometric measure could be established, only studies that used an acceptable reference standard in adulthood [i.e. a multicomponent model, D₂O, underwater (hydrostatic) weighting, ADP or DEXA] were included. BMI was added to the list of reference standards as it is generally accepted as a suitable estimate in adults and we expected it to be the most commonly used adult measure (see *Appendix 2*).

The diagnostic accuracy of childhood measures of obesity

- *Population* Studies recruiting children and/or adolescents (up to the age of 18 years as defined in the NICE CG43 obesity guidelines) were eligible for inclusion. Studies recruiting a mixture of adults and children/adolescents were included if the results for children/adolescents were reported separately. Studies had to recruit either a population-based sample of children or overweight/obese children; studies conducted only in children who were not overweight or obese were excluded.
- *Interventions* The following simple measures were evaluated: BMI, NC, WC, WHR, WHtR, BAI, Ponderal Index, Benn's Index, FMI, SFT, BIA and NIR.
- *Reference standard* A multicomponent model that measures four or five components was considered the gold standard for assessing the accuracy of simple anthropometric measures of adiposity in children, because the precision of such a model is considered to be higher than other complex measures. The other complex measures, such as DEXA, D₂O and densitometry [underwater (hydrostatic) weighting or ADP], were accepted as reference standards as they are more commonly used in research studies; these were considered imperfect reference standards.
- *Outcomes* The study had to report either summary estimates of diagnostic accuracy or sufficient data from which these could be derived.

- *Study design* Prospective single-gate (diagnostic cohort) studies that evaluated any one of the interventions of interest in comparison with any one of the reference standards were eligible for inclusion. For measures for which these are not available, prospective two-gate (diagnostic case-control) studies were included; these had to match cases and controls on at least age and sex, or provide estimates of sensitivity and specificity that had been adjusted for these variables.

The acceptability and ease of use of childhood measures of obesity

The original intention was to identify primary studies that undertook a robust evaluation (such as the use of questionnaires or interviews) of the acceptability and ease of the most promising measure(s) in terms of diagnostic and predictive accuracy. Given that the majority of the data identified were for BMI, this was amended to a search for studies of acceptability and ease of use for the four measures most commonly used in clinical practice: BMI, SFT, WHR and WHtR. Studies could be from the perspective of the child, parent or health professional. Studies that discussed acceptability or ease of implementation with no direct measurement were not included. Given the recent changes in distribution across the population, the emphasis placed on education and intervention for obesity and general attitudes towards obesity, the inclusion of primary studies was initially restricted to those conducted within the previous 5 years (search start date 2008). It was expected that the number of studies addressing this issue would be small. Only one study was identified that met the inclusion criteria.⁷³ Two further studies were identified from the searches for questions 1, 2 and 3 that were published in 2006⁷⁴ and 2007;⁷⁵ given the paucity of evidence, the results of these are also presented.

To supplement the systematic review, a simple elicitation exercise (survey) was performed to obtain some indication of the attitudes of children, school nurses and parents to the measures being evaluated. Ethical approval from the Carnegie Faculty Committee, Leeds Metropolitan University, UK, was obtained. Overweight and obese children attending a weight management summer camp, parents of the children attending the weight management camp and school nurses were asked to complete a structured questionnaire developed specifically for the project that was suitable for the age group concerned. Opinions were elicited for the same four measures being evaluated in the systematic review of acceptability and ease of use: BMI, SFT, WHR and WHtR.

Data extraction strategy

Data extraction was conducted by one reviewer using standardised data extraction forms and independently checked by a second reviewer; separate forms were developed for the different review questions. Discrepancies were resolved by discussion, with involvement of a third reviewer when necessary. Data from multiple publications of the same study were extracted and reported as a single study, unless there was no overlap. Extraction included data on study details (e.g. author, year, country, setting, number of participants), patient characteristics (e.g. age, sex, ethnicity), details of intervention [measure used; classification and reference data used; timing of measurement; threshold used for diagnosis of overweight and obesity; variations in the method used when undertaking the measurement (e.g. equations used)], study quality and reported outcomes as specified above. For the morbidity review, where studies reported adjusted and non-adjusted outcome results, adjusted values were extracted, and where different levels of adjustments were reported [e.g. adjusting for age and sex only vs. adjusting for age, sex and socioeconomic status (SES)], results with the highest number of adjustments were generally preferred. However, results where adult weight status was *not* adjusted for were preferred to estimates that were adjusted for this variable. Full data extraction tables are given in *Appendix 3*.

Quality assessment strategy

The quality of the individual studies was assessed by one reviewer and independently checked by a second reviewer. No primary study was excluded based on the result of the quality assessment; disagreements were resolved by consensus and, if necessary, a third reviewer was consulted. The quality of included

studies was assessed using standard checklists suitable for the study design: Quality Assessment of Diagnostic Accuracy Studies (QUADAS) was used for studies of diagnostic accuracy,^{76,77} and Quality in Prognosis Studies (QUIPS) formed the basis of the assessment of the studies of predictive value.^{78,79} These tools were adapted as necessary to be review question-specific and to incorporate topic-specific quality issues; the most important of these adaptations was an assessment of measurement bias. Blinding of the assessors to index tests and reference standards was not assessed in the review of diagnostic accuracy owing to the visual clues at the time of the assessment.

The quality of the recent and relevant systematic reviews under consideration for inclusion in the current review was assessed using the criteria used by CRD for inclusion on the DARE database. Those that were included as a basis for the current review were assessed in terms of the strategy used to identify studies; the clarity of the review question and reproducibility of the inclusion criteria; the use of methods to reduce error and bias during the review process; the appropriateness of the quality assessment tool used to assess primary studies and the reporting of the results, analyses undertaken and interpretation of the results; the appropriateness of the conclusions drawn; and whether or not the patient population was representative. Primary qualitative studies were assessed using the Critical Appraisal Skills Programme Qualitative Research Checklist.⁸⁰ Full results of the quality assessments and guidance for their completion are given in *Appendix 4*.

Data analysis

Review of prediction of adult morbidities

The review of the association between childhood obesity and adult obesity-related morbidity, and the prediction of adult morbidities from childhood obesity status, was based on the identified cohort studies. Most cohorts were reported in multiple publications. Different publications concerning the same cohort were all included, provided they reported on different morbidities or reported results at different childhood ages.

Although studies reported many morbidity outcomes, only the following were considered in the meta-analyses:

- diabetes (adult-onset, type 2)
- CHD
- stroke
- hypertension
- breast cancer
- all other cancers, combined.

These were the only protocol-specified morbidities reported in at least two cohorts. Cancers were combined because a range of different cancers were reported within and across cohorts. In the narrative review we also considered hypercholesterolaemia and metabolic syndrome.

As results were reported at different ages, we grouped ages as:

- under 7 years
- 7–11 years
- 12–18 years.

The first group represents young children who may experience adiposity rebound, where BMI declines up to around age 7 years. The other two groups represent typical UK division between primary- and secondary-level education.

Studies reported results in a variety of ways, including numbers of morbidities in different BMI categories, ORs comparing different categories of BMI, ORs between different centiles of BMI, ORs per standard deviation (SD) increase in BMI (or, equivalently, per BMI z-score unit) and across different reference populations. Given the diversity in reporting, a direct meta-analysis of results was not feasible. In order to perform a meta-analysis, all results were converted into ORs per SD of BMI (with 95% CIs), and into estimates of predictive performance in terms of sensitivity at specified obesity thresholds. The approach used for this conversion followed the methods of Morris and Wald⁷⁰ for converting reported ORs into estimates of predictive performance. It requires some assumptions about the distributions of obesity in the childhood population, specifically:

- that BMI follows a normal distribution
- that the SD of BMI is the same in people with and without the morbidity
- that the morbidity is rare.

It is acknowledged that the first assumption is invalid, as BMI is not normally distributed and has a positive skew, but this assumption is required for a meta-analysis to be performed, and it is applied equally to all studies, so any error applies uniformly across the analysis. The other assumptions are more reasonable in this context. Tests on simulated data suggest that, for positively skewed distributions of BMI, these assumptions may slightly overestimate ORs, but the overestimation is unlikely to exceed an absolute increase of 0.1. Using these assumptions will therefore also lead to overestimates of predictive accuracy by increasing estimates of sensitivity. The effect of the assumptions is uncertain, but tests on simulated data suggest that the area under the summary receiver operating characteristic (ROC) curve could be overestimated by up to 20%. As data in publications were presented as ORs without data on the distribution of BMI, it was not possible to transform these data to better represent a skewed distribution.

For each morbidity outcome and within each age group, a DerSimonian–Laird random-effects meta-analysis was performed to pool ORs per SD of BMI across cohorts. This produced a summary estimate of the association between childhood obesity and adult morbidity. As the SDs are specific to each cohort, these results should be interpreted as the OR per SD in a ‘typical’ population. To aid interpretation, some ORs were converted into odds per kg/m² of BMI, based on the SD of BMI in adolescents in the UK (about 2.5 kg/m²).⁸¹

Meta-analyses of the predictive accuracy of childhood obesity for predicting future morbidity were also performed. For each study, the sensitivities for predicting the morbidity among overweight (85th centile of BMI) and obese (95th centile) children were calculated using the methods of Morris and Wald⁷⁰ described above. These sensitivities and their 95% CIs were then pooled across studies in standard DerSimonian–Laird random-effects meta-analyses to summarise the predictive sensitivity of childhood obesity to predict adult morbidity. These pooled estimates were converted into summary ROC curves. The assumption that the disease is rare means that specificity cannot be calculated in these analyses; only sensitivity at specified thresholds of BMI were presented, rather than true ROC curves. All analyses were performed using the R version 3.1 software (The R Foundation for Statistical Computing, Vienna, Austria).

No analyses of potential for publication bias were performed given both the limited number of studies in each meta-analysis and the uncertainty over the validity of such tests when reviewing predictive or prognostic outcomes.

All cohort studies in this review reported single measurements of BMI rather than repeated measurements over time. The use of single measurements may lead to regression to the mean, because children with an extreme measurement at a particular time are more likely to have a less extreme result at some later time, leading to underestimation of the association. Although regression to the mean is an acknowledged problem in measurements that change rapidly over time, such as blood pressure or blood lipids,⁸² it is unlikely to be a problem for BMI, which by its nature can vary little over short periods of time.

The aim of this review was to assess the ability of childhood obesity to predict adult morbidity; for this reason, no adjustment for adult morbidity was considered.

Review of tracking of obesity into adulthood

The analysis of the studies tracking obesity from childhood to adulthood was based on the diagnostic accuracy data extracted from these studies. Data were reported for tracking from childhood obesity (defined as BMI above the 95th centile) or overweight (above the 85th centile) to adult obesity (defined as BMI above the 95th centile or over 30 kg/m²) or adult overweight (above the 85th centile or over 25 kg/m²).

This allowed for four separate tracking analyses:

- childhood obesity to later obesity
- childhood obesity to later overweight or obesity
- childhood overweight or obesity to later obesity
- childhood overweight or obesity to later overweight or obesity.

Some studies reported data on only one of these comparisons, some on two and some on all four, so certain studies contributed to only some of the analyses.

Ages were split into four categories:

- childhood (ages 7–11 years)
- adolescence (ages 12–18 years)
- adulthood (age 20 years and over)
- aged over 30 years (to examine longer-term obesity tracking).

Studies reporting on obesity below age 7 years were excluded to avoid including children with adiposity rebound.

Given these ages, analyses were conducted to examine tracking:

- from childhood to adolescence
- from childhood to adulthood
- from adolescence to adulthood
- from adolescence to aged over 30 years.

Analyses were not stratified by sex as these data were too limited. Only BMI was considered as only two studies reported data on any other obesity measure (WC).

To assess the association between childhood obesity and adult obesity, the risk of being obese in adulthood given obesity status in childhood was calculated for each study from the diagnostic data. The RR of adult obesity, with its 95% CI, when comparing obese and non-obese children was calculated. These RRs were pooled in a DerSimonian–Laird random-effects meta-analysis, stratified by age group at time of obesity measurement.

The diagnostic accuracy data were synthesised in meta-analyses to estimate summary sensitivity, specificity and positive predictive values (PPVs) across the studies. As sensitivity and specificity are known to be correlated, the bivariate model was used to jointly analyse sensitivity and specificity.⁸³ Summary ROC curves were produced using the hierarchical summary ROC (HSROC) model,⁸⁴ which is mathematically equivalent to the bivariate model. PPVs were similarly jointly modelled with negative predictive values (NPVs) using an adaptation of the bivariate model. These analyses did not correct for differences in obesity prevalence, which will lead to heterogeneity in PPVs and NPVs. The bivariate model requires full diagnostic accuracy data (i.e. numbers of true and false positives, and true and false negatives); therefore, studies that only

presented summary sensitivity and specificity data were excluded. All results were presented as summary estimates with 95% CIs and HSROC curves, plotted in ROC space. The more formal 95% joint confidence regions for sensitivity and specificity were not presented for reasons of clarity.

No analyses of potential for publication bias were performed given uncertainty over the validity of such tests when reviewing predictive or prognostic outcomes.

All analyses were performed using the R software, using in-house code designed to be equivalent to the *metandi* library available for Stata version 13 (StataCorp LP, College Station, TX, USA).

Review of diagnostic accuracy

The review of studies of diagnostic accuracy was primarily a narrative review owing to the substantial clinical heterogeneity across the studies. The assessment of diagnostic accuracy was conducted as a supportive question to the primary reviews of predictive accuracy. As a result, data extraction was planned for those thresholds used by studies in the reviews of predictive accuracy. Given that the majority of studies in the predictive accuracy reviews evaluated BMI, using a range of commonly used cut-off points (85th centile, 95th centile, one and two SDs), these data were extracted from the diagnostic accuracy studies evaluating BMI. The other index tests of interest were rarely evaluated in the studies of predictive accuracy, and the thresholds for these tests are less well established. As a result, data were extracted for a more diverse range of cut-off points. Where a study did not report the threshold used, these data were extracted. Study details and results were tabulated.

For the analysis of BMI, inclusion was restricted to those studies that used a cut-off point of 85th centile for overweight and 95th centile for obesity and were conducted in a population representative of the UK child population. This gave us the most homogeneous data set that could be derived from the BMI studies, and we considered these to be the most informative data and those that would be the most reflective of the accuracy of BMI when used in a setting such as a school, where screening often takes place. To produce summary estimates of accuracy for BMI, HSROC curves were produced and the bivariate model fitted as described above for the tracking review using Stata version 13.

For the studies evaluating tests other than BMI, a narrative synthesis was presented, as there were fewer studies that were too heterogeneous to pool. We considered the most robust data to be from those studies that conducted direct comparisons of more than one test (two or more tests conducted in the same patients, using the same reference standard in all patients). We therefore used these studies to gain an insight into the comparative accuracy of the tests being evaluated. The results of these studies were tabulated and a narrative synthesis provided; limited numbers of studies and the range of obesity measures considered precluded any meta-analysis of these data. To aid interpretation of these data, estimates of sensitivity and specificity from studies which compared the diagnostic accuracy of BMI with some other simple obesity measure were plotted in ROC space, and diagnostic ORs (DORs) were calculated. This could only be undertaken for those studies from which 2×2 data could be extracted or derived; therefore, there are some test results in the tables of sensitivity and specificity that do not appear in the diagrams.

To help understand why one test may have a better predictive accuracy than another, we planned to compare the sensitivities and specificities for predictive and diagnostic accuracy of those tests evaluated in the predictive accuracy reviews. There were insufficient predictive accuracy data for non-BMI measures for this to be completed.

Review of the acceptability and ease of use of simple childhood measures of obesity

Study details and results have been summarised in tables and a narrative provided. The results of the elicitation exercise have been summarised in a narrative, with the summary results presented in tabulated form.

Chapter 3 Results

Flow of studies through the review

The screening process was undertaken in three stages. The initial stage was to screen for relevant systematic reviews for the morbidity review, and reviews and primary studies for the tracking and diagnostic accuracy reviews. After deduplication, there were 10,296 retrievals from the initial electronic searches, which were supplemented by the searching of bibliographies of relevant reviews, and primary diagnostic accuracy studies, which added 62 studies; seven studies were identified in the subsequent search for primary studies for the morbidity review which were also screened for inclusion in the tracking and diagnostic accuracy reviews (*Figure 1*).

Once the relevant systematic reviews were identified from the first screening stage for the morbidity review,^{18–22} these were used to set the parameters of the second search for primary studies. After deduplication, there were 5690 retrievals from the electronic searches, which were supplemented by the searching of bibliographies of the previous reviews of the prediction of adult morbidities, which added 52 studies. A further 30 primary studies from the initial screening stage were also considered potentially relevant and screened for the review of adult morbidities (*Figure 2*).

The third stage of screening was for the review of acceptability and ease of use review. From the focused searches conducted, 1494 citations were retrieved from the electronic searches; three further studies were screened that were identified during stage one of the screening process (*Figure 3*).

Across the three searches and screening stages, 12 papers were unobtainable; for eight, the review team considered there to be sufficient information available to reliably exclude the study from the review,^{85–92} and for four a decision could not be made, but the study had to be excluded owing to lack of data.^{93–96} Twenty studies were excluded from the review as they were linked to included studies and did not provide unique data.^{97–116}

After completion of the screening process, 95 studies were included in the review; 23 evaluated the tracking of obesity into adulthood,^{117–139} 37 the association between obesity in childhood/adolescence and morbidity in adolescence/adulthood,^{117,118,123,129,140–172} 34 diagnostic accuracy^{173–206} and 5 acceptability and/or ease of use.^{73–75,207,208}

For the review of adult morbidities, 13 reviews were identified.^{18–22,209–217} One was an abstract for which there was no full paper.²¹⁰ Of the remaining 12, most evaluated only BMI.^{18–22,213–215,217} Only the review by Whitlock *et al.* (2005)²¹⁴ included studies of childhood measurements of interest other than BMI. The review reported on weight-to-height ratios and SFT and their correlation with outcomes in adulthood such as fasting insulin levels, cholesterol and blood pressure. Although the reviews by Park *et al.* (2011),¹⁸ Reilly *et al.* (2011),²² Owen *et al.* (2009),²¹ Lloyd *et al.* (2010)²⁰ and Lloyd *et al.* (2012)¹⁹ were considered the most recent relevant, the overlap in included studies across all of the identified reviews was poor. As a result, no individual reviews were considered to be sufficiently complete. Therefore, the included studies from all of the identified reviews were screened. In addition, the bibliographies of relevant reviews that were identified by the searches but were not considered suitable for updating (mainly because they did not appear to use systematic methodology) were also searched. All potentially relevant studies were retrieved from these reviews, regardless of the age of the study.

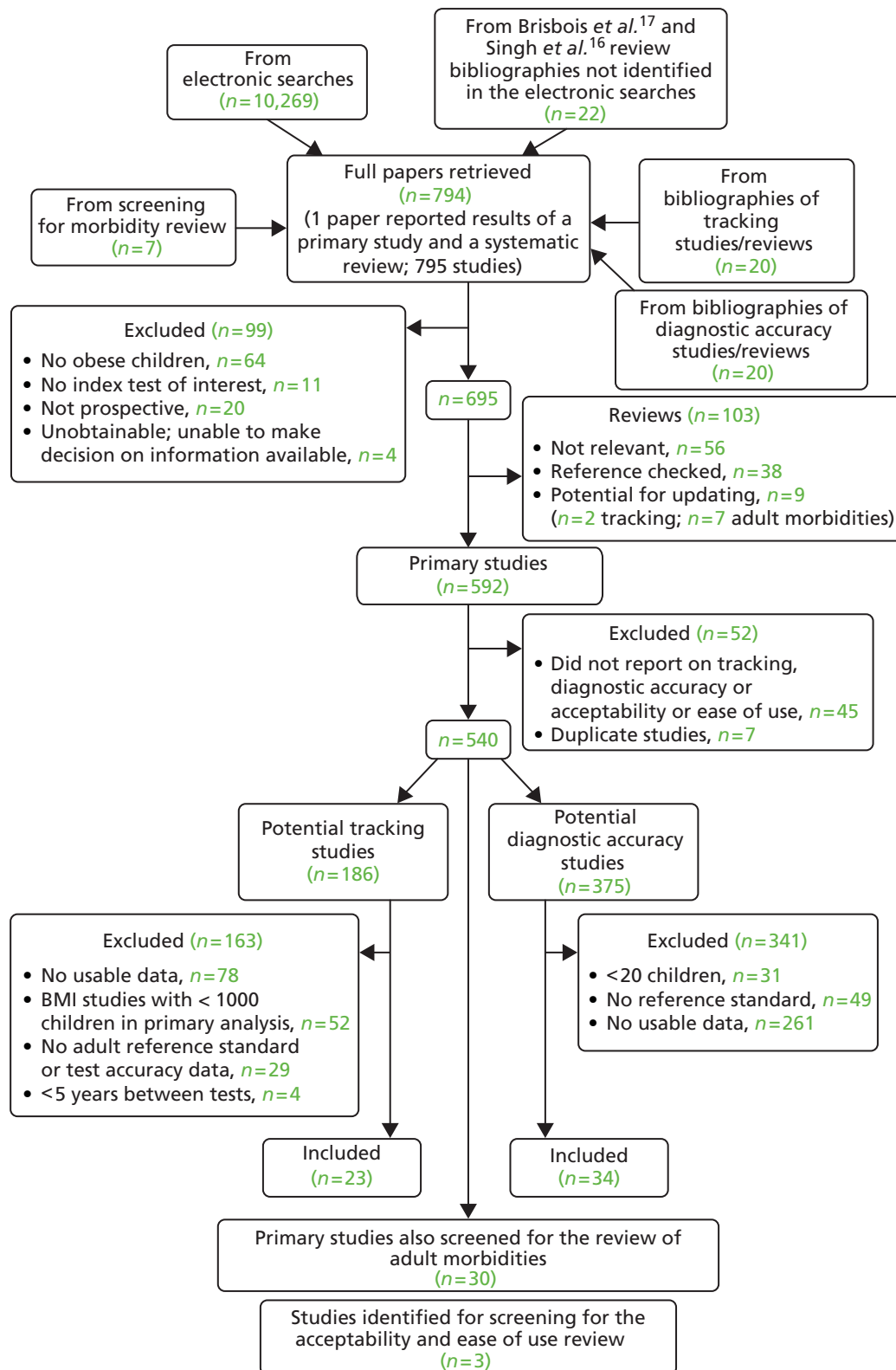


FIGURE 1 Flow of studies through the initial screening period of the review to identify systematic reviews for the tracking and adult morbidity reviews, and primary studies for the review of tracking and diagnostic accuracy.

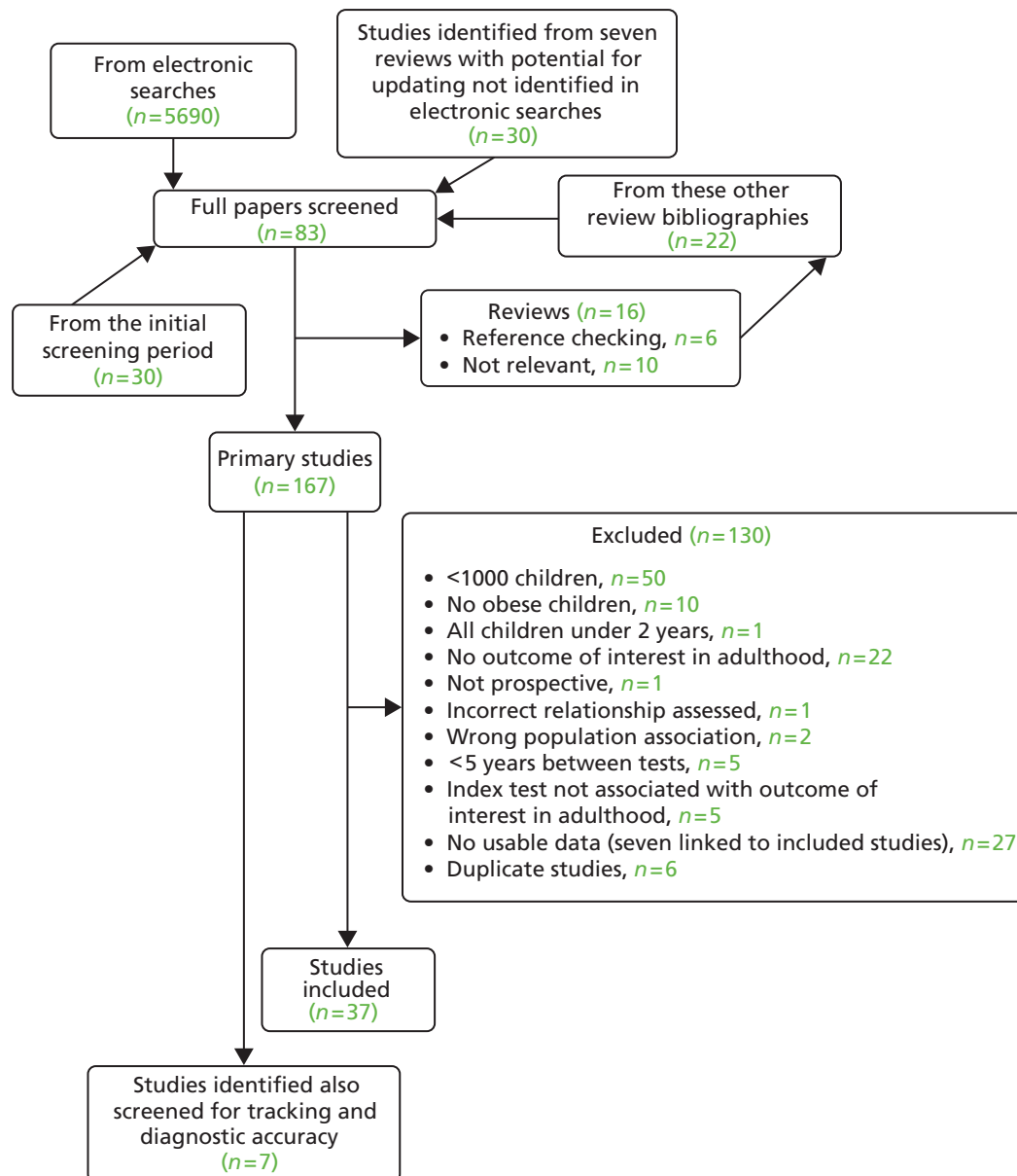


FIGURE 2 Flow of studies through the second screening period of the review to identify primary studies of the relationship between childhood overweight and obesity and adult morbidities.

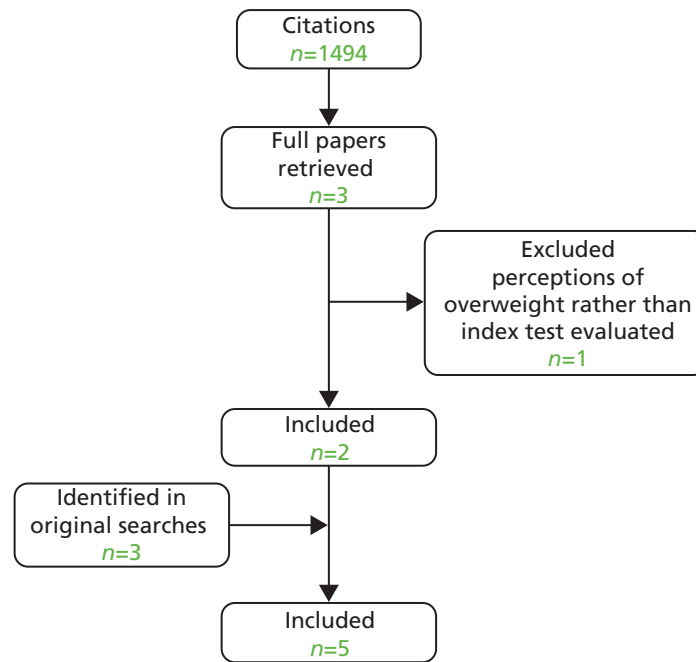


FIGURE 3 Flow of studies through the third screening period of the review to identify primary studies of the acceptability and ease of use of four childhood measures of obesity.

Review of prediction of adult morbidities

Summary of the existing systematic reviews of the prediction of adult morbidities

Of the 13 reviews with potential for being updated that were identified,^{18–22,209–217} the reviews by Park *et al.* (2012),¹⁸ Reilly *et al.* (2011),²² Owen *et al.* (2009),²¹ Lloyd *et al.* (2010)²⁰ and Lloyd *et al.* (2012)¹⁹ were the most recent and relevant to our review of adult morbidities. This subsection presents a brief critical summary of these five reviews.

Reilly *et al.* (2011)²² did not restrict their searches to any particular childhood measure of obesity, but only found studies on BMI and self-reported/recalled 'weight status'. All other reviews included only BMI as a simple childhood measure of obesity. Most studies included in the reviews used cohort designs, although a smaller number of case–control studies were also eligible. Population eligibility criteria varied across the studies; Reilly *et al.* (2011)²² and Lloyd *et al.* (2010)²⁰ included children from birth to age 18 years, but Park *et al.* (2012)¹⁸ and Lloyd *et al.* (2012)¹⁹ excluded children aged under 2 years. The review by Owen *et al.* (2009)²¹ reported on a significantly wider age range as it included individuals from birth up to age 30 years. The large majority of the studies were conducted in general populations from Europe (particularly Scandinavian countries and the UK) and the USA. None of the studies appeared to include specifically selected populations of children (such as children with cancer or children undergoing a weight reduction intervention). None of the reviews reported a restriction on sample size, and therefore the size of the studies varied widely, from under 100 to over 1.1 million participants.

Eligible outcomes varied across the reviews. The reviews by Park *et al.* (2012)¹⁸ and Reilly *et al.* (2011)²² had the broadest scope as they focused on both adult mortality and morbidity. Lloyd *et al.* (2010)²⁰ reported outcomes relating to CVD events and CVD risk, and Owen *et al.* (2009)²¹ focused on CHD events. The review by Lloyd *et al.* (2012)¹⁹ was the only one to focus exclusively on metabolic syndrome and its individual components [type 2 diabetes, total cholesterol, triglycerides, high-density lipoprotein (HDL-) cholesterol, low-density lipoprotein (LDL-) cholesterol, fasting insulin, insulin resistance]. The number of individual studies included in the reviews ranged from 11 [Lloyd *et al.* (2012)¹⁹] to 39 [Park *et al.* (2012)¹⁸].

The quality of included studies was evaluated in three reviews.^{18–20} However, only Lloyd *et al.* (2010²⁰ and 2012¹⁹) reported the results of their quality assessments, which were based on the Newcastle Ottawa Scale. The key methodological limitations that they identified related to variation in type and number of adjustments made in the analyses of the primary studies, and the relatively young age of adults at follow-up in some studies. Quality relating to participant selection, comparability of study groups and measurement of outcomes was generally considered acceptable.

Only Owen *et al.* (2009)²¹ combined studies in a meta-analysis, stratified by baseline age group. All others reported the results of their included studies narratively by outcome. Lloyd *et al.* (2010²⁰ and 2012¹⁹), Park *et al.* (2012)¹⁸ and Owen *et al.* (2009)²¹ also grouped studies based on whether or not they adjusted for adult BMI in their analyses.

In all reviews, a majority of studies reported a positive and statistically significant association between childhood BMI and adult morbidity. However, results varied by outcome. Both Park *et al.* (2012)¹⁸ and Reilly *et al.* (2011)²² found consistent evidence of a statistically significant positive association between childhood BMI and diabetes in adulthood. Park *et al.* (2012)¹⁸ reported that ORs for a one-unit increase in BMI SD score ranged from 1.22 (95% CI 1.10 to 1.36) at school entry ($n = 5793$) to 2.04 (95% CI 1.7 to 2.4) at 16 years of age ($n = 10,683$). Only 1 small study out of 10 found no association between the two variables. However, all three studies that adjusted for adult BMI found that the association was no longer significant after adjustment. In the review by Reilly *et al.* (2011),²² all three studies reporting diabetes outcomes found a significant increase in risk of developing the morbidity in those who were overweight or obese in childhood. Effect sizes were reported for only one study, showing significant association between overweight and obesity at age 5 years and self-reported diabetes at age 21 years (OR 2.6, 95% CI 1.3 to 5.2; $n = 2639$). Lloyd *et al.* (2012)¹⁹ found little evidence that childhood obesity is an independent risk factor for diabetes mortality, although their result was based on a single study.

Evidence of an association between childhood BMI and adult CHD was somewhat more mixed. The pooled analyses from Owen *et al.* (2009)²¹ showed that a 1-SD increase in BMI in early childhood [2–6 years (three studies)] was associated with reduced CHD risk (RR 0.94, 95% CI 0.82 to 1.07), although the association was not statistically significant. A weak positive association was found between later CHD risk and a 1-SD increase in BMI in later childhood [7 to < 18 years; RR 1.09, 95% CI 1.00 to 1.20 (seven studies)]. Both analyses showed high levels of heterogeneity. In the review by Park *et al.* (2012),¹⁸ 10 of the 15 studies that explored the relationship between BMI in childhood and objective measures of CHD events reported that increased BMI or overweight at ages 2–25 years was associated with increased risk of CHD in later life. HRs ranged from 1.53 (95% CI not reported) for CHD mortality associated with high BMI at age 11 years to 5.43 (95% CI 2.77 to 10.62) for CHD associated with high BMI at age 17 years. One study ($n = 181$) found that higher BMI at ages 13–18 years was associated with increased risk of CHD morbidity and mortality in men but not in women. The remaining studies reported no association between BMI at ages 2–22 years and CHD. Reilly *et al.* (2011)²² and Lloyd *et al.* (2010)²⁰ both found that two out of three studies which examined the association between childhood BMI and CHD events reported a positive association.

Evidence of an association between childhood BMI and stroke in adulthood was mixed. Park *et al.* (2012)¹⁸ found that, out of nine relevant studies, only four found positive association between BMI and stroke in adulthood. Four studies (including three British studies) reported no association and one showed an inverse relationship between higher BMI at age 7 years and future stroke. Reilly *et al.* (2011)²² reported that two out of three studies which reported on stroke found a significant association between childhood BMI and morbidity in adulthood. Lloyd *et al.* (2010)²⁰ found a pooled study from three historical cohorts and a single study which reported no significantly increased risk of CHD and stroke incidence in adults who were overweight or obese as children.

Evidence of an association between childhood BMI and the risk of developing metabolic syndrome in adulthood was limited. Lloyd *et al.* (2012)¹⁹ found only three studies which considered the link between the two variables. Two studies found that higher childhood BMI was associated with increased odds of

developing metabolic syndrome in adulthood. The third study was the only one to adjust for adult BMI, and found that higher childhood BMI was associated with lower risk of metabolic syndrome in adult life when accounting for adult BMI.

Both Park *et al.* (2012)¹⁸ and Reilly *et al.* (2011)²² found consistent evidence of a statistically significant positive association between overweight or increased BMI in childhood and hypertension in adulthood. Park *et al.* (2012)¹⁸ reported ORs for overweight or increased BMI in childhood that ranged from 1.35 (95% CI 1.13 to 1.64) at age 7 years to 3.75 (95% CI 3.45 to 4.07) at ages 16–19 years in five studies. In the four studies identified by Reilly *et al.* (2011),²² ORs ranged from 1.46 (95% CI 1.01 to 2.12) to 5.1 (95% CI 1.4 to 18.1). On the other hand, Lloyd *et al.* (2010)²⁰ found less consistent evidence that childhood obesity was an independent risk factor for hypertension.

None of the reviews reported studies focusing on hypercholesterolaemia as an outcome in adulthood. Lloyd *et al.* (2012)¹⁹ reported on studies focusing on LDL- and HDL-cholesterol levels. The review found little evidence to support the view that childhood obesity is an independent risk factor for higher LDL- and HDL-cholesterol levels.

Significantly less evidence was found on cancer. Park *et al.* (2012)¹⁸ found limited evidence that childhood BMI is associated with increased risk of colorectal and kidney cancers. Reilly *et al.* (2011)²² found a single study on the association between BMI and cancer, which reported a significant 30% increase (95% CI 10% to 54%) in smoking-related cancers per 1-SD increase in childhood BMI ($n = 2997$).

Reviews differed in their interpretation of the strength and clinical significance of the associations found. They also differed in the emphasis and importance placed on adjustments made for adult BMI. This, in addition to the fact that there was relatively little overlap across the reviews in terms of included studies, may explain why the conclusions of the reviews differed.

Reilly *et al.* (2011)²² concluded that there is a relatively large and highly consistent body of evidence which shows that overweight and obesity in childhood and adolescence have substantial and adverse long-term consequences for physical health. However, we feel that these conclusions were too strong; there was some variation in the size and direction of the effect estimates reported. Additionally, there were concerns about several aspects of the review methods and limited reporting of the study results. Therefore, the conclusions of Reilly *et al.* (2011)²² appear insufficiently cautious and may not be reliable.

The conclusions of Park *et al.* (2012)¹⁸ were more nuanced and more accurately reflected the evidence found. They stated that there is a consistent body of evidence for associations between childhood overweight, unadjusted for adult BMI, and cardiovascular outcomes and mortality in adulthood. They also concluded that evidence for stroke outcomes is mixed, and that there is limited evidence that childhood BMI is associated with increased risk of colorectal and kidney cancers. They also remarked that few studies have assessed the independent effects of childhood overweight on adult disease, and the results of these have been inconclusive.

Owen *et al.* (2009)²¹ concluded that higher levels of BMI may be related to increased levels of CHD risk from early childhood onwards. They stated that the control of obesity from childhood onwards may be an important priority for long-term CHD prevention, although they noted that the independent contribution of early obesity to CHD risk still needs to be established. The review by Owen *et al.* was the only one that conducted a meta-analysis, and the choice of methods appeared appropriate in view of the evidence found, although evidence of significant heterogeneity was reported. However, it is unclear why the authors concluded that higher BMI was associated with an increased risk of morbidity from early childhood even though they reported a weak inverse relationship with adult CHD risk in children under age 7 years. Additionally, the small magnitude of the pooled estimates in later childhood suggests that their clinical relevance may be limited in the context of adult CHD risk prediction. Therefore, the conclusions of the review may not be sufficiently cautious.

The conclusions from Lloyd *et al.* (2010)²⁰ placed greater emphasis on the influence of adult BMI in the association between childhood BMI and adult morbidity than those of Owen *et al.* (2009)²¹ or Park *et al.* (2012).¹⁸ The authors stated that they found little evidence to suggest that childhood obesity is an independent risk factor for CVD risk. They stated that, instead, relationships observed are dependent on the tracking of BMI from childhood to adulthood. Although the evidence found by Lloyd *et al.* (2010)²⁰ appears insufficient to support the notion that childhood obesity is an independent risk factor for CVD risk, the review did not discuss the risks associated with standard adjustment for adult BMI, which may lead to overadjustment bias.²¹⁸ Additionally, the evidence presented by the review was insufficient to suggest that the relationships observed were dependent on the tracking of BMI from childhood to adulthood. Therefore, the conclusions of Lloyd *et al.* (2010)²⁰ may not be reliable.

Lloyd *et al.* (2012)¹⁹ also concluded that there is little evidence to support the view that childhood obesity is an independent risk factor for adult blood lipid status, insulin levels, metabolic syndrome or type 2 diabetes. The conclusions reflected the evidence found, although the volume of the evidence on diabetes was significantly smaller than that reported by Park *et al.* (2012)¹⁸ or Reilly *et al.* (2011).²²

Among all five reviews, it appeared that the review by Park *et al.* (2012)¹⁸ was better conducted and yielded the most reliable conclusions. However, with the exception of the review by Owen *et al.* (2009),²¹ none of the reviews conducted a meta-analysis, which limited the strength of their results. Additionally, none included studies on childhood measurements other than BMI, which limits their relevance to our review questions. Some reviews addressed the issue of BMI tracking into adulthood as a potential confounder in the association between childhood BMI and adult morbidity. However, none formally evaluated the extent to which childhood measures of obesity accurately predict the tracking of obesity into adulthood. Finally, all reviews reported on the association between BMI and adult morbidities (generally expressed as ORs, RRs or HRs), but none in terms of predictive accuracy, and none used formal methods to calculate the predictive performance of childhood obesity for predicting future morbidity. This overview of recent systematic reviews highlights important gaps in the evidence for the predictive power of childhood obesity as a predictor of adult morbidity.

Quality and assessment of bias of the included primary studies for the prediction of adult morbidities

Thirty-seven studies (22 cohorts) met the inclusion criteria for the review of predictive accuracy.^{117,118,123,129,140–172} The assessment of risk of bias is presented in *Table 2* and the full quality assessment in *Appendix 4*. The most common methodological weaknesses were attrition bias and gaps in reporting about attrition rates, followed by outcomes bias (due to self-reporting of morbidities). Biases associated with selection, childhood measurements, use of confounders, reporting and analysis were low in most studies.

Seven studies used self-reported outcome measures and were considered at high risk of outcome bias.^{118,123,129,148,155,160,168} One study used drug medication use as a proxy for hypertension and risk of outcome bias was unclear.¹⁴³ Bias associated with childhood weight status measurement was high in one study, where BMI was calculated based on adolescents' self-reporting of height and weight.¹²⁹ One study did not report sufficient information on the site of WC measurements,¹⁶⁸ and the only study that used SFT as a childhood measurement did not report how the sum of SFTs was calculated.¹⁷¹ Thirty-two studies adjusted for age and sex in their analyses, and were therefore considered at low risk of confounding bias. Two studies did not adjust for sex in their analyses;^{118,169} one adjusted for sex but not age;¹⁴⁶ and one did not adjust for either sex or age.¹⁶⁸ One study had a high risk of reporting bias due to partial reporting of results.¹⁵⁸

TABLE 2 Prediction of adult morbidities: risk of bias assessment

Author (publication year)	Risk of selection bias	Risk of attrition bias	Risk of bias prognostic factor	Risk of bias with outcome	Risk of bias due to confounders	Risk of reporting/analysis bias
Ahlgren (2004) ¹⁴⁰	Low	Unclear	Low	Low	Low	Low
Baker (2007) ¹⁴²	Low	Unclear	Low	Low	Low	Low
Baker (2007) ¹⁴¹	Low	Low	Low	Low	Low	Low
Barker (2002) ¹⁴³	Low	Unclear	Low	Unclear	Low	Low
Barker (2005) ¹⁴⁴	Low	Low	Low	Low	Low	Low
Berentzen (2013) ¹⁴⁵	Low	Low	Low	Low	Low	Low
Bjorge (2004) ¹⁴⁶	Low	Low	Low	Low	Low	Low
Bjorge (2008) ¹⁴⁷	Low	Low	Low	Low	Low	Low
Cheng (2011) ¹¹⁷	Low	High	Low	Low	Unclear	Low
Cheung (2004) ¹¹⁸	Low	High	Low	High	High	Low
De Stavola (2004) ¹⁴⁸	Low	Low	Low	High	Low	Low
Engeland (2003) ¹⁴⁹	Low	Low	Low	Low	Low	Low
Eriksson (2001) ¹⁵⁰	Low	Unclear	Low	Low	Low	Low
Forsen (2000) ¹⁵¹	Low	Low	Low	Low	Low	Low
Forsen (2004) ¹⁵²	Low	High	Low	Low	Low	Low
Goldhaber-Fiebert (2013) ¹²³	Low	Unclear	Low	High	Low	Low
Gunnell (1998) ¹⁵³	Low	High	Low	Low	Low	Low
Hilakivi-Clarke (2001) ¹⁵⁴	Low	Unclear	Low	Low	Low	Low
Hyponen (2003) ¹⁵⁵	Low	High	Low	High	Low	Low
Israeli (2007) ¹⁵⁶	Low	Unclear	Low	Low	Low	Low
Janssen (2005) ¹⁵⁷	Low	High	Low	Low	Low	Low
Jeffreys (2004) ¹⁵⁸	Unclear	Low	Low	Low	Low	Unclear

Author (publication year)	Risk of selection bias	Risk of attrition bias	Risk of bias prognostic factor	Risk of bias with outcome	Risk of bias due to confounders	Risk of reporting/analysis bias
Lawlor (2005) ¹⁵⁹	Low	Low	Low	Low	Low	Low
Lawlor (2006) ¹⁶⁰	Low	High	Low	High	Low	Low
Leiba (2012) ¹⁶¹	Low	Unclear	Low	Low	Low	Low
Leiba (2013) ¹⁶²	Low	Unclear	Low	Low	Low	Low
Levi (2011) ¹⁶³	Low	Unclear	Low	Low	Low	Low
Levi (2012) ¹⁶⁴	Low	Unclear	Low	Low	Low	Low
Li (2007) ¹⁶⁵	Low	Low	Low	Low	Low	Low
Magnussen (2010) ¹⁶⁶	Unclear	High	Low	Low	Low	Low
Mattsson (2008) ¹⁶⁷	Low	High	Low	Low	Low	Low
Merten (2010) ¹²⁹	Low	High	Unclear	High	Low	Low
Morrison (2010) ¹⁶⁸	Low	High	Low/unclear ^a	High	High	Low
Osmond (2007) ¹⁶⁹	Low	Low	Low	Low	High	Low
Sachdev (2009) ¹⁷⁰	Low	High	Low	Low	Low	Low
Schmidt (2011) ¹⁷¹	Low	High	Low/unclear ^b	Low	Low	Low
Tirosh (2011) ¹⁷²	Low	Low	Low	Low	Low	Low
Total	0 high 35 low 2 unclear	13 high 13 low 11 unclear	0 high 36 low 3 unclear ^{a,b}	7 high 29 low 1 unclear	3 high 33 low 1 unclear	0 high 36 low 1 unclear

a Low for BMI; unclear for WC.

b Low for WC, BMI and WHR; unclear for sum SFT.

Characteristics of studies included in the review of prediction of adult morbidities

Study characteristics for prediction of adult morbidities

The study characteristics are presented in *Table 3*. All 37 studies^{117,118,123,129,140–172} included in the prediction of adult morbidity review used BMI (calculated as kg/m²) as a childhood measurement (for details see *Appendix 3*). Only three studies used a childhood measurement other than BMI. Three used WC in childhood,^{117,168,171} and one study also measured the sum of SFTs and WHR.¹⁷¹ No other simple measure of childhood obesity was investigated in relation to adult morbidity.

Definitions of overweight and obesity, methods of standardisation and references used to calculate weight category varied across the studies. Details are given in *Appendix 3* (see *Table 49*). Fifteen studies used an external reference population to define overweight/obesity status and stratify the cohort according to childhood weight status. Twenty-five studies used their own cohort as a reference population. Seven studies reported using internally and externally derived reference populations in their analyses. Of the 15 studies with external reference populations, 10 used a CDC (2000)²¹⁹ reference population, four used Cole (2000),²²⁰ one used Cole (1990)²²¹ and one used a Chinese reference population. Of the 25 studies with internal reference populations, 16 standardised BMI measurements as z-scores. Of those, most (13) calculated age- and sex-specific z-scores. Three studies calculated age-specific z-scores only and adjusted for sex in their analyses.

TABLE 3 Prediction of adult morbidities review: study characteristics

Study/cohort name	Study	Country	Study dates		Setting for anthropometric measure in childhood
			Start	Finish	
Aberdeen	Lawlor (2005) ¹⁵⁹	Scotland	1950	2000	NR
Children of the 1950s cohort	Lawlor (2006) ¹⁶⁰				
Boyd Orr	Gunnell (1998) ¹⁵³	England, Scotland	1937	1995	NR
	Jeffreys (2004) ¹⁵⁸				
British birth cohort 1958	Hypponen (2003) ¹⁵⁵	England, Wales, Scotland	1958	2000	NR
	Li (2007) ¹⁶⁵				
MRC NSHD	De Stavola (2004) ¹⁴⁸	UK	1946	1999	School, community
NCDS	Cheung (2004) ¹¹⁸	UK	1958	2000	NR
Copenhagen	Ahlgren (2004) ¹⁴⁰	Denmark	1930	Up to 2011	School
CSHRR (born 1930–76)	Baker (2007) ¹⁴²				
	Baker (2007) ¹⁴¹				
	Berentzen (2013) ¹⁴⁵				
Young Finns	Mattsson (2008) ¹⁶⁷	Finland	1980	2001	NR
Cardiovascular Risk in Young Finns (born approximately 1962–77)	Magnussen (2010) ¹⁶⁶				
Helsinki 1924	Forsen (2000) ¹⁵¹	Finland	1924	Up to 1997	School
University Central Hospital (born 1924–33)	Hilakivi-Clarke (2001) ¹⁵⁴				

TABLE 3 Prediction of adult morbidities review: study characteristics (*continued*)

Study/cohort name	Study	Country	Study dates		Setting for anthropometric measure in childhood
			Start	Finish	
Helsinki 1934	Barker (2002) ¹⁴³	Finland	1934	Up to 2003	School, outpatient clinics
University Central Hospital, born 1934–44	Barker (2005) ¹⁴⁴				
	Eriksson (2001) ¹⁵⁰				
	Forsen (2004) ¹⁵²				
	Osmond (2007) ¹⁶⁹				
Norway	Bjorge (2004) ¹⁴⁶	Norway	1963	Up to 2005	School
1963–99	Bjorge (2008) ¹⁴⁷				
	Engeland (2003) ¹⁴⁹				
Bogalusa/Young Finns	Magnussen (2010) ¹⁶⁶	USA and Finland	1984	2007	NR
Bogalusa and Cardiovascular Risk in Young Finns (pooled)					
NLSAH	Merten (2010) ¹²⁹	USA	1995	2001	NR
Bogalusa	Janssen (2005) ¹⁵⁷	USA	1976	1996	NR
Bogalusa Heart Study					
NGHS/PFS	Morrison (2010) ¹⁶⁸	USA	PFS: 1973 NGHS: NR	PFS: 2003 NGHS: NR	NR
NLSY79, PSID, NHANES	Goldhaber-Fiebert (2013) ¹²³	USA	1970	2008	Community
ASHFS	Schmidt (2011) ¹⁷¹	Australia	1985	2006	School
1985 (born approximately 1970–8)					
Israel SPEC	Israeli (2007) ¹⁵⁶	Israel	1976	NR	Military medical examination centre
Medical Corps SPEC	Tirosh (2011) ¹⁷²				
Israeli army	Leiba (2012) ¹⁶¹	Israel	1967	2006	Military service recruitment centres
(Born approximately 1948–89)	Levi (2012) ¹⁶⁴				
	Levi (2011) ¹⁶³				
	Leiba (2013) ¹⁶²				
Delhi	Sachdev (2009) ¹⁷⁰	India	1969	2002	NR
(Born from 1969)					
BCAMSS	Cheng (2011) ¹¹⁷	China	2004	2010	School

ASHFS, Australian Schools Health Fitness Survey; BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; CSHRR, Copenhagen Health Records Register; MRC NSHD, Medical Research Council National Survey of Health and Development; NCDs, National Child Development Study; NGHS, National Growth and Health study; NHANES, National Health and Nutrition Evaluation Surveys; NLSAH, National Longitudinal Study of Adolescent Health; NLSY79, National Longitudinal Survey of Youth; NR, not reported; PFS, Princeton follow-up study; PSID, Population Study of Income Dynamics; SPEC, Staff Periodic Examination Center.

Studies were published between 1998 and 2013. Most studies (23 out of 36) were conducted in northern Europe. Eight studies were conducted in the UK, eight in Finland, four in Denmark and three in Norway. Six studies were from Israel, and four were conducted in the USA, one in Australia, one in China and one in India. All studies were designed as longitudinal studies except for three that used data collected as part of a tuberculosis screening programme,^{146,147,149} and six in the context of a military medical examination.^{156,161–164,172} All childhood measurements were made directly, except for one which used recall.¹²⁹

One-third of the studies made all their childhood measurements in school. Some studies collected measurements in school as well as in the community¹⁴⁸ or outpatient settings. In six studies, participants' BMIs were measured in Israeli military centres. Further study characteristics are presented in *Table 3*.

Many of the identified cohorts were commenced between the 1920s and the 1950s, and social conditions for children have changed considerably since that time. It is not clear, therefore, whether or not the association between childhood obesity and adult morbidity from such cohorts accurately reflects the association in present-day children.

Population characteristics for prediction of adult morbidities

The population characteristics are presented in *Table 4* and *Appendix 3*. The size of the cohorts varied widely, from 1889 to over 1.1 million individuals. Baseline age varied across the studies. Children aged between 12 and 18 years were the most often represented, followed by those aged 7–11 years and children aged 6 years or under. Twenty-eight studies measured weight status among children aged over 11 years. Twenty-three studies included children at ages 7–11 years, and seven studies included children at age 6 years or under. Most studies (23 out of 36) included more than one age group. Where reported, birth year of participants ranged from 1924 to 1989.

Seven studies included male individuals only^{150,156,161–164,172} and five studies focused exclusively on females.^{140,148,149,152,154} All other studies included mixed populations. Three USA-based studies included a significant proportion of black American children.^{129,157,168} Two studies classed all or nearly all of their participants as Caucasian.^{156,167} Four studies, which focused on the Israeli Army cohort, reported a varied range of geographical origins.^{129,162–164} The remaining 27 studies did not report the ethnicity or origin of the children they included.

Seven studies reported data on baseline SES. Of those, three were part of the Israeli army cohort,^{161,162,164} where most individuals were classed as having 'medium' SES. Most individuals in the Cardiovascular Risk in Young Finns cohort were also classed as having medium SES,¹⁶⁷ although SES definitions were not provided in these studies. Children in the remaining three studies reported a majority of individuals whose fathers were from a low SES.^{151,152,158}

TABLE 4 Prediction of adult morbidities review: population characteristics

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow (years)	Male (%)
Ahlgren (2004) ¹⁴⁰	Copenhagen – CSHRR	161,063	117,415	7–14	NR	0
Baker (2007) ¹⁴²	Copenhagen – CSHRR	276,835	NR	7–13	NR	51
Baker (2007) ¹⁴¹	Copenhagen – CSHRR	276,835	NR	7–13	≥ 25	51
Barker (2002) ¹⁴³	Helsinki (1934–44)	10,519	8760	1–12	27–63	53
Barker (2005) ¹⁴⁴	Helsinki (1934–44)	10,519	8760	0–11	27–64	53
Berentzen (2013) ¹⁴⁵	Copenhagen – CSHRR	372,636	285,884	7–13	31–80	51
Bjorge (2004) ¹⁴⁶	Norway 1963–99	227,224	227,221	14–19	47–52	51
Bjorge (2008) ¹⁴⁷	Norway 1963–99	227,000	226,682	14–19	Mean 52	51
Cheng (2011) ¹¹⁷	Beijing – BCAMSS	2189	1184	6–16	16 (SD 1.8)	54

TABLE 4 Prediction of adult morbidities review: population characteristics (*continued*)

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow (years)	Male (%)
Cheung (2004) ¹¹⁸	UK – NCDS	17,000	12,327	7, 11, 16	42	52
De Stavola (2004) ¹⁴⁸	UK – MRC NSHD	2547	2187	2–15	47–53	0
Engeland (2003) ¹⁴⁹	Norway 1963–99	NR	111,883	14–19	Mean 41	0
Eriksson (2001) ¹⁵⁰	Helsinki (1934–44)	5502	3544	0–12	27–63	100
Forsen (2000) ¹⁵¹	Helsinki (1924–34)	NR	7086	6–16	31–73	51
Forsen (2004) ¹⁵²	Helsinki (1934–44)	5486	3003	0–11	27–64	0
Goldhaber-Fiebert (2013) ¹²³	USA – NLSY79/PSID/ NHANES	NR	2780	2–15	38–49	51
Gunnell (1998) ¹⁵³	England and Scotland (Boyd Orr)	NR	2399	2–14	Up to 73	49
Hilakivi-Clarke (2001) ¹⁵⁴	Helsinki (1924–34)	NR	3447	7–15	Minimum 38 (76% > 50)	0
Hypponen (2003) ¹⁵⁵	Great Britain – British birth cohort	16,751	10,683	7, 11, 16	41	NR
Israeli (2007) ¹⁵⁶	Israel – SPEC	18,513	NR	16–19	26–45	100
Janssen (2005) ¹⁵⁷	USA – Bogalusa Heart Study	3865	1709	4–15	19–38	44
Jeffreys (2004) ¹⁵⁸	England and Scotland (Boyd Orr)	2997	2347	2–14	Up to 66	49
Lawlor (2005) ¹⁵⁹	Aberdeen cohort	12,150	11,106	Mean 4.9	48–54	NR
Lawlor (2006) ¹⁶⁰	Aberdeen cohort	12,150	5793	Mean 4.9	46–50	NR
Leiba (2012) ¹⁶¹	Israeli army	NR	1,110,835	16–19	Mean 35	100
Leiba (2013) ¹⁶²	Israeli army	NR	1,110,835	16–19	Mean 44	100
Levi (2011) ¹⁶³	Israeli army	NR	1,109,864	16–19	18.7–57.3	100
Levi (2012) ¹⁶⁴	Israeli army	NR	720,927	16–19	29–56	100
Li (2007) ¹⁶⁵	Great Britain – British birth cohort	13,294	9285	7–16	45	52
Mattsson (2008) ¹⁶⁷	Cardiovascular Risk in Young Finns	4320	2195	3–18	24–39	46
Magnussen (2010) ¹⁶⁶	Cardiovascular Risk in Young Finns/Bogalusa	20,745	10,439	12–19	19–26	51.1
Merten (2010) ¹²⁹	USA – NLSAH	1889 (PFS: 822; NGHS: 1067)	Up to 1058 (NGHS)	PFS: mean 12.4; NGHS: NR	PFS: 32–44; NGHS: 19	PFS: 47; NGHS: 0
Morrison (2010) ¹⁶⁸	USA – NGHS and PFS	NR	12,439	0–11	NR	52
Osmond (2007) ¹⁶⁹	Helsinki (1934–44)	8181	1492	2–14	26–33	58
Sachdev (2009) ¹⁷⁰	India (Delhi)	8498	2188	7–15	26–36	50
Schmidt (2011) ¹⁷¹	Australia – ASHFS	NR	37,674	Mean 17.1	Mean 34	100
Tirosh (2011) ¹⁷²	Israel – SPEC	161,063	117,415	Median 7.2–14.5	NR	0

ASHFS, Australian Schools Health Fitness Survey; BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; CSHRR, Copenhagen Health Records Register; MRC NSHD, Medical Research Council National Survey of Health and Development; NCDS, National Child Development Study; NGHS, National Growth and Health study; NHANES, National Health and Nutrition Evaluation Surveys; NLSAH, National Longitudinal Study of Adolescent Health; NLSY79, National Longitudinal Survey of Youth; NR, not reported; PFS, Princeton follow-up study; PSID, Population Study of Income Dynamics; SPEC, Staff Periodic Examination Center.

Sixteen studies reported baseline data on the proportion of children who were overweight and/or obese according to BMI at baseline.^{117,118,123,146,147,149,156–165} Definitions of overweight and obese varied across these studies. One study [Cheng *et al.* (2011)¹¹⁷] reported a high percentage of obese children at baseline (40.8%). The percentage of obese children ranged from 1% to 6.4% in other studies.^{118,123,147,156,157,159,160,165} Where reported, the percentage of overweight children ranged from 6% to 18% at baseline.^{118,123,146,147,156,157,159,160,165} In one study, the majority of children were overweight or obese at baseline [Cheng *et al.* (2011)¹¹⁷]. The percentage of children who were overweight or obese ranged from 3.8% to 21% in other studies.^{118,123,147,149,156–165}

Findings from the review of adult morbidity

Meta-analysis

The meta-analysis was based on 26 published articles representing 13 cohort studies,^{117,129,140–142,145,146,148–151,153–155,158–166,168,169,172} which provided data that could be converted into an OR per 1-SD increase in BMI for each morbidity. There were 32 different classifications of morbidity reported. This analysis considered only those morbidities described in *Chapter 2*.

Analysis of the association between childhood obesity/overweight and adult morbidity

A series of plots of the OR per SD increase in BMI for having a morbidity (with 95% CIs) are presented for each cohort and each morbidity, according to the age at which BMI was measured. *Figures 4–7* present results for diabetes, CHD and cancers, as examples. A plot showing the results for all morbidities is provided in *Appendix 5*.

Figure 4 shows the ORs for having adult diabetes, according to age. This shows that most cohorts showed a statistically significant association between childhood BMI and adult diabetes, with ORs ranging from 1.2 to 2.5 per SD BMI. *Figure 5* shows the association with CHD. Results here were more varied, with two cohorts (Helsinki,¹⁵⁰ Aberdeen¹⁵⁹) showing no association and the others showing a modest increase in

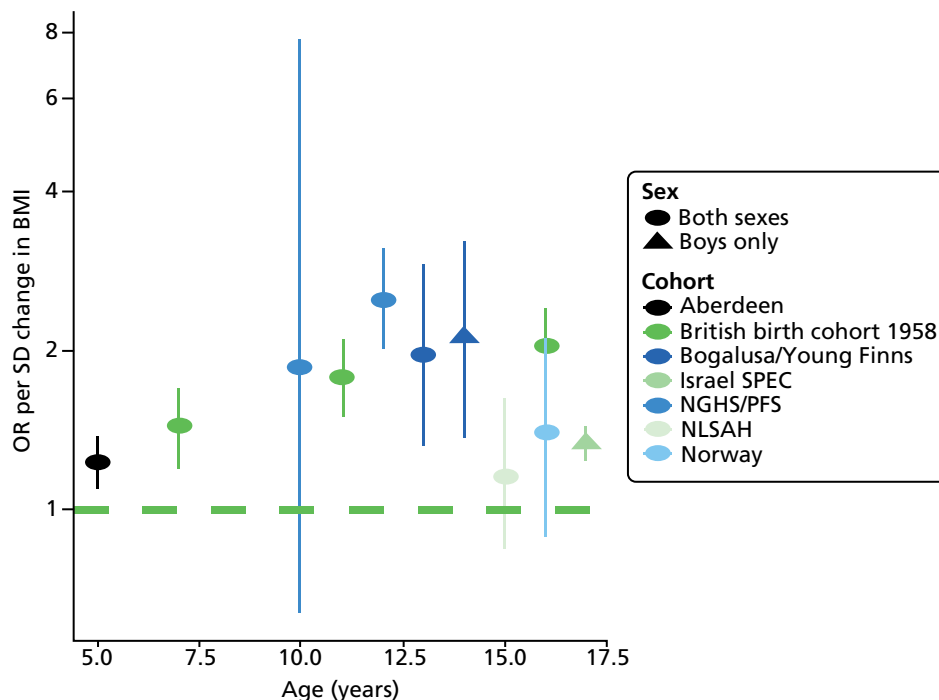


FIGURE 4 Childhood BMI and incidence of adult diabetes. NGHS, National Growth and Health study; NLSAH, National Longitudinal Study of Adolescent Health; PFS, Princeton follow-up study; SPEC, Staff Periodic Examination Center.

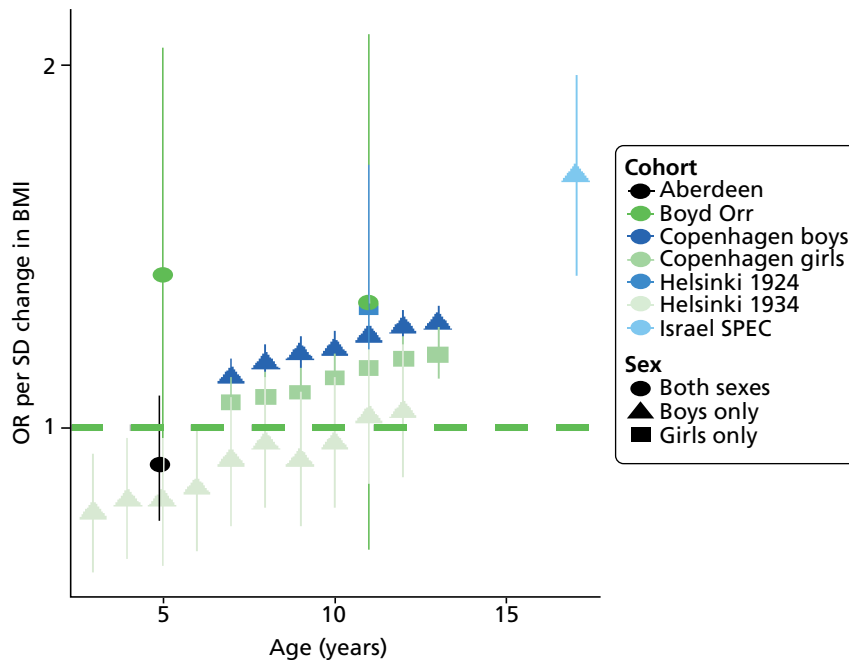


FIGURE 5 Childhood BMI and incidence of adult CHD. SPEC, Staff Periodic Examination Center.

odds of CHD with increased BMI. *Figure 6* shows the association of BMI with breast cancer. In this case there were no statistically significant results in any cohort. *Figure 7* shows the results for other cancers. The cohort studies reported on a large number of cancers, but the general trend appears to be that higher BMI is associated with higher odds of most cancers.

The meta-analyses of ORs per SD BMI of these cohort studies are presented in forest plots, categorised by age at BMI measurement (*Figures 8–13*).

Figure 8 shows the results of the meta-analysis of diabetes. There is a positive association, with an OR of 1.7 for every SD increase in BMI. That is approximately equivalent to a 24% increase in odds per kg/m² increase in BMI for an adolescent. There is no evidence that this is different in the under-twelves and over-twelves, although data for under-twelves are limited.

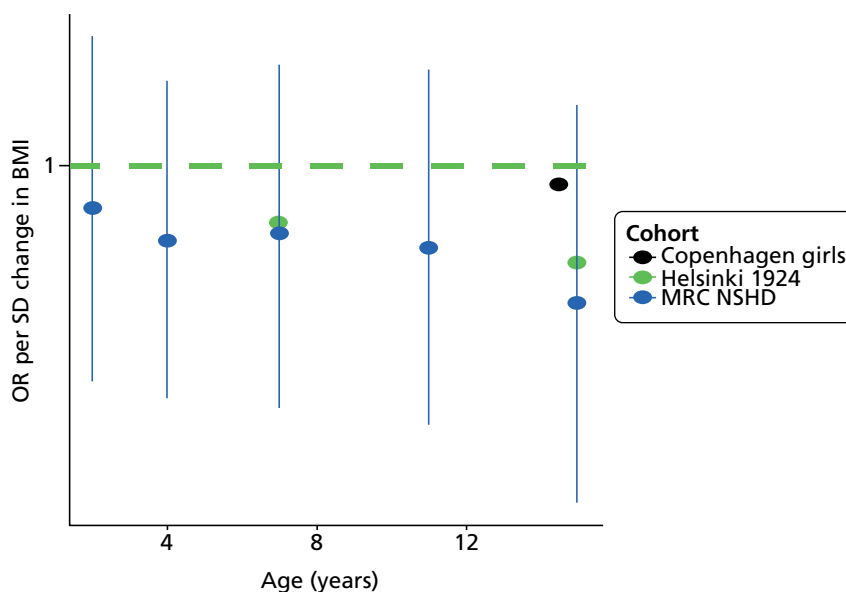


FIGURE 6 Childhood BMI and incidence of adult breast cancer. MRC NSHD, Medical Research Council National Survey of Health and Development.

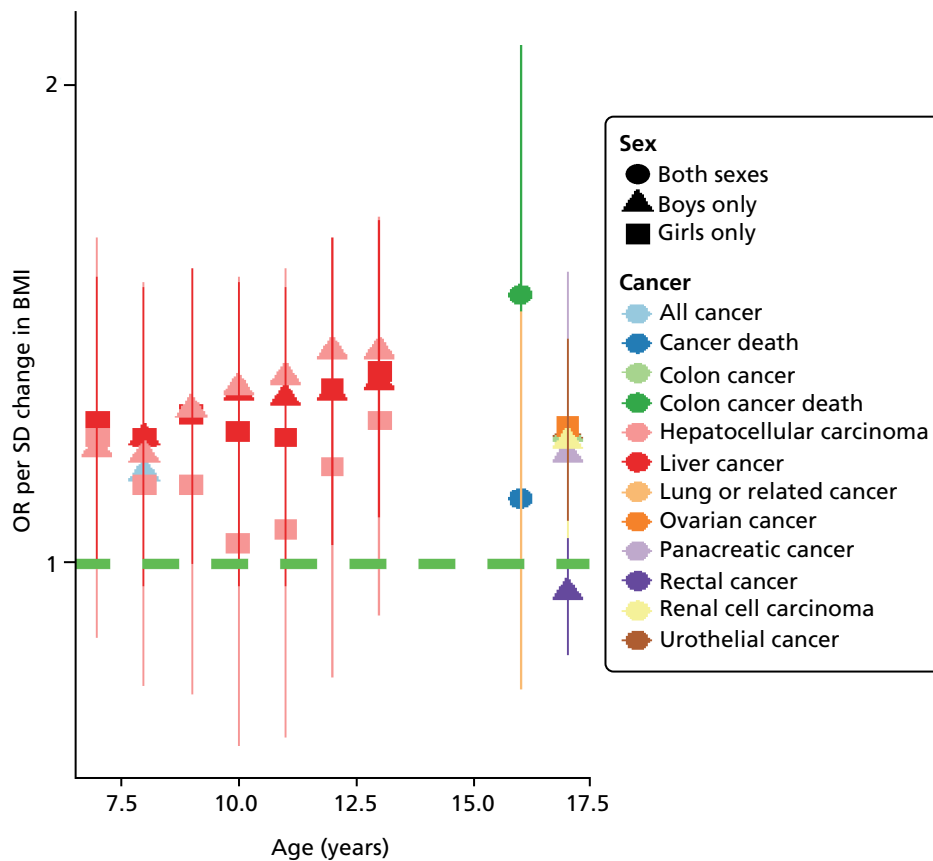


FIGURE 7 Childhood BMI and incidence of other cancers.

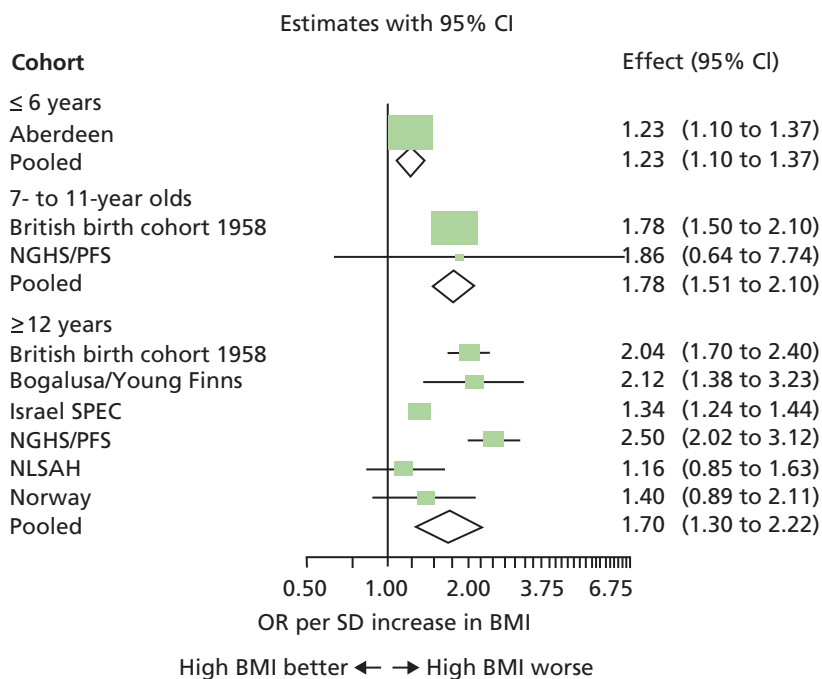


FIGURE 8 Forest plot of the association between childhood BMI and diabetes. NGHS, National Growth and Health study; NLSAH, National Longitudinal Study of Adolescent Health; PFS, Princeton follow-up study; SPEC, Staff Periodic Examination Center.

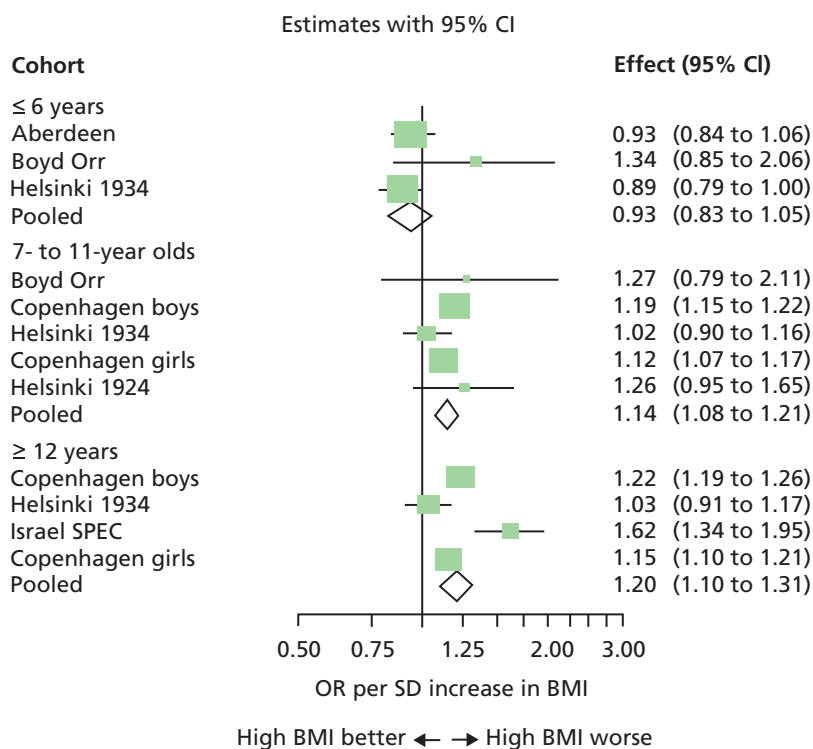


FIGURE 9 Forest plot of the association between childhood BMI and CHD. SPEC, Staff Periodic Examination Center.

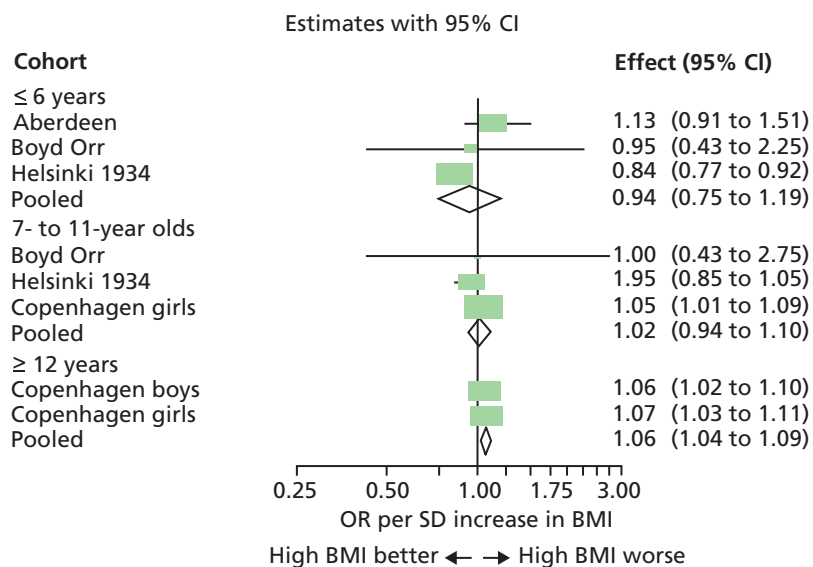


FIGURE 10 Forest plot of the association between childhood BMI and stroke.

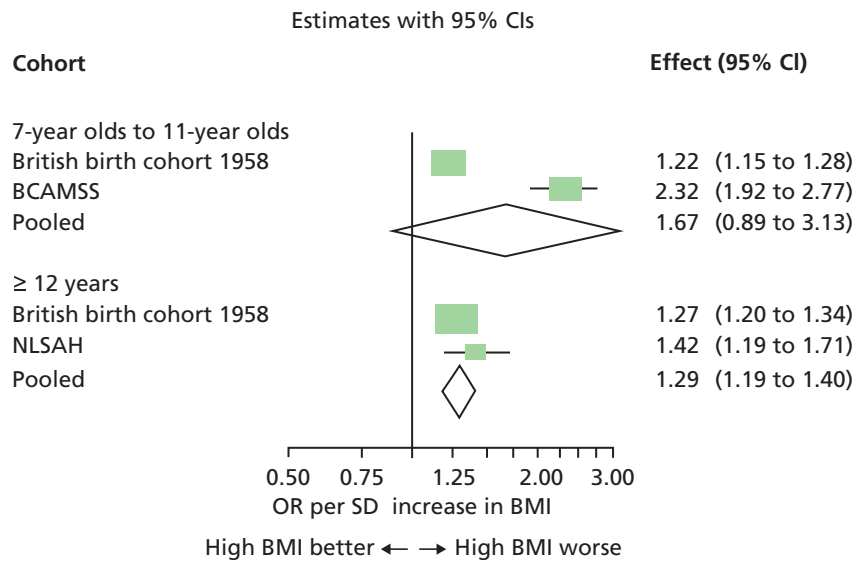


FIGURE 11 Forest plot of the association between childhood BMI and hypertension. BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; NLSAH, National Longitudinal Study of Adolescent Health.

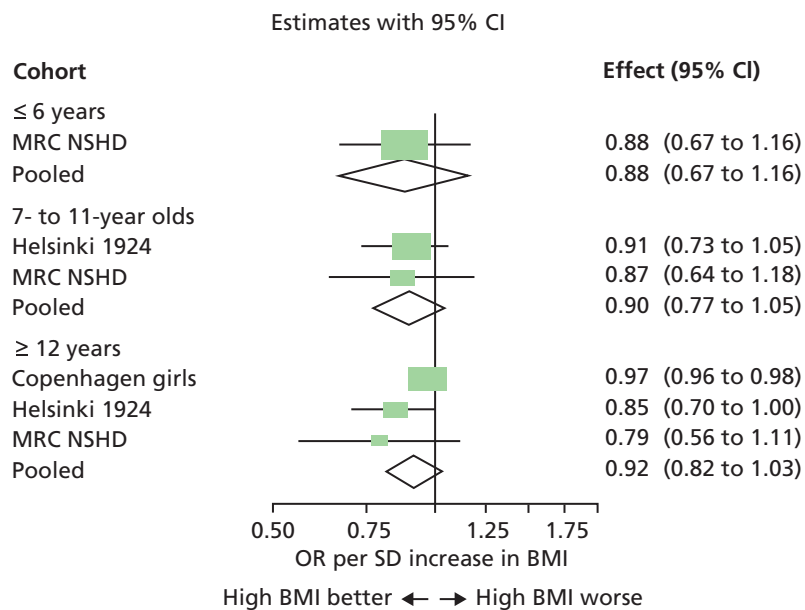


FIGURE 12 Forest plot of the association between childhood BMI and breast cancer. MRC NSHD, Medical Research Council National Survey of Health and Development.

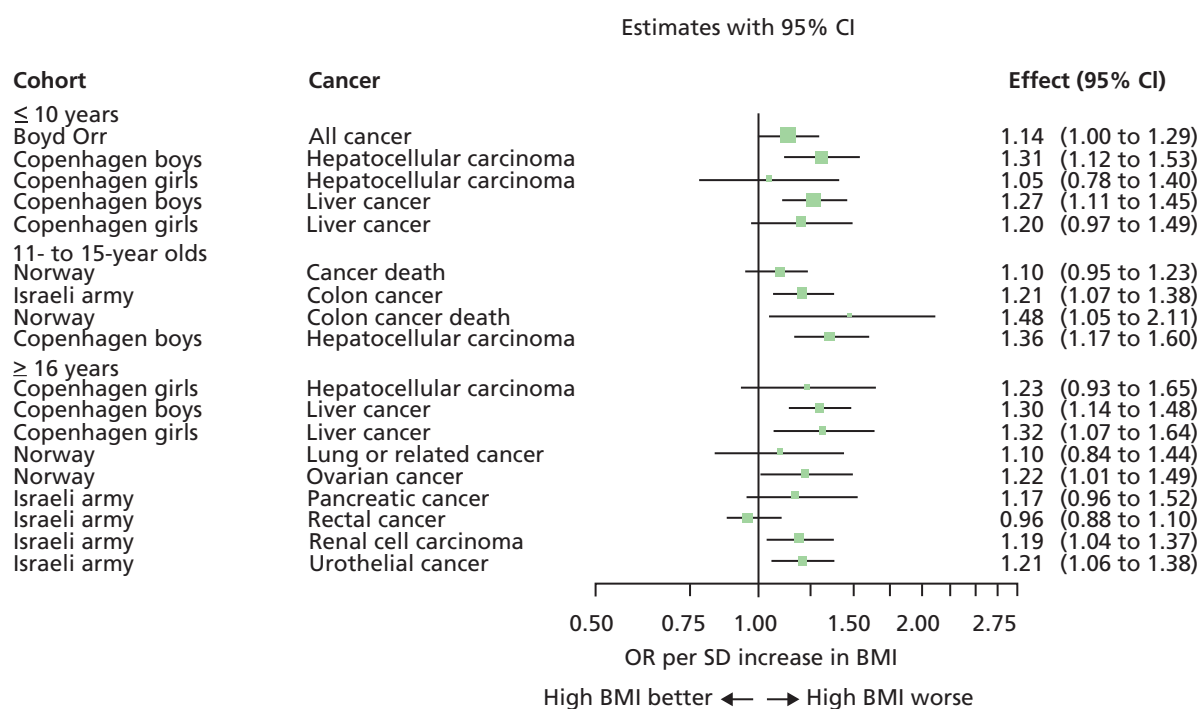


FIGURE 13 Forest plot of the association between childhood BMI and cancers.

Figure 9 shows that there is a positive association between childhood BMI and CHD, but it is weak, with an OR per SD BMI of 1.2 in those aged over 12 years (approximately equivalent to an 8% increase in odds per kg/m² increase in BMI for an adolescent). Again, there is no evidence that the association differs between children aged under and over 12 years, although an increasing trend with age was observed in two cohorts (see Figure 5).^{142,150}

Figure 10 shows the association with stroke. There is little evidence of any association between childhood BMI and stroke; the statistically significant result in those aged over 12 years is based on a single-cohort study.¹⁴² Figure 11 shows the association with hypertension. There is some evidence that childhood BMI is positively associated with odds of adult hypertension, but the results are based on only three cohorts.^{117,129,165}

Figure 12 shows the relationship between childhood BMI and breast cancer. The results are not statistically significant, but the trend is negative. Figure 13 shows the association between childhood BMI and other cancers. No pooled result is presented because of the diversity of types of cancer and because more than one cancer is reported in some cohorts, but the overall trend is for a modest positive association between BMI and the odds of cancer. The results are comparatively homogeneous, with an increase in odds of around 1.2 per SD increase in BMI.

It should be noted that, because of the incorrect assumption that BMI is normally distributed, all the summary ORs presented in Figures 8–13 are likely to be overestimates.

Prediction of future morbidity from childhood body mass index

The analyses so far have examined the association between childhood BMI and adult morbidity. This section considers how well childhood BMI predicts future morbidity.

Given the normality assumptions made about the distribution of BMI described in *Chapter 2*, the association between BMI and morbidity can be used to estimate the predictive performance of childhood obesity for predicting future morbidity. This is because there is a simple relationship between OR per SD and the sensitivity at a specified threshold of BMI (i.e. the proportion of adults with the morbidity who were above the specified threshold of BMI in childhood). As noted in *Chapter 2*, this assumption is likely to result in overestimation of these sensitivities.

Results for sensitivity at the 85th centile of childhood BMI and above are presented, that is what proportion of adult morbidity occurs in children who might be considered overweight or obese, based on their BMI. *Figure 14* presents the results for diabetes, and *Figure 15* those for CHD. Plots for other morbidities are given in *Appendix 5*.

The pattern of these two figures is identical to that seen in *Figures 4* and *5*, although the scales differ. The pattern of results is likewise the same for all other morbidities (see *Appendix 5*). These two examples show that, despite the association between obesity and later morbidity, childhood obesity is a poor predictor of morbidity. At best, around 40% of adults with diabetes were overweight or obese (above the 85th centile of BMI) as children. Only around 20% of adult CHD morbidities occurred in the most overweight 15% of children. Based on these findings, it appears that childhood BMI is not a useful predictor of future heart disease.

Summary receiver operating characteristic curves

To summarise the ability of childhood BMI to predict future morbidity, summary ROC curves are presented, based, again, on the assumptions of normally distributed BMI, and using the results from the analyses presented in the forest plots above (see *Figures 4–13*). As noted in *Chapter 2*, these summary curves probably overestimate predictive accuracy.

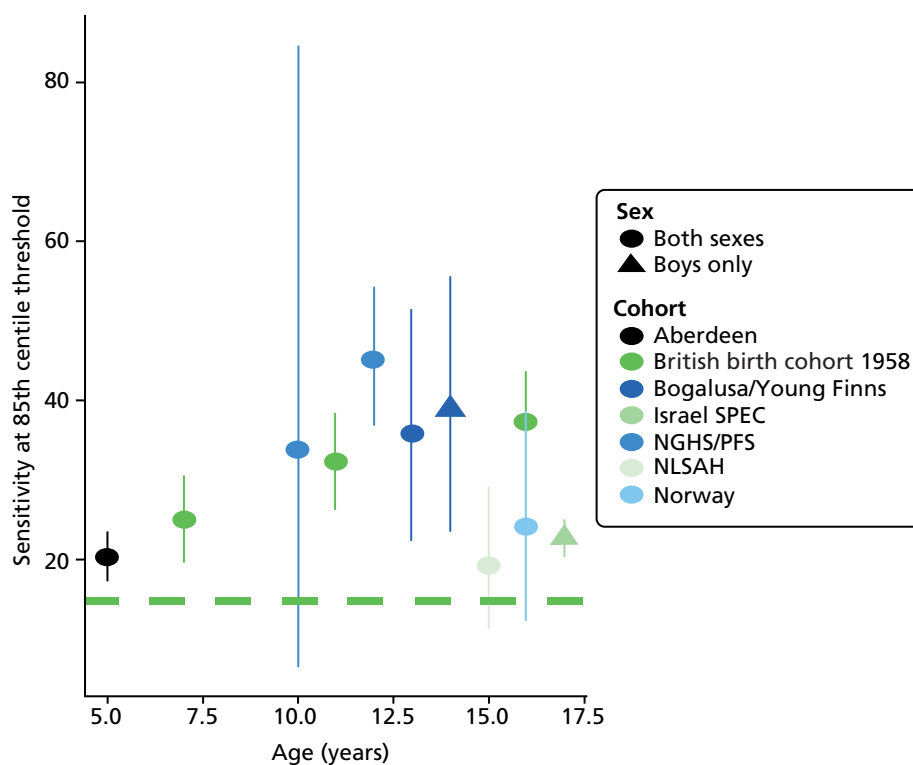


FIGURE 14 Predicting future diabetes from childhood BMI. NGHS, National Growth and Health study; NLSAH, National Longitudinal Study of Adolescent Health; PFS, Princeton follow-up study; SPEC, Staff Periodic Examination Center.

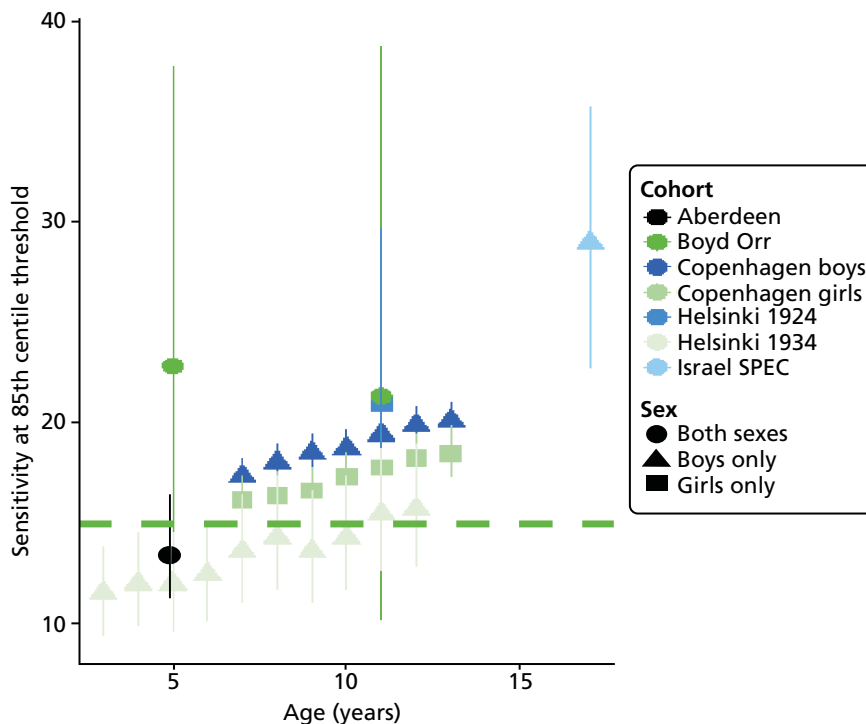


FIGURE 15 Predicting future CHD from childhood BMI. SPEC, Staff Periodic Examination Center.

There are two figures: *Figure 16* shows summary ROC curves for predicting morbidities for ages 7–11 years, and *Figure 17* shows the ROC curves for children aged 12 years and over (these data are too sparse to present ROCs for under-sevens). Breast cancer and stroke are not included, as the analyses above found no evidence of an association between BMI and these morbidities.

The figures show that the power of BMI measurement to predict adult morbidities is poor. BMI cannot adequately predict future CHD or cancer (the cancer ROC curve is hidden under the CHD curve in *Figure 17*). Only around 20% of future CHD and cancer occurs in overweight or obese children.

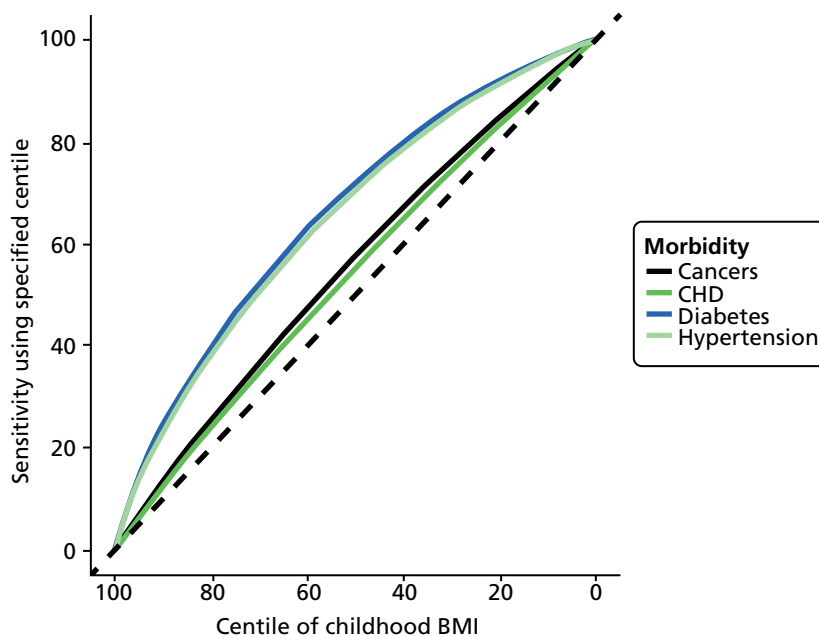


FIGURE 16 Receiver operating characteristic curves for predicting future morbidity from BMI at ages 7–11 years.

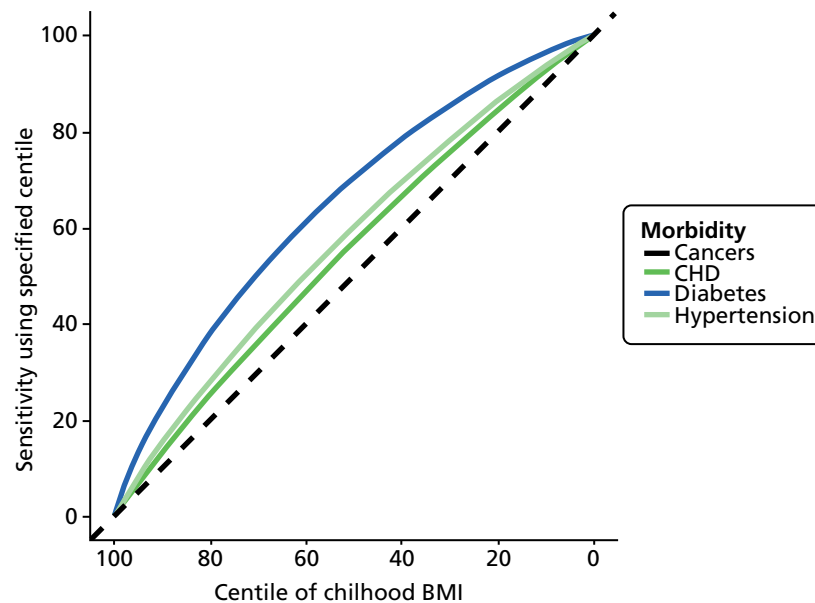


FIGURE 17 Receiver operating characteristic curves for predicting future morbidity from BMI at ages 12 years and over.

If we consider only obese children (above the 95th centile), then obesity cannot predict CHD or cancer; the results are no better than chance. Even for diabetes, which has the strongest association with obesity, only around 35% of adult diabetics were obese or overweight as adolescents. The ROC curve for hypertension is presented, but may not be reliable as it is based on very limited data (two cohorts). It should also be noted that, because of the assumption that BMI is normally distributed, even these poor levels of predictive accuracy may be overestimates.

Narrative review

Fourteen eligible studies reported relevant outcomes data that could not be included in the meta-analyses.^{117,118,123,129,143,144,146,151,156,157,167,168,170,171} Of those, three also reported data that were included in the quantitative synthesis.^{117,129,168}

Thirteen studies included in the narrative review reported data on the association between childhood measurements and adult morbidity expressed in terms of RR, OR, HR or cumulative incidence.^{117,123,129,143,144,146,151,156,157,166,167,170,171} Predictive accuracy data [expressed in terms of sensitivity, specificity and area under the curve (AUC)] were reported in four studies.^{118,168,170,171}

The evidence presented below was generally consistent with the findings presented in the meta-analyses, and provided relatively little additional evidence. However, unlike the meta-analyses, we were able to present some additional findings on simple measures of obesity other than BMI (WC, WHR, sum of SFTs), as well as the association between childhood weight status and future development of the metabolic syndrome in adults.

Association between childhood measurements and adult morbidity (13 studies)

All 13 studies used BMI as a weight status measurement in childhood. Two studies used WC in addition to BMI,^{117,171} and one study reported additional results for WHR and sum of SFTs.¹⁷¹ The following morbidities were reported: type II diabetes (two studies),^{123,151} CHD (one study),¹⁴⁴ renal cell carcinoma (one study),¹⁴⁶ metabolic syndrome (five studies),^{157,166,167,170,171} hypertension (six studies),^{117,123,143,156,157,171} and hypercholesterolaemia (one study).²²² All studies found positive associations between childhood measurements of weight status and morbidities in adulthood.

Type 2 diabetes (two studies) Forsen *et al.* (2000)¹⁵¹ found a positive trend in cumulative incidence of type 2 diabetes in adulthood associated with higher BMI at 11 years in a cohort of 7806 males and females. Although statistically significant, the strength of the association was not reported. Subgroup analyses found that in women, BMI at every age from 7 to 15 years was significantly associated with risk of the disease, but not in men.

Goldhaber-Fiebert *et al.* (2013)¹²³ found a weak association between BMI below age 10 years and projected diabetes in adulthood. For those who were white and above the 85th centile (CDC 2000²¹⁹) at age 5 years, their model predicted that 7.9% of males would develop uncontrolled diabetes by their mid-40s, compared with an estimated 4.9% below that threshold (RR 1.6 for males). At age 15 years, the strength of the association was significantly higher. In this age group, it was estimated that 12.6% of males above the 85th centile (CDC 2000²¹⁹) would develop uncontrolled diabetes by their mid-40s, whereas 2.8% of males below the threshold would develop the condition (RR 4.5 for males). RRs were not reported for females or for other ethnicity groups.

Coronary heart disease (one study) Barker *et al.* (2005)¹⁴⁴ found that low BMI at age 2 years and high BMI at 11 years were both associated with higher risk of CHD events. The HRs associated with an increase in BMI of 1 SD were 0.76 (95% CI 0.66 to 0.87) for boys and 0.62 (95% CI 0.46 to 0.82) for girls at age 2 years, and 1.14 (95% CI 1.00 to 1.31) for boys and 1.35 (95% CI 1.02 to 1.78) for girls at age 11 years. Subgroup analyses stratified by BMI at ages 2 and 11 years found that the risk of developing CHD in adulthood was highest among children with a low BMI at age 2 years who had a high BMI at 11 years (HR 3.1, 95% CI 1.3 to 7.8), compared with children with a high BMI at age 2 years and a low BMI at 11 years.

Hypertension (six studies) There was consistent evidence of a positive association between childhood weight status and hypertension in adulthood. The odds of developing hypertension in adulthood were higher in male regular army personnel who were classed as overweight or obese according to BMI [Israeli *et al.* (2007)¹⁵⁶]. Among individuals with normal baseline blood pressure, a BMI above 25 kg/m² at ages 16.5–19 years was associated with significantly higher odds of being hypertensive at ages 26–45 years than a BMI below that threshold (OR 2.28, 95% CI 2.08 to 2.51 for a BMI of 25–30 kg/m²; OR 5.45, 95% CI 4.75 to 6.24 for a BMI above 30 kg/m²). Associations were higher for adolescents who were hypertensive at baseline (OR 3.1, 95% CI 2.78 to 3.46 for a BMI of 25–30 kg/m²; OR 6.45, 95% CI 5.53 to 7.53 for a BMI above 30 kg/m²).

The Chinese study by Cheng *et al.* (2011)¹¹⁷ reported higher odds of developing hypertension in adulthood among obese and overweight children measured at a mean age of approximately 11 years. Based on WC, obese children had an OR of 3.9 (95% CI 2.8 to 5.3) of being hypertensive 9 years later compared with non-obese children. When BMI was used to calculate weight status, the study also found increased odds of being hypertensive at follow-up among overweight (OR 2.6, 95% CI 1.6 to 4.2) and obese children (OR 4.9, 95% CI 3.4 to 7.0) compared with children with healthy weight status. Although associations between childhood obesity and hypertension in adulthood were reported for both WC and BMI, the comparators used for calculating ORs differed between the two measurements (obese vs. non-obese for WC, obese vs. healthy weight for BMI), limiting the comparability of the estimates of association. Additionally, the study did not assess the predictive accuracy of either of the childhood measurements. Therefore, the predictive accuracy of BMI and WC could not be compared.

Schmidt *et al.* (2011)¹⁷¹ also found a positive association between childhood WC and hypertension in adulthood. The risk of being hypertensive in adulthood was higher in girls for every 10-cm increase in WC (RR 1.6, 95% CI 1.2 to 2.1) than in boys (RR 1.2, 95% CI 1.0 to 1.4). WC measurements were not adjusted for age, although they were made in children aged from 7 to 15 years.

Barker *et al.* (2002)¹⁴³ found a statistically significant association between high BMI from 8 to 12 years and hypertensive drug use in adulthood. At age 12 years, the study reported a statistically significant increase in the cumulative incidence of hypertension for each additional BMI point (14.2%, 95% CI 12.3% to 16.0%, for an adjusted BMI of 16 kg/m², and 19.9%, 95% CI 18.1% to 21.7%, for an adjusted BMI of > 18 kg/m²).

Janssen *et al.* (2005)¹⁵⁷ found a significant increase in the odds of developing hypertension measured with BMI at ages 5–14 years in overweight and obese children, although the relationship was statistically significant in obese children only (OR 4.39, 95% CI 1.83 to 9.72).

The model developed by Goldhaber-Fiebert *et al.* (2013)¹²³ found that prevalence of hypertension in adulthood would be higher among children above the 85th centile of a US population distribution (CDC 2000²¹⁹) at ages 5 and 15 years, irrespective of sex and ethnic group. However, the authors did not report whether or not these differences were statistically significant, nor did they report sufficient data to evaluate the extent to which higher childhood BMI may accurately predict hypertension among adults.

Hypercholesterolaemia (one study) Only one study reported an association between childhood obesity and future development of hypercholesterolaemia in adulthood. Merten *et al.* (2010)²²² found that adolescents who were obese according to BMI had higher odds of developing hypercholesterolaemia 6 years later (OR 1.81, 95% CI 1.22 to 2.75). Further results are presented in *Table 5*.

Metabolic syndrome (five studies) The definitions of metabolic syndrome differed slightly among the studies that reported this outcome. Three^{166,170,171} used the International Diabetes Federation (IDF) 2009 criteria,²²³ one¹⁶⁷ used the IDF 2005 definition²²⁴ and one defined metabolic syndrome according to the National Cholesterol Education Program.¹⁵⁷ All studies reported a positive association between childhood weight status and future metabolic syndrome.

Sachdev *et al.* (2009)¹⁷⁰ reported a statistically significant association between BMI at all ages from 2 to 14 years and metabolic syndrome at ages 26–33 years. The strength of the association was greater in adolescents (OR 1.87, 95% CI 1.65 to 2.12), followed by children at 11 (OR 1.63, 95% CI 1.43 to 1.85) and 8 years (OR 1.36, 95% CI 1.21 to 1.53). The strength of the association was weaker among children at 6 years or under (OR 1.19, 95% CI 1.05 to 1.35 at age 5 years; OR 1.2, 95% CI 1.04 to 1.37 at age 2 years).

Schmidt *et al.* (2011)¹⁷¹ reported the association between the risk of developing metabolic syndrome in adults and four different childhood measurements (BMI, WC, WHR and sum of SFTs) taken at ages 7–15 years. The risk of developing metabolic syndrome in adulthood was significantly higher among children within the highest quartile of the cohort than in the lowest quartile for all measurements, and the strength of the association was systematically greater in girls than in boys. The strongest associations between metabolic syndrome and childhood measurements were found with sum of SFT in girls (RR 11.2, 95% CI 1.4 to 91.3) and WC in boys (RR 4.8, 95% CI 2.5 to 9.2). The most conservative estimates were found with WHR in girls (RR 4.6, 95% CI 1.5 to 14.1), as well as in boys (RR 2.1, 95% CI 1.3 to 3.6). However, most results lacked precision (as evidenced by the wide CIs), making it difficult to compare the extent to which the strength of the associations varied across obesity measures. Additionally, the study did not report estimates of predictive accuracy for any of the childhood measurements. Therefore, the relative predictive accuracy of these childhood measures cannot be evaluated.

Magnussen *et al.* (2010)¹⁶⁶ pooled data from the Young Finns Study [also reported in Mattsson *et al.* (2008)¹⁶⁷] with results from the Bogalusa Heart Study on metabolic syndrome. The pooled analysis used the 91st centile as the threshold for obesity (based on Cole 2000²²⁰), and found a statistically significant association between obesity at ages 9–18 years and metabolic syndrome at ages 24–41 years (RR 2.5, 95% CI 2.0 to 3.1).

Janssen *et al.* (2005)¹⁵⁷ found a statistically significant increase in the odds of developing metabolic syndrome in adulthood among overweight (OR 2.53, 95% CI 2.26 to 5.42) and obese children (OR 4.62, 95% CI 2.81 to 7.45) measured with BMI at ages 5–14 years. Similar results were reported for hypertension, although the association was statistically significant in obese children only (OR 4.39, 95% CI 1.83 to 9.72).

TABLE 5 Results of studies not included in the quantitative synthesis: estimates of association

Study	Age at baseline (years)	Age at follow-up (years)	n at follow-up	Outcome	Comparison	Childhood measurement	Effect size (95% CI)	Adjustment
Forsen (2000) ¹⁵¹	11	31–73	7806	T2DM	NA	BMI ≤ 15.3 kg/m ² BMI 15.4–15.9 kg/m ² BMI 16.0–16.6 kg/m ² BMI 16.7–17.4 kg/m ² BMI > 17.4 kg/m ²	Cumulative incidence 5.8% Cumulative incidence 6.7% Cumulative incidence 5.9% Cumulative incidence 6.7% Cumulative incidence 8.4% (p-value for trend in women and both sexes < 0.001)	Age and sex
Goldhaber-Fiebert (2013) ²³	5–15	38–49	2780	T2DM	> 85th vs. < 85th centile	BMI at 5 years BMI at 15 years	RR 1.6 (NR) RR 4.5 (NR)	Age and sex
Barker (2005) ¹⁴⁴	2 and 11	27–64	8760	CHD (fatal or non-fatal)	NA	BMI (< 85th centile) BMI (> 85th centile)	Prevalence 38.9–63.1% Prevalence 44.1–66.9%	Age and sex
Bjorge (2004) ¹⁴⁶	14–19	45	227,221	RCC	Per 1-SD increase at 2 years Per 1-SD increase at 11 years	BMI	HR 0.76 (0.66 to 0.87) ^a HR 1.14 (1.00 to 1.31) ^a	Age and sex
Janssen (2005) ¹⁵⁷	5–14	19–38	1709	Metabolic syndrome (NCEP) Hypertension	OW vs. < 85th centile ^b OW vs. < 85th centile ^b	BMI BMI	RR 2.64 (1.48 to 4.7) (boys) RR 1.48 (0.57 to 3.85) (girls) OR 2.53 (2.26 to 5.42) OR 4.62 (2.81 to 7.45) OR 2.04 (0.7 to 5.12) OR 4.39 (1.83 to 9.72)	Age, sex, race, follow-up length

continued

TABLE 5 Results of studies not included in the quantitative synthesis: estimates of association (continued)

Study	Age at baseline (years)	Age at follow-up (years)	n at follow-up	Outcome	Comparison	Childhood measurement	Effect size (95% CI)	Adjustment
Sachdev (2009) ¹⁷⁰	2–14	26–33	1492	Metabolic syndrome (IDF 2009 ²²³)	Per 1-SD increase	BMI at 2 years	OR 1.2 (1.04 to 1.37)	Age and sex
						BMI at 5 years	OR 1.19 (1.05 to 1.35)	
						BMI at 8 years	OR 1.36 (1.21 to 1.53)	
						BMI at 11 years	OR 1.63 (1.43 to 1.85)	
						BMI at 14 years	OR 1.87 (1.65 to 2.12)	
Mattsson (2008) ¹⁶⁷	3–15	24–39	2195	Metabolic syndrome (IDF 2005 ²²⁴)	> 80th centile (approximately 17 kg/m ²)	BMI at 3–9 years	OR 3.0 (2.0 to 4.7)	Age and sex
						BMI at 12–15 years	OR 2.1 (1.4 to 3.1)	
Magnussen (2010) ¹⁶⁶	9–18	24–41	1755–1781	Metabolic syndrome (IDF 2009 ²²³)	OW/O vs. non-OW/O ^c	BMI	RR 2.5 (2 to 3.1)	All other metabolic syndrome components at baseline, follow-up duration, cohort
Schmidt (2011) ¹⁷¹	7–15	26–36	2188	Metabolic syndrome (IDF 2009 ²²³)	4th quartile vs. 1st quartile	WC	RR 4.8 (2.5 to 9.2) (men)	Age, sex, follow-up
						BMI	RR 5.8 (2.4 to 14.2) (women)	
						BMI	RR 3.0 (1.7 to 5.4) (men)	
						WHR	RR 5.0 (2.0 to 12.3) (women)	
						WHR	RR 2.1 (1.3 to 3.6) (men)	
						Sum SFT	RR 4.6 (1.5 to 14.1) (women)	
Hypertension				10-cm increase	WC	RR 2.6 (1.0 to 7.2) (men)		
						RR 11.2 (1.4 to 91.3) (women)		
						RR 1.2 (1.0 to 1.4) (men)	Sex, change in WC, smoking, alcohol consumption	
							RR 1.6 (1.2 to 2.1) (women)	

Study	Age at baseline (years)	Age at follow-up (years)	n at follow-up	Outcome	Comparison	Childhood measurement	Effect size (95% CI)	Adjustment
Cheng (2011) ¹¹⁷	10.5	NR	1180	Hypertension	O vs. non-O OW vs. HW O vs. HW	WC ^d BMI ^d	OR 3.9 (2.8 to 5.3) OR 2.6 (1.6 to 4.2) OR 4.9 (3.4 to 7.0)	Age and sex
Barker (2002) ¹⁴³	12	27–63	8760	Hypertension	NA	BMI (16 kg/m ²) BMI (17 kg/m ²) BMI (18 kg/m ²) BMI (> 18 kg/m ²)	Cumulative incidence 14.2% (12.3% to 16%) Cumulative incidence 14.2% (12.4% to 16%) Cumulative incidence 15.4% (13.5% to 17.4%) Cumulative incidence 19.9% (18.1% to 21.7%)	Age only
Israeli (2007) ¹⁵⁶	16.5–19	26–45	18,513	Hypertension	OW vs. HW ^e	BMI (25–30 kg/m ²)	OR 2.28 (2.08 to 2.51) (normal baseline tension) OR 3.1 (2.78 to 3.46) (high normal baseline tension) OR 5.45 (4.75 to 6.24) (normal baseline tension) OR 6.45 (5.53 to 7.53) (high normal baseline tension)	Age and sex
Merten (2010) ¹²⁹	12–19	19–26	10,439	Hypercholesterolaemia	O vs. non-O ^b	BMI	OR 1.81 (1.22 to 2.75)	Sex, ethnicity, adult obesity, SES

HW, healthy weight; IDF, International Diabetes Federation; NA, not applicable; NCEP, National Cholesterol Education Program; NR, not reported; O, obese; OW, overweight; RCC, renal cell carcinoma; T2DM, type 2 diabetes mellitus.

a Estimates which were not included in the quantitative synthesis as they were extracted after the analyses.

b CDC 2000.²¹⁹

c Cole 2000.²²⁰

d Chinese government standard for most.

e WHO cut-off points for BMI (O: ≥ 30 kg/m; OW: 25.0–29.9 kg/m²; HW: < 25 kg/m²).

Mattsson *et al.* (2008)¹⁶⁷ (Young Finns Study) reported a statistically significant association with metabolic syndrome in adulthood among children with a BMI above the 80th centile of the cohort and those below that threshold. Unlike the findings of Sachdev *et al.* (2009),¹⁷⁰ the strength of the association tended to be greater among younger children (OR 3.0, 95% CI 2.0 to 4.7 at ages 3–9 years; OR 2.1, 95% CI 1.4 to 3.1 at ages 12–15 years).

Cancer (one study) Bjorge *et al.* (2004)¹⁴⁶ found a statistically significant association between BMI above the 85th centile (CDC 2000²¹⁹) and renal cell carcinoma at age 45 years in a sample of 115,267 adolescent boys (RR 2.64, 95% CI 1.48 to 4.7). However, the association was not statistically significant in 111,954 adolescent girls (RR 1.48, 95% CI 0.57 to 3.85). The fact that Bjorge *et al.* (2004)¹⁴⁶ found a statistically significant association between BMI and renal cell carcinoma in adolescent boys but not in girls may be explained by a lack of power. Although the sample was large, the outcome of interest was very rare and therefore the subgroup of girls may not have been sufficiently large to show a statistically significant result.

Predicting future morbidity (four studies)

Four studies that were not included in the quantitative synthesis reported data on predictive accuracy (Table 6).^{118,168,170,171} Overall, they confirmed the findings of the quantitative synthesis: obesity and overweight are poor predictors of future morbidity in adulthood.

All reported weak estimates of predictive accuracy. Among the three studies that reported measures of sensitivity and specificity,^{166,168,170} all found that childhood BMI had high specificity but poor sensitivity when predicting adult morbidity. Of those, only one compared the predictive accuracy of more than one childhood measurement.¹⁶⁸ The study found that BMI and WC were equally accurate (high specificity and poor sensitivity) in predicting future morbidity among 10-year-old girls. The following outcomes were reported in adulthood: type 2 diabetes (two studies),^{118,168} metabolic syndrome (two studies)^{166,170} and hypertension (one study).¹¹⁸

Diabetes (two studies) Cheung *et al.* (2004)¹¹⁸ reported that BMI values at ages 7, 11 and 16 years could predict self-reported history of diabetes at age 42 years. However, estimates were weak, with AUCs ranging from 0.58 to 0.61. Morrison *et al.* (2010)¹⁶⁸ found that BMI and WC were equally accurate in predicting early adulthood diabetes in a relatively small sample ($n = 1067$) of 10-year-old obese girls. Both measurements had high specificity (96%) but low sensitivity (13%).

Hypertension (one study) Cheung *et al.* (2004)¹¹⁸ reported that BMI values at ages 11 and 16 years could predict self-reported hypertension at age 42 years. However, as with diabetes, predictive estimates of adult hypertension were weak (AUC 0.56 at age 11 years and 0.60 at age 16 years). Further results are presented in Table 6.

Metabolic syndrome (two studies) Sachdev *et al.* (2009)¹⁷⁰ found that BMI at 5, 8, 11 and 14 years had very high specificity (97–99%) but very low sensitivity (1–7%) when predicting metabolic syndrome in adulthood at ages 26–33 years. The pooled analysis from Magnussen *et al.* (2010)¹⁶⁶ reported lower specificity (80%) and higher sensitivity (50.8%) for predicting adult metabolic syndrome at ages 24–41 years (CIs were not reported). The differences between the two studies may be explained by the use of different cut-off points. The pooled analysis from Magnussen *et al.* (2010)¹⁶⁶ used a lower BMI cut-off point than the study by Sachdev *et al.* (2009)¹⁷⁰ [internally derived 75th centile vs. IOTF 85th centile in Sachdev *et al.* (2009)¹⁷⁰].

Cancer (one study) Cheung *et al.* (2004)¹¹⁸ found that BMI at ages 7, 11 and 16 years was a poor predictor of self-reported cancer at age 42 years (AUC ranging from 0.46 to 0.53).

TABLE 6 Results of studies not included in the quantitative synthesis: estimates of predictive accuracy

Study	Age at baseline (years)	Age at follow-up (years)	n at follow-up	Outcome	Comparison	Childhood measurement	Summary estimate (95% CI)	Adjustment
Morrison (2010) ¹⁸⁸	10	19	1067	T2DM	O vs. non-O	WC	Sensitivity: 13 Specificity: 96 PPV: 2 NPV: 99	None
						BMI	Sensitivity: 13 Specificity: 96 PPV: 3 NPV: 99	
Cheung (2004) ¹¹⁸	7–16 years	42	4047–4592	Cancer	NA	BMI at 7 years	AUC: 0.46 (0.41 to 0.51)	Age
						BMI at 11 years	AUC: 0.47 (0.42 to 0.513)	
						BMI at 16 years	AUC: 0.53 (0.47 to 0.58)	
				Hypertension		BMI at 7 years	AUC: 0.51 (0.48 to 0.53)	
						BMI at 11 years	AUC: 0.56 (0.53 to 0.59)	
						BMI at 16 years	AUC: 0.6 (0.57 to 0.63)	
				Diabetes		BMI at 7 years	AUC: 0.58 (0.51 to 0.66)	
						BMI at 11 years	AUC: 0.60 (0.52 to 0.67)	
						BMI at 16 years	AUC: 0.61 (0.54 to 0.68)	
				Metabolic syndrome	Cut-off: ≥ 85 th centile (IOTF)	BMI at 5 years	Sensitivity: 1 Specificity: 98	Age, sex

continued

TABLE 6 Results of studies not included in the quantitative synthesis: estimates of predictive accuracy (continued)

Study	Age at baseline (years)	Age at follow-up (years)	n at follow-up	Outcome	Comparison	Childhood measurement	Summary estimate (95% CI)	Adjustment	
Sachdev (2009) ¹⁷⁰	2–14	26–33		Metabolic syndrome	Cut-off: ≥ 75 th centile (internally derived)	BMI at 8 years	Sensitivity: 1 Specificity: 99	Age, sex	
						BMI at 11 years	Sensitivity: 2 Specificity: 99		
						BMI at 14 years	Sensitivity: 7 Specificity: 97		
						BMI	Sensitivity: 50.8 Specificity: 80.0		
					Cut-off: ≥ 85 th centile (IOTF)	BMI at 5 years	Sensitivity: 1 Specificity: 98		
						BMI at 8 years	Sensitivity: 1 Specificity: 99		
						BMI at 11 years	Sensitivity: 2 Specificity: 99		
						BMI at 14 years	Sensitivity: 7 Specificity: 97		
	Schmidt (2011) ¹⁷¹	7–15	26–36	2188	Metabolic syndrome (IDF 2009 ²²³)	4th quartile vs. 1st quartile	Sum SFT: boys	Sensitivity: 30 (16 to 47) Specificity: 82 (77 to 86) AUC: 0.624	
							Sum SFT: girls	Sensitivity: 58 (28 to 85) Specificity: 83 (79 to 87) AUC: 0.777	

Study	Age at baseline (years)	Age at follow-up (years)	n at follow-up	Outcome	Comparison	Childhood measurement	Summary estimate (95% CI)	Adjustment
						Sum SFT: unselected	Sensitivity: 37 (23 to 52) Specificity: 82 (79 to 85) AUC: NR	
					4th quartile vs. 1st quartile	WC: boys	Sensitivity: 45 (36 to 55) Specificity: 80 (77 to 82) AUC: 0.686	
						WC: girls	Sensitivity: 49 (33 to 65) Specificity: 81 (78 to 83) AUC: 0.721	
						WC: unselected	Sensitivity: 46 (38 to 54) Specificity: 80 (78 to 82) AUC: NR	
					4th quartile vs. 1st quartile	WHR: boys	Sensitivity: 34 (25 to 43) Specificity: 79 (77 to 82) AUC: 0.612	
						WHR: girls	Sensitivity: 33 (19 to 49) Specificity: 79 (77 to 82) AUC: 0.672	
						WHR: unselected	Sensitivity: 33 (26 to 41) Specificity: 79 (78 to 81) AUC: NR	

NA, not applicable; NR, not reported; O, obese; T2DM, type 2 diabetes mellitus.

Comparison of 'simple' measures of childhood obesity for prediction of adult morbidities

The evidence comparing BMI with alternative 'simple' measures of childhood obesity for predicting adult morbidity was very limited; the available studies are summarised in *Table 7*. As seen in the previous sections, only three studies evaluated relevant measures other than BMI.^{117,168,171} All studies were relatively small ($n = 1067$ to $n = 2188$). All were subject to high risk of attrition bias^{117,168,171} and one was at high risk of bias associated with confounding factors and outcomes.¹⁶⁸

The available studies provide data only on WC, WHR and the sum of SFT measurements at more than one site (sum SFT). Accuracy data were only available for WC for predicting of diabetes.¹⁶⁸ Measures of association (RR, OR) between childhood measurements and adult morbidities were available for WC (for hypertension^{117,171} and metabolic syndrome¹⁷¹), and for WHR and sum SFT (metabolic syndrome only).¹⁷¹

Schmidt *et al.* (2011)¹⁷¹ reported the association between the risk of developing the metabolic syndrome in adults and four different childhood measurements (BMI, WC, WHR and sum SFTs) between the ages of 7 and 15 years. As seen earlier, the association between the risk of developing the metabolic syndrome in adulthood and childhood weight status was consistently positive and statistically significant across all four childhood measures, and the strength of the associations was systematically greater in girls than in boys. However, most results lacked precision (as evidenced by the wide CIs), making it difficult to compare the strength of the associations across obesity measures.

The Chinese study by Cheng *et al.* (2011)¹¹⁷ reported higher odds of developing hypertension in adulthood among obese and overweight children measured at a mean age of approximately 11 years with both WC and BMI. Although associations between childhood obesity and hypertension in adulthood were reported for both WC and BMI, the comparators used for calculating ORs differed between the two measurements (obese vs. non-obese for WC, obese vs. healthy weight for BMI), which limits the comparability of the estimates of association. Additionally, as with Schmidt *et al.* (2011),¹⁷¹ the study did not assess the predictive accuracy of either of the childhood measurements. Therefore, their relative predictive accuracy cannot be compared.

Two studies compared the predictive accuracy of more than one childhood measure; one evaluated BMI and WC for predicting type 2 diabetes,¹⁶⁸ and the other WC, SFT and WHR for predicting metabolic syndrome.¹⁷¹ The study evaluating BMI and WC found that they were equally accurate in predicting early adult diabetes when conducted in 10-year-old girls; both had equally high specificity (96%) and poor sensitivity (13%).¹⁶⁸ However, the study had several limitations: the outcome of interest was collected through self-report and may have been contaminated by type 1 diabetes, follow-up duration was limited to only 9 years and the study did not report how WC was measured (including measurement site). The other study¹⁷¹ that categorised the most obese 25% as the 'at-risk' group reported poor sensitivity, which was generally below 50%, and moderate specificity; SFT appeared to be the most accurate of the three obesity measures (see *Table 7*).

Review of morbidities: summary of findings and conclusions

This review identified 37 cohort studies on the association between childhood weight status and adult morbidities. Of these, 26 were included in the meta-analyses. All the studies were large or very large cohort studies, most being from large national or community data sets. However, large proportions of participants were lost at final follow-up in many studies, making attrition the most common source of bias. Although most studies adjusted for key confounders such as age and sex, the observational design of the studies means that confounding bias cannot be ruled out. Studies were very diverse, with weight status measured at different ages and in different populations. Most studies tended to focus on older cohorts. Follow-up duration and age at final follow-up also varied significantly between the studies. In addition, relatively few studies were found for some outcomes. Given the range of morbidity-related outcomes that could be reported (particularly the large number of types of cancer), there is a possibility of selective reporting, where cohorts reported only outcomes showing a positive association between BMI and the outcome. These limitations should be considered when interpreting the results.

TABLE 7 Results of studies including 'simple' childhood measures other than BMI

Study	Age at baseline (years)	Age at follow-up (years)	Childhood measurement	n at follow-up	Outcome	Comparison	Effect size (95% CI)	Adjustment
Schmidt (2011) ¹⁷¹	7–15	26–36	WC	2188	Metabolic syndrome (IDF)	4th quartile vs. 1st quartile	RR 4.8 (2.5 to 9.2) (men) RR 5.8 (2.4 to 14.2) (women)	Age, sex, follow-up
			BMI			4th quartile vs. 1st quartile	RR 3.0 (1.7 to 5.4) (men) RR 5.0 (2.0 to 12.3) (women)	
			WHR			4th quartile vs. 1st quartile	RR 2.1 (1.3 to 3.6) (men) RR 4.6 (1.5 to 14.1) (women)	
			Sum SFT			4th quartile vs. 1st quartile	RR 2.6 (1.0 to 7.2) (men) RR 11.2 (1.4 to 91.3) (women)	
Cheng (2011) ¹⁷⁷	10.5	NR	WC	2062	Hypertension	10-cm increase	RR 1.2 (1.0 to 1.4) (men) RR 1.6 (1.2 to 2.1) (women)	Sex, change in WC, smoking, alcohol consumption
			BMI	1180	Hypertension	O vs. non-O	OR 3.9 (2.8 to 5.3) OR 2.6 (1.6 to 4.2)	Age, sex
						O vs. HW	OR 4.9 (3.4 to 7.0)	Age, sex
Morrison (2010) ¹⁶⁸	10	19	WC	1067	T2DM	O vs. non-O	Sensitivity: 13 Specificity: 96 PPV: 2 NPV: 99	None
			BMI			O vs. non-O	Sensitivity: 13 Specificity: 96 PPV: 3 NPV: 99	None

HW, healthy weight; NR, not reported; O, obese; OW, overweight; T2DM, type 2 diabetes mellitus.

Overall, most studies reported a positive, statistically significant association between measures of childhood weight status and adult morbidity, but the findings varied by morbidity. There was consistent evidence of a statistically significant but modest association between childhood BMI and adult diabetes; there was insufficient evidence to show whether or not the association is stronger among older children. Results for CHD were more mixed, with some cohorts showing a negative association (in early childhood) or no association, and others showing a modest increase in odds of CHD with increased BMI. There is insufficient evidence to show whether or not the association differs significantly between under- and over-twelves. However, evidence from some cohorts suggests an increasing trend with age. There is little evidence of any association between obesity and stroke; the statistically significant result in the over-twelves is based on a single cohort study.

There was some consistent evidence that childhood obesity and overweight are positively associated with metabolic syndrome in adulthood. There was some very limited evidence suggesting that the strength of the associations may vary according to age and measurement tool. There was also some consistent evidence that childhood obesity and overweight are positively associated with odds of adult hypertension, although the results are based on a relatively limited number of cohorts. There was some evidence of a statistically significant positive association between BMI in adolescence and hypercholesterolaemia in early adulthood, although the evidence is based on a single cohort with limited follow-up.

The cohorts reported on a large number of cancers (although few cohorts were found for each site-specific cancer), and the general trend appears to be that obesity leads to a modest increase in risk for most cancers for which evidence was available (except for breast cancer and rectal cancer).

Despite the association between obesity and later morbidity, childhood BMI is a poor predictor of adult morbidity. At best, around 40% of adults with diabetes were overweight or obese (above the 85th centile of BMI) as children. There was some evidence from a single cohort that BMI and WC had equally high specificity and poor sensitivity when used to predict future diabetes. At most, 20% of future CHD and cancers occur in overweight or obese children. If we consider only obese children (above the 95th centile), then obesity cannot predict CHD or cancer; the results are no better than chance. Therefore, childhood BMI is not a good predictor of future heart disease or cancer.

There was some evidence that BMI has good specificity but poor sensitivity when used to predict metabolic syndrome in adults, although this finding is based on very few and small cohorts. This means that most adults who do not develop metabolic syndrome as adults were also not obese as children; however, this tells us nothing about obese children. There is some evidence from a relatively small cohort that BMI values at ages 11 and 16 years were weakly predictive of hypertension in adulthood. No evidence was found on the predictive value or association between childhood weight status and hypercholesterolaemia in adulthood.

The evidence for the predictive accuracy of simple measures other than BMI was limited, and could not be included in the meta-analyses. Only three relatively small studies used WC, and only one used WHR and measurements of SFT. Based on this evidence, the extent to which these simple measures of childhood weight status can be compared is very limited. Only one study reported predictive accuracy data on WC and BMI, and found that both had equally high specificity and low sensitivity when predicting future adult morbidity.

Overall, there was consistent evidence of positive associations between childhood measurements of weight status and morbidities in adulthood. Although higher childhood BMI tends to be associated with a higher risk of morbidity in adulthood, overall it is a poor predictor of adult morbidity. This is because the association between obesity and morbidity would need to be strong (i.e. a large RR) in order for obesity to be an effective predictor of later morbidity.²²⁵ There is also no evidence favouring the accuracy of any of the other simple measures of childhood weight status for predicting future adult morbidity.

Review of tracking of obesity into adulthood

For the review of tracking of obesity into adulthood, five systematic reviews (across six publications) with potential for being updated were identified.^{16,17,211,214,215,226} None of the reviews specifically evaluated the accuracy of simple childhood measures of obesity in predicting adult obesity. The most recent and relevant reviews were by Singh *et al.* (2008)¹⁶ and Brisbois *et al.* (2012).¹⁷ The bibliographies of all the systematic reviews and other relevant reviews were screened for potentially relevant studies, regardless of the age of the study.

Summary of the existing systematic reviews by Singh *et al.* (2008) and Brisbois *et al.* (2012)

The systematic review by Singh *et al.* (2008)¹⁶ examined the evidence of the persistence of childhood overweight. The review included prospective or retrospective longitudinal studies that made at least one anthropometric measurement during youth (age ≤ 18 years) and one during adulthood (age ≥ 19 years), using BMI, SFT or WC. Eighteen studies in 25 articles were included in the review. The quality of the included studies was assessed in duplicate by the two reviewers and 52% of the articles were rated as being of high methodological quality.

All the included studies reported that overweight or obese youths were at increased risk of becoming overweight or obese adults. Four studies that stratified for different levels of youth overweight suggested that persistence of overweight was greater with increased level of overweight. It was unclear if persistence varied with sex. When only high-quality studies were included in the analysis, the risk of overweight children becoming overweight adults was at least double that for normal-weight children. Overall, the percentage of obese adolescents becoming overweight or obese adults was higher than that of obese children (24–90% based on three high-quality studies). The review concluded that there is strong evidence of moderate persistence of overweight in both overweight and obese children. A significant limitation of the review was that it was unclear how comprehensive the searches had been, and whether or not relevant studies may have been missed. Furthermore, it presented only a narrative synthesis of the results from the included studies and focused on the association between childhood and adult obesity rather than the predictive accuracy of childhood obesity. In addition, as the review's searches had been conducted in February 2007 the list of included studies was potentially out of date. Therefore, this review was used only as a source of relevant studies for the current review.

The systematic review by Brisbois *et al.* (2012)¹⁷ evaluated a number of factors in children aged 5 years or under which are the most significant predictors of the development of obesity in adulthood. Studies were eligible if they included healthy individuals, performed child and adult measurements for each individual and reported quantitative results. The searching appeared adequate but the lack of overlap with Singh *et al.* (2008)¹⁶ raised questions over how comprehensive it had been.

The review included 24 studies, and almost all reported a significant association between childhood overweight or obesity and adult obesity. The review concluded that early childhood obesity was a probable marker of adult obesity.

The main limitations of this review were that only early childhood was considered and it was possible that studies had been missed. Furthermore, many of the studies included reported only correlation coefficients, and only a narrative synthesis of study results was conducted. Therefore, as with the review by Singh *et al.* (2008),¹⁶ this review was used as a source of relevant studies for the current review.

Quality and assessment of bias of the included primary studies of tracking of obesity into adulthood

In total, 23 studies were identified for the review of the tracking of childhood obesity into adulthood. These are listed in *Table 8*.

TABLE 8 Tracking review: risk of bias assessment

Study	Risk of selection bias	Risk of attrition bias	Risk of bias associated with the prognostic factor	Risk of bias associated with outcome	Risk of bias due to confounders	Risk of reporting or analysis bias
Cheng (2011) ¹¹⁷	Low	High	Low	Low	UC	Low
Cheung (2004) ¹¹⁸	Low	High	Low	High	High	Low
Engeland (2004) ¹¹⁹	Low	Mod/UC	Mod/UC	Mod/UC	Low	Low
Freedman (2001) ¹²⁰	Low	Low	Mod/UC	Mod/UC	Mod/UC	Low
Freedman (2005) ¹²²	Low	Mod/UC	Low	Low	Low	Low
Freedman (2005) ¹²¹	Low	Low	Low	Low	Low	Low
Goldhaber-Fiebert (2013) ¹²³	Low	Mod/UC	Mod/UC	Mod/UC	Low	Low
Gordon-Larsen (2004) ¹²⁴	Low	Mod/UC	Low	High	Low	Low
Juhola (2011) ¹²⁵	Low	Mod/UC	Mod/UC	Mod/UC	Low	Low
Juonala (2006) ¹²⁶	Low	High	Mod/UC	Mod/UC	High	Low
Liddle (2012) ¹²⁷	Low	Mod/UC	Low	High	Mod/UC	Low
Mamun (2005) ¹²⁸	Low	Mod/UC	Low	Low	Mod/UC	Low
Merten (2010) ¹²⁹	Low	Mod/UC	Mod/UC	Mod/UC	Mod/UC	Low
Nakano (2010) ¹³¹	Low	Mod/UC	Low	Low	Low	Low
Nakano (2010) ¹³⁰	Low	Mod/UC	Low	Low	Low	Low
Patton (2011) ¹³²	Low	Mod/UC	Mod/UC	Mod/UC	Low	Low
Power (1997) ¹³³	Low	Mod/UC	Low	Low	Low	Low
Reilly (2011) ¹³⁴	Low	Mod/UC	Low	Low	Mod/UC	Low
Starc (2011) ¹³⁵	Low	Low	Low	Low	Low	Low
Stovitz (2010) ¹³⁶	Low	Mod/UC	Low	Low	Mod/UC	Low
Thompson (2007) ¹³⁷	Low	Mod/UC	Low	Mod/UC	Low	Low
Venn (2007) ¹³⁸	Low	Mod/UC	Mod/UC	Mod/UC	Mod/UC	Low
Wang (2008) ¹³⁹	Low	Low	Mod/UC	Mod/UC	Low	Low
All studies	All low	16 mod/UC 3 high 4 low	14 low 9 mod/UC	10 mod/UC 10 low 3 high	13 low 2 high 8 mod/UC	All low

Mod, moderate; UC, unclear.

The results of the quality and risk of bias assessment are summarised in *Table 8* and given in full in *Appendix 4*. All the studies were cohort studies, and so they are already subject to greater bias than a randomised controlled trial would be. However, all the studies were large, most being from national or community data sets. The main potential source of bias arises from the lack of control in retaining participants in the cohorts; thus, although the initial cohorts were very large, many thousands of participants were not followed up at the final assessment. In itself this might not be a source of bias, but the majority of study reports did not confirm that the final cohort followed up was representative of the complete initial sample. Confounding was another significant potential source of bias in these studies. Although some presented results by age and sex, most did not, and the wide age ranges included in some studies increased the potential for age-associated effects that could not be accounted for.

Characteristics of studies included the review of tracking of obesity into adulthood

There was some overlap between a number of the studies, as they were based on the same initial cohorts. Three were based on the Bogalusa cohort in the Southern States of the USA, and two each were based on the National Child Development Study (1958 British birth cohort) (NCDS), the National Longitudinal Study of Adolescent Health (NLSAH) cohort, the Young Finns cohort, Tokushima Prefecture and the Mater-University Study of Pregnancy (MUSP) cohort in Australia (*Table 9*). Each study included in the review provided some unique data in terms of age of childhood assessment, adult assessment or analysis by age, sex or race. Only unique data are included in the meta-analysis and narrative synthesis.

Study characteristics for tracking of obesity into adulthood

The study characteristics are summarised in *Table 10* and presented in full in *Appendix 3*. The included studies were all longitudinal cohort studies in which these data were collected prospectively. They were conducted in various countries: the USA (nine studies), UK (three studies), other European countries (four studies: two in Finland, one in Norway and one in Slovenia), Australia (four studies), Japan (two studies) and China (one study). The start dates of the studies ranged from 1958 to 2008, with follow-up between 6 and 42 years; 11 of the 23 studies had follow-up of 20 years or longer.

The setting for studies was not always completely clear, although not surprisingly most involved schoolchildren measured in school or the community. The childhood measures are listed in *Appendix 3*. In all studies, BMI was assessed in childhood (or adolescence), and in all but one study¹²⁷ BMI was the only measure in childhood. In all studies, childhood BMI was routinely reported in kg/m², and was sometimes standardised to reference data. Ten studies used IOTF⁶¹/Cole 2000²²⁰/WHO⁴⁵ reference populations. Others used the CDC 2000²¹⁹ reference growth charts or the UK90 reference.²²¹ All were extracted as equivalent to the 85th and 95th centile cut-off points in childhood to determine overweight and obesity respectively. The Bogalusa cohort used the 95th centile to define overweight. However, data at the 85th and 95th centiles were used to define overweight and obesity, in accordance with other studies. One study [Juonola *et al.* (2006)¹²⁶] used the 80th and 90th centiles as the cut-off points for overweight and obesity; this study was included in the analyses as if it had used the 95th centile.

Skinfold thickness was the childhood measurement in only one included study¹²⁷ (and was used in addition to BMI); it was measured at one site and measurements were converted to a z-score internally adjusted for age and sex. Cut-off points were generated from proportions of overweight/obese similar to Cole 2000²²⁰ BMI subgroups (BMI was also measured).

Details of the BMI measure used in adults are listed in *Appendix 3*. In summary, all assessments of adult weight status used the BMI cut-off points for overweight and obesity of 25 kg/m² and 30 kg/m². For adolescents, all studies used the cut-off points for overweight and obesity of the 85th and 95th centiles respectively, with the exception of Juonola *et al.* (2006),¹²⁶ based on the Young Finns cohort, which used the 80th and 90th centiles respectively.

TABLE 9 Tracking review: overlap of studies based on the same cohorts

Cohort name	Study	Country in which study conducted	Study dates		Details of individual 'study' (paper)
			From	To	
Bogalusa	Freedman (2001) ¹²⁰	USA	1973	1996	This analysis based on 2617 participants re-examined as adults (age 27 years)
	Freedman (2005) ¹²²		1973	1994	This analysis based on 2610 participants re-examined as adults (age 27 years)
	Freedman (2005) ¹²¹		1973	1996	This analysis based on 2392 participants re-examined as adults (age 27 years)
Young Finns	Juhola (2011) ¹²⁵	Finland	1980	2007	Cohort followed up in 2001 (age 30–45 years). Results presented stratified by different age at baseline, but only summary data presented
	Juonala (2006) ¹²⁶	Finland	1980	2001	Cohort followed up in 2007 (age 24–39 years). Data presented across broad age groups
MUSP	Liddle (2012) ¹²⁷	Australia	1986	NR (follow-up for 18 years)	Tracked children from age 5 to age 21 years (range 18.2–23.1 years)
	Mamun (2005) ¹²⁸	Australia	1986–90	2000–4	Tracked children from age 5 to age 14 years
NCDS (1958 British birth cohort)	Power (1997) ¹³³	UK	1958	1991	Tracked participants from age 7 to age 33 years
	Cheung (2004) ¹¹⁸	UK	1958	2000	Tracked participants from age 7 to age 33 years; calculated sensitivity and specificity, etc. Compare with results from Power (1997) ¹³³
NLSAH	Gordon-Larsen (2004) ¹²⁴	USA	1996	2002	Tracking of wave II participants to wave III participants, stratified by age in wave II
	Merten (2010) ¹²⁹	USA	1995	2001	Tracking of wave I participants to wave III participants
Tokushima Prefecture	Nakano (2010) ¹³¹	Japan	2001	2008	Participants followed up for 7 years. Only included children who were aged 7 years at first measure [i.e. a subset of participants in Nakano (2010) ¹³⁰]
	Nakano (2010) ¹³⁰	Japan	2001	2007	Participants followed up for 6 years. Although whole cohort overlaps with Nakano (2010), ¹³¹ the extracted data were only for a cohort aged 8 years at first measure ($n = 5697$) and so study does not overlap with other Nakano study

NR, not reported.

TABLE 10 Tracking review: study characteristics

Cohort name	Study	Country in which study conducted	Study dates		Setting for anthropometric measure in childhood
			Start	Finish	
1988–90 Slovenian cohort	Starc (2011) ¹³⁵	Slovenia	1997	2008	School
ALSPAC	Reilly (2011) ¹³⁴	UK	1998/1999	2003/2004	Research clinic
ASHFS	Venn (2007) ¹³⁸	Australia	1985	2005	School
BCAMSS	Cheng (2011) ¹¹⁷	China	2004	2011	School
Bogalusa	Freedman (2001) ¹²⁰	USA	1973	1996	School
	Freedman (2005) ¹²²	USA	1973	1994	School
	Freedman (2005) ¹²¹	USA	1973	1996	School
Cardiovascular Risk in Young Finns	Juhola (2011) ¹²⁵	Finland	1980	2007	NR
	Juonala (2006) ¹²⁶	Finland	1980	2001	NR
CATCH	Stovitz (2010) ¹³⁶	USA	1991	2001	School
MUSP	Liddle (2012) ¹²⁷	Australia	1986	NR (follow-up for 18 years)	NR
	Mamun (2005) ¹²⁸	Australia	1986–90	2000–4	NR
NCDS (1958 British birth cohort)	Power (1997) ¹³³	UK	1958	1991	Community
	Cheung (2004) ¹¹⁸	UK	1958	2000	Community
NGHS/PFS	Thompson (2007) ¹³⁷	USA	1986	1997	School
NHANES, NLSY79	Goldhaber-Fiebert (2013) ¹²³	USA	1970	2008	Community
NLSAH	Gordon-Larsen (2004) ¹²⁴	USA	1996	2002	School
	Merten (2010) ¹²⁹	USA	1995	2001	School
NLSY79	Wang (2008) ¹³⁹	USA	1981	2002	Interview/survey
None	Engeland (2004) ¹¹⁹	Norway	1963	1999	Community
None	Patton (2011) ¹³²	Australia	1992	2003	School
Tokushima Prefecture	Nakano (2010) ¹³¹	Japan	2001	2008	School
	Nakano (2010) ¹³⁰	Japan	2001	2007	School

ALSPAC, Avon Longitudinal Study of Parents and Children; ASHFS, Australian Schools Health Fitness Survey; BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; CATCH, Child and Adolescent Trial for Cardiovascular Health; NGHS, National Growth and Health study; NHANES, National Health and Nutrition Evaluation Surveys; NLSY79, National Longitudinal Survey of Youth; NR, not reported; PFS, Princeton follow-up study.

Population characteristics for tracking of obesity into adulthood

The sample sizes of the cohorts at baseline ranged from 1943 to 227,003 (*Table 11*; see also *Appendix 3*), and at follow-up from 1309 to 128,121. The age range for the baseline measurements varied across the studies, with the youngest age being 2 years and the oldest 19 years. Of the 23 studies, nine included a mix of children and adolescents at baseline, five just children and six just adolescents.

Four studies^{128,130,131,134} tracked weight status from childhood to adolescence, in two studies^{123,135} the latest follow-up age was 18 years and five studies included participants as young as 18 years in their follow-up.^{117,120–122,127,136} The oldest cohorts at final follow-up included participants aged 24–54 years¹¹⁹ and in one case participants aged 37–38 years.¹³⁹ The cohorts generally included equal proportions of males and females; the Bogalusa cohort had a slightly lower proportion of males (43%). The ethnicity and mix of ethnicities within the cohorts varied by country. The SES of participants was reported in only four of the studies.^{127,132,134,139} Of those, one reported that 47% had achieved college-level education or above,¹³⁹ and the other three reported that maternal/parental education levels were post high school for 20–50%.^{127,132,134} Where reported, the proportion of overweight or obese children at baseline varied considerably; overweight ranged from 5% to 18% and obesity from 2% to 17%, with generally higher rates in girls and older children.

Findings of the review of tracking of obesity into adulthood

Data extracted from the included studies, and calculated sensitivity, specificity and PPV by study, are presented in *Appendix 3*.

Overview of the studies of tracking of obesity into adulthood

To give an overview of these data, we present three figures showing sensitivity, specificity and PPV according to childhood age of BMI measurement and sex for each study. These plots show the diagnostic performance of using obesity in children (> 95th centile), according to age at measurement, to predict obesity in adults (aged ≥ 20 years).

Figure 18 shows that sensitivity is generally low – less than 40% – with the exception of one study [Thompson *et al.* (2007)¹³⁷]. Most obese adults were therefore not obese in childhood. There is no obvious trend in sensitivity with age or sex. There appears to be considerable heterogeneity across studies, with sensitivities ranging from 10% to over 60% at age 16 years. *Figure 19* shows that specificity is much higher and more consistent, ranging from 93% to nearly 100%. This means that nearly all non-obese adults were also not obese as children; however, this tells us nothing about the obese adults and children who are of concern. The PPV tells us what proportion of obese children go on to become obese adults. This is shown in *Figure 20*. The results are very heterogeneous, ranging from 40% to over 90%. The PPV depends on the prevalence of obesity, so some of this heterogeneity may be a result of varying obesity prevalence across studies.

The results do suggest that obesity is moderately persistent, at least between adolescence and adulthood.

Meta-analysis of tracking of obesity into adulthood

All tracking studies that reported full diagnostic data (i.e. numbers of true and false positives, and true and false negatives) were included in the meta-analyses, except for the study by Liddle *et al.* (2012),^{127,128} which was of children aged 5 years only and therefore did not fall into the lowest age category of the meta-analysis (7–11 years); the results of this study are presented in the previous section. Different studies reported data on different comparisons between childhood and adult obesity or overweight, and at different ages. *Table 12* gives a summary of which studies were included in which analyses; not all publications provided data for the meta-analysis. Studies reported tracking in a variety of ways, with some, for example, examining tracking of childhood obesity to adult obesity, some adolescent overweight to adult obesity and some childhood overweight to adolescent overweight, and therefore most meta-analyses include few studies.

TABLE 11 Tracking review: population characteristics

Study	Number at baseline	Number at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Percentage overweight or obese in childhood
Cheng (2011) ¹¹⁷	2189	1184	6–16	12–22	Overweight: 15.3 Obese: 40.8
Cheung (2004) ¹¹⁸	17,000	12,327; analysis on randomly selected 50% sample	7, 11, 16	33	Overweight: 10.4 Obese: 2.2
Engeland (2004) ¹¹⁹	227,003	128,121	14–19	24–54	Overweight: 4.9 for boys and 7.3 for girls
Freedman (2001) ¹²⁰	9597	2617	2–17	18–37	Obese: 7
Freedman (2005) ¹²²	11,411	2610	2–17	18–37	Overweight: 7 for boys and 6 for girls
Freedman (2005) ¹²¹	7923	2392	5–14	18–37	Overweight: ≈7
Goldhaber-Fiebert (2013) ¹²³	NR	4884 (tracking)	2–15	18	Overweight: 9–10 for 5-year-olds; 14–15 for 15-year-olds Obese: 12–13 for 5-year-olds; 11–17 for 15-year-olds
Gordon-Larsen (2004) ¹²⁴	14,438	9795 (including total population at 13–15 years, 16–17 years and 18–20 years)	13–20	19–26	Obese: 10.9
Juhola (2011) ¹²⁵	3596	2204	3–18	30–45	NR
Juonala (2006) ¹²⁶	3596	2260	3–18	24–39	Overweight: 10.5 Obese: 8.6
Liddle (2012) ¹²⁷	3960	1755	5	18.2–23.1	NR
Mamun (2005) ¹²⁸	NR	2794	5	14	Overweight/obese: 17
Merten (2010) ¹²⁹	20,745	10,439	12–19	22	NR
Nakano (2010) ¹³⁰	22,827	16,245	8	14	Overweight: 18.28 for boys and 17.09 for girls Obese: 5.94 for boys and 4.13 for girls
Nakano (2010) ¹³¹	7506	5024	7	14	NR
Patton (2011) ¹³²	1943	1520	Mean 15	24	NR
Power (1997) ¹³³	17,733	11,407	7–16	33	NR
Reilly (2011) ¹³⁴	7759	5175	7	13	Overweight: 8.1 for males and 9.6 for females Obese: 8.2 for males and 6.8 for females
Starc (2011) ¹³⁵	21,777	4833	Mean 7	18	Overweight: 13.2 for males and 13.1 for females Obese: 5.7 for males and 4.4 for females

continued

TABLE 11 Tracking review: population characteristics (*continued*)

Study	Number at baseline	Number at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Percentage overweight or obese in childhood
Stovitz (2010) ¹³⁶	5106	2802	Mean 8	Mean 18.3	Overweight: 14.9 Obese: 10.5
Thompson (2007) ¹³⁷	1963	1669	10–16	21–23	Overweight: at baseline, 7.4–8.7 for Caucasian; 17.4–18.2 for AA
Venn (2007) ¹³⁸	8498	4571	7–15	24–34	Overweight: 8.3 for boys and 9.7 for girls Obese: 1.5 for boys and 1.4 for girls
Wang (2008) ¹³⁹	2513	1309	16–17	37–38	Overweight: 8 Obese: 3

AA, African American; NR, not reported.

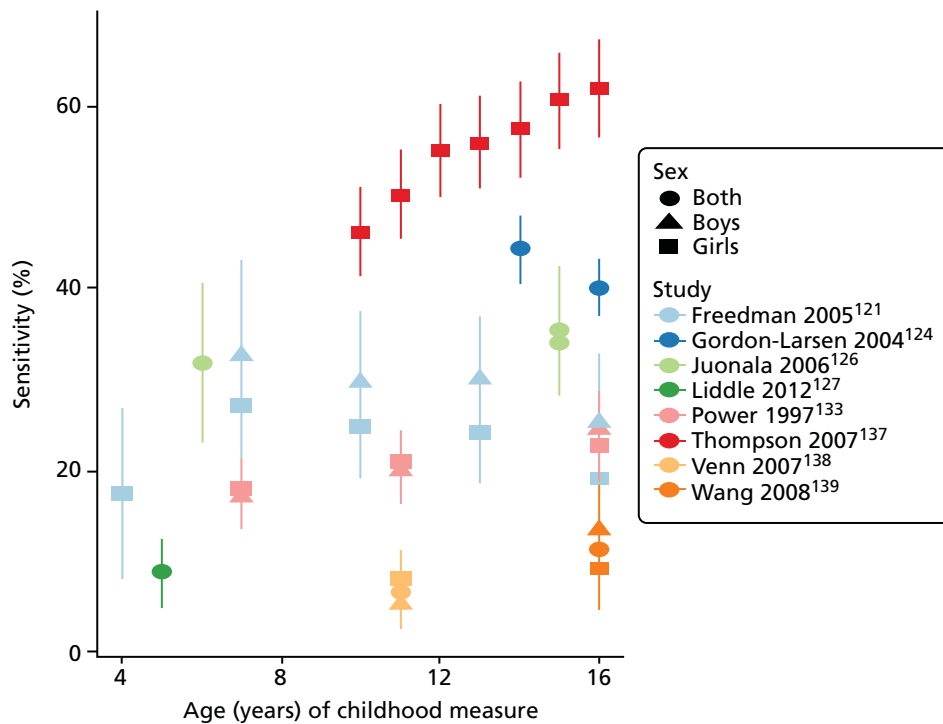


FIGURE 18 Sensitivity for predicting adult obesity from childhood obesity.

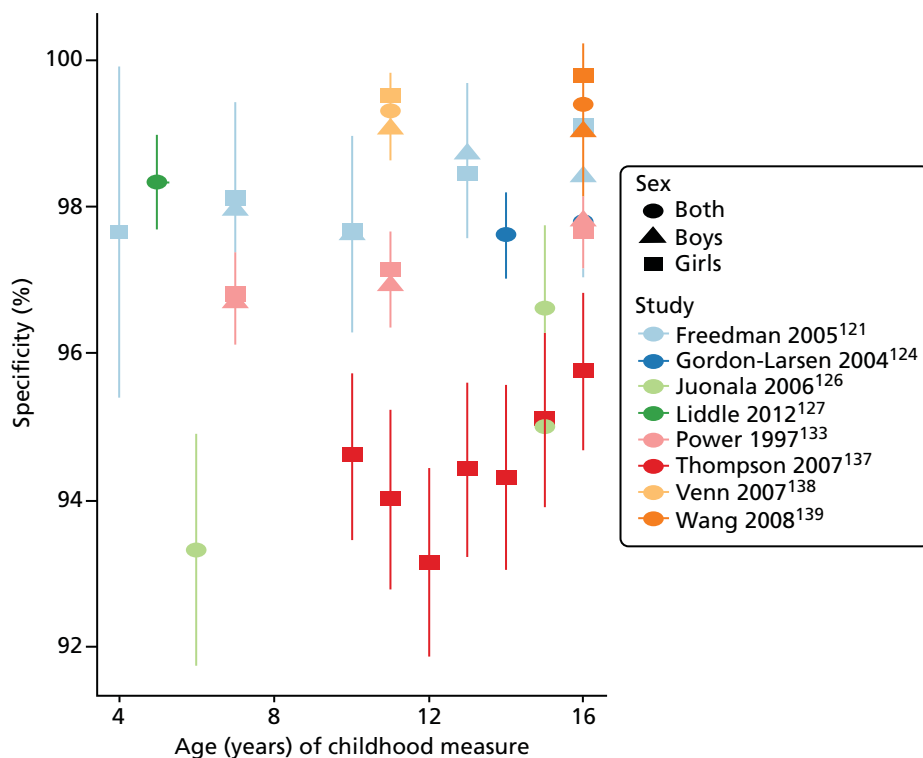


FIGURE 19 Specificity for predicting adult obesity from childhood obesity.

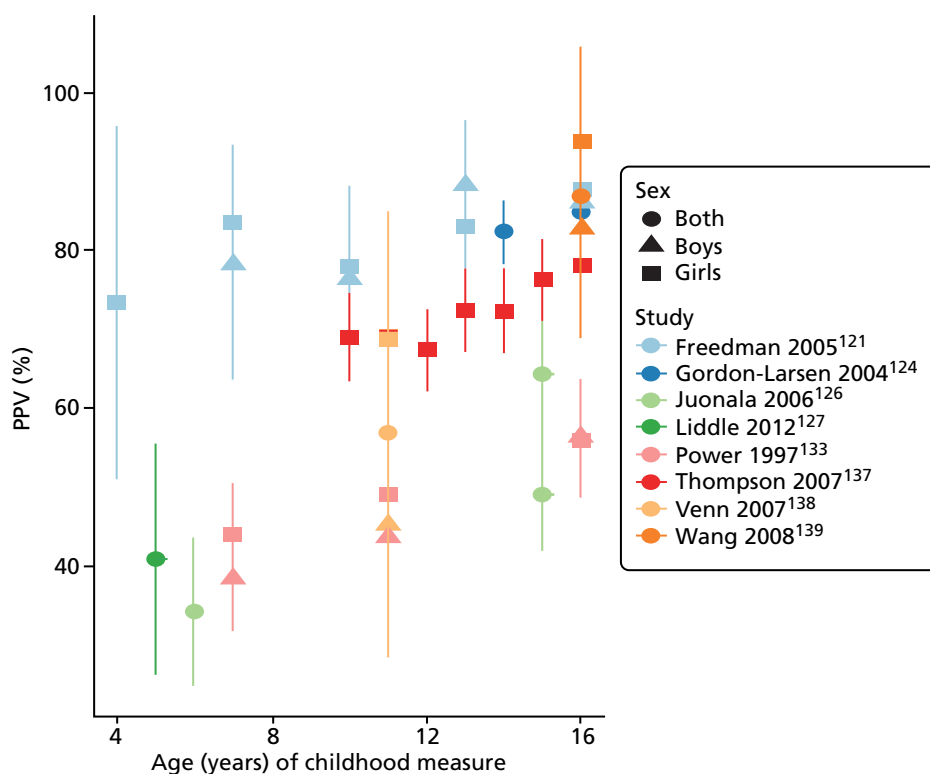


FIGURE 20 Positive predictive value for predicting adult obesity from childhood obesity.

TABLE 12 Inclusion of tracking studies in the various meta-analyses

Study	Obesity categories			Age categories				
	Childhood obesity to:		Childhood overweight or obesity to:	Child to adolescent	Child to adult	Adolescent to adult	Adolescent to over 30 years	
	Adult obesity	Adult obesity or overweight	Adult obesity	Adult obesity or overweight	Child to adolescent	Child to adult	Adolescent to adult	Adolescent to over 30 years
Cheng (2011) ¹¹⁷	X	X	X	X	X			
Power (1997) ¹³³	X	X				X	X	X
Reilly (2011) ¹³⁴	X	X	X	X	X			
Starc (2011) ¹³⁵	X	X	X	X	X			
Venn (2007) ¹³⁸	X	X	X	X		X		
Freedman (2005) ¹²²	X		X			X	X	X
Gordon-Larsen (2004) ¹²⁴	X		X				X	X
Juonala (2006) ¹²⁶	X		X				X	X
Thompson (2007) ¹³⁷	X					X	X	X
Wang (2008) ¹³⁹	X		X				X	X
Freedman (2005) ¹²¹		X		X		X		
Patton (2011) ¹³²		X					X	X
Engeland (2004) ¹¹⁹			X				X	X
Nakano (2010) ¹³⁰				X				X
Nakano (2010) ¹³¹				X			X	X
Stovitz (2010) ¹³⁶				X			X	X

Note: four studies did not provide unique data for the meta-analysis: Freedman (2001),¹²⁰ Juhola (2011),¹²⁵ Mamun (2005)¹²⁸ and Merten (2010).¹²⁹

Association between childhood weight status and adult obesity

Figure 21 shows the forest plot for the meta-analysis of RR of being obese as an adult among children who were obese. The association is strong, with obese children being more than five times more likely to be obese as adults than non-obese children. There is no apparent difference in this RR between younger and older age groups.

Tracking from childhood weight status to adult obesity

Childhood obesity to later obesity Figure 22 shows the results of the joint meta-analyses of sensitivity and specificity when predicting adult obesity (≥ 95 th centile or $> 30 \text{ kg/m}^2$) from childhood obesity (≥ 95 th centile of BMI). Four results are shown: child to adolescent (three studies), child to adult (four studies),

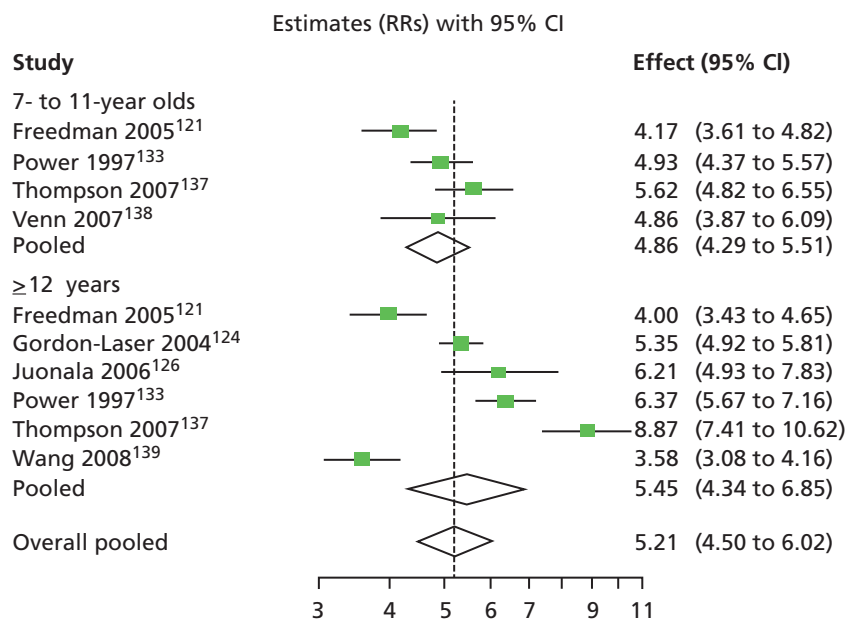


FIGURE 21 Forest plot of the association between childhood obesity and adult obesity.

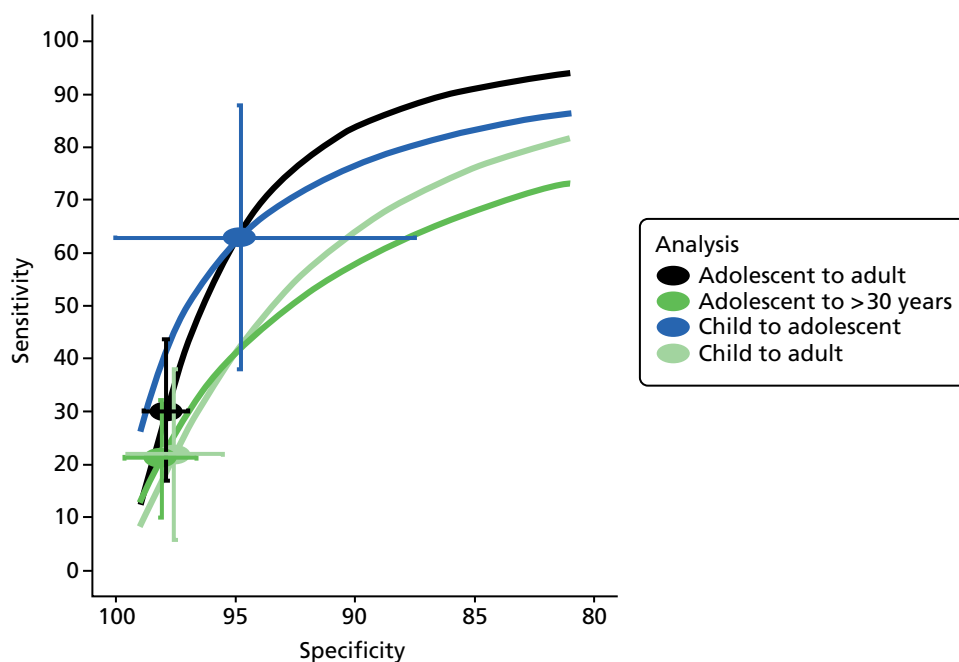


FIGURE 22 Tracking of childhood obesity to adult obesity.

adolescent to adult (six studies) and adolescent to over 30 years (three studies). The points show the summary sensitivities and specificities with their 95% CIs; the curves are the summary HSROC curves.

Figure 22 shows that obesity tracking is strongest over short time periods. Childhood obesity does track reasonably well to adolescent obesity; 62% of obese adolescents were obese in earlier childhood. A high specificity of 95% means that nearly all non-obese adolescents were non-obese children. For tracking into adulthood, the specificities of around 98% mean that nearly all non-obese adults were not obese in childhood or adolescence. However, by contrast, the low sensitivities mean that most obese adults were not obese as children. About 70% of obese adults were not obese in childhood or adolescence and 80% of over-thirties were not obese in adolescence.

Childhood overweight or obesity to later obesity Figure 23 shows the results for whether or not childhood obesity or overweight (≥ 85 th centile of BMI) tracks to later obesity (≥ 95 th centile or ≥ 30 kg/m²). Four results are shown: child to adolescent (three studies), child to adult (two studies), adolescent to adult (five studies) and adolescent to age over 30 years (three studies). The pattern of results is similar to that for childhood obesity, with low sensitivity to detect adult obesity; around 60% of obese adults were neither overweight nor obese as adolescents. Childhood overweight is, however, a good predictor of adolescent obesity; 90% of obese adolescents were overweight or obese in earlier childhood.

Tracking from childhood to adult overweight or obesity

Childhood overweight or obesity to later overweight or obesity Figure 24 shows the results of the joint meta-analyses examining whether or not childhood overweight or obesity (≥ 85 th centile of BMI) tracks to later overweight or obesity (≥ 85 th centile or > 25 kg/m²). Three results are shown: child to adolescent (six studies), child to adult (two studies) and adolescent to adult (two studies). There was only one study with data from adolescence to age over 30 years, so no analysis could be performed. We note that there were few data here for tracking into adulthood.

The results for childhood to adolescence suggest that 65% of obese or overweight adolescents were obese or overweight at younger ages. The limited data for tracking to adulthood suggest very low sensitivity; about three-quarters of overweight adults were not overweight in younger childhood.

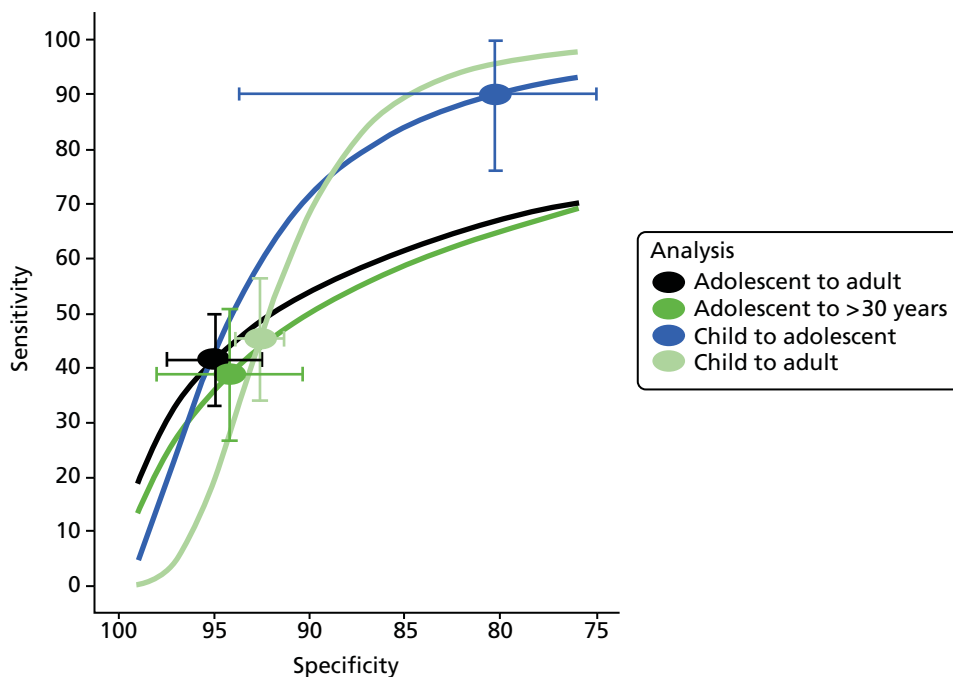


FIGURE 23 Tracking of childhood overweight or obesity to adult obesity.

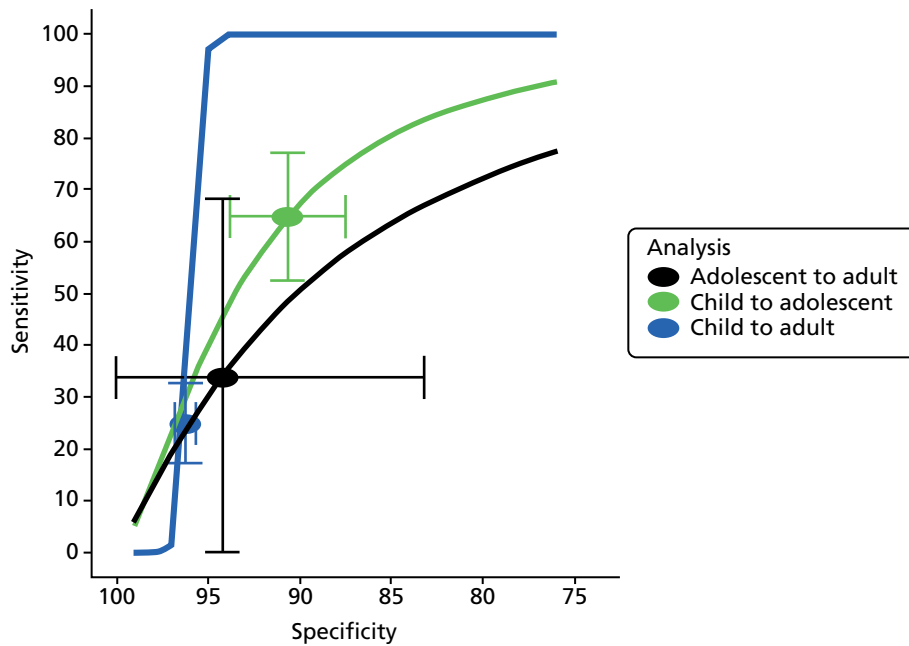


FIGURE 24 Tracking of childhood overweight or obesity to adult overweight or obesity.

Childhood obesity to later overweight or obesity Figure 25 shows how childhood obesity (excluding overweight) tracks to adult obesity or overweight. Three results are shown: child to adolescent (three studies), child to adult (three studies) and adolescent to adult (two studies). The results are broadly similar to those obtained for using childhood overweight to predict adult overweight. The results for childhood to adolescence suggest that 35% of obese or overweight adolescents were obese at younger ages. The substantial majority of overweight adults (around 90%) were not obese as children.

Positive predictive values

Meta-analyses of the PPV, which estimates the proportion of obese children who will go on to become obese adults, are presented in Figures 26 and 27. The analyses are similar to those presented above, with the same studies in each analysis as for the equivalent analyses given above.

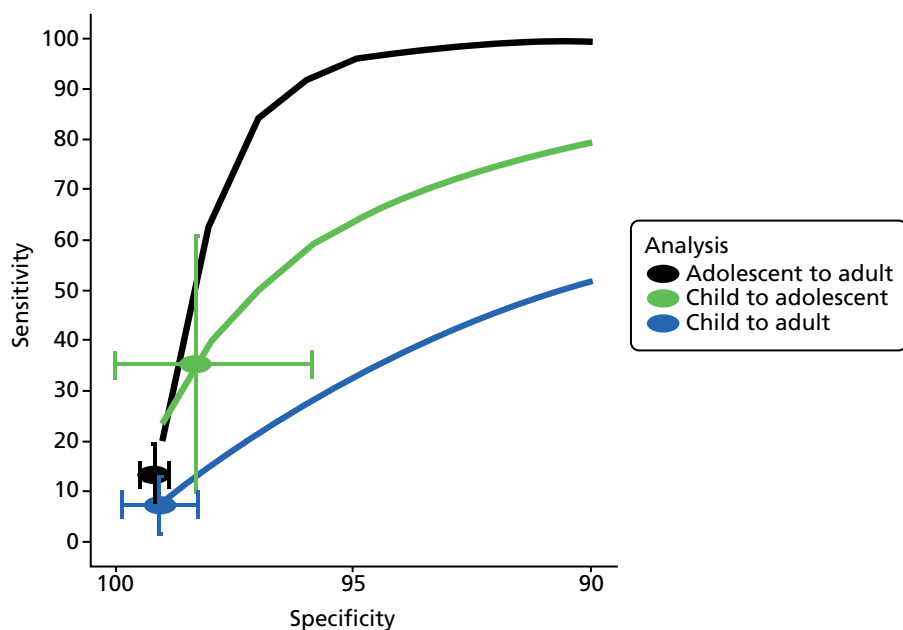


FIGURE 25 Tracking of childhood obesity to adult overweight or obesity.

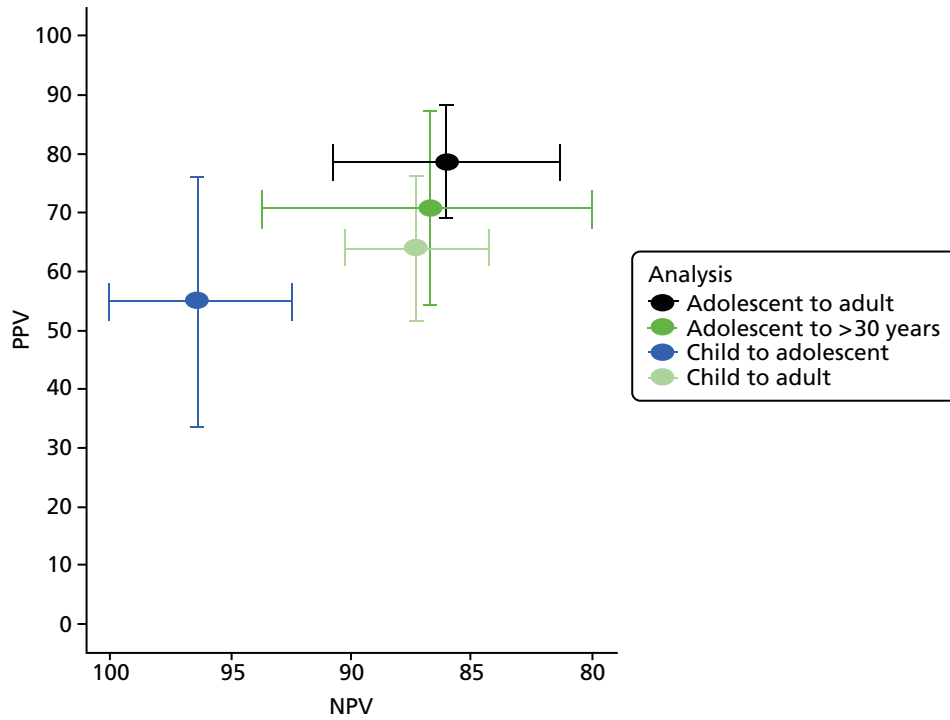


FIGURE 26 Positive predictive value for childhood obesity when tracking to adult obesity.

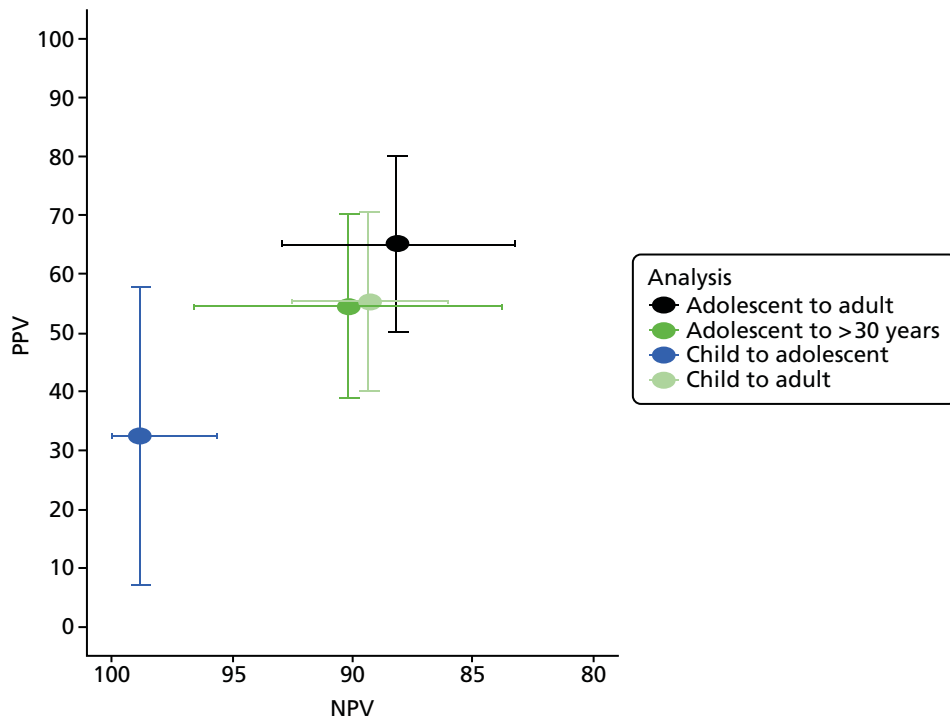


FIGURE 27 Positive predictive value for childhood overweight and obesity when tracking to adult obesity.

Figure 26 shows the PPV and NPV for predicting adult obesity from childhood obesity, classified according to age as before. This shows that obesity is moderately persistent into adulthood; just under 80% of obese adolescents were still obese as adults, although that declines to 70% when adult ages are restricted to over 30 years. Childhood obesity does not track so strongly into adolescence, however, with just over half of all children still obese as adolescents, although data were limited and therefore CIs are wide. The NPV results show that non-obesity does track into adulthood; more than 85% of non-obese children will still be non-obese in adulthood. However, this does mean that a small proportion (10–15%) of non-obese children will be obese by early adulthood.

Figure 27 shows the equivalent PPV and NPV for tracking of childhood overweight or obesity to later obesity. The pattern of results is similar, but the PPVs are smaller as many overweight children will not become obese adults. Around 66% of obese or overweight adolescents will be obese in early adulthood, dropping to around 55% by age 30 years. Only about 30% of obese or overweight children will go on to be obese in adolescence.

As both PPV and NPV depend on the prevalence of obesity, the results of these analyses should be interpreted as predictive values in a population with average obesity prevalence.

Additional information from studies that could not be included in the meta-analysis

Four studies reported data that could not be included in the meta-analyses: Goldhaber-Fiebert *et al.* (2013),¹²³ Cheung *et al.* (2004),¹¹⁸ Juhola *et al.* (2011)¹²⁵ and Liddle *et al.* (2012).¹²⁷ The extracted data are presented in *Appendix 3*. The results of these studies were broadly consistent with the findings of the meta-analyses.

The study by Goldhaber-Fiebert *et al.* (2013)¹²³ could not be included in any meta-analysis, as it was not a straightforward analysis of cohort data, but included microsimulations based on combined data sets in order to estimate how well childhood obesity predicts adult obesity and to forecast the obesity-related health of future US adults. Data were sourced from the National Longitudinal Survey of Youth (NLSY79), Population Study of Income Dynamics (PSID) and National Health and Nutrition Evaluation Surveys (NHANES). The authors estimated test characteristics and predictive values of childhood BMI to identify 2-, 5-, 10- and 15-year-olds who will become obese at age 18 years (12% of 18-year-olds in the study were obese). The analysis found that screening at age 15 years would miss 9% of those who become obese adults, but screening at age 5 years would miss 50%. The predictive value of obesity screening below age 10 years was low even when maternal obesity was included as a predictor. It should be noted that the main results do not include Hispanics, owing to sample size. The authors concluded that 'Early childhood obesity assessment adds limited information to later childhood assessment. Targeted later childhood approaches or universal strategies to prevent unhealthy weight gain should be considered'.

In the context of the present review, the results for measurement at age 15 years were not included as the distance between ages 15 and 18 years was considered too short. The results for measurements taken at ages 2, 5 and 10 years are presented in *Appendix 3*. The results reflect those of the meta-analysis in that childhood overweight or childhood obesity did not accurately predict obesity or overweight/obesity at age 18 years. Sensitivity did increase with increasing age of assessment in childhood, with the highest found to be the sensitivity of overweight in unselected boys at age 10 years (sensitivity 88%, 95% CI 80% to 93%) and unselected black and Hispanic children at age 10 years (sensitivity 88%, 95% CI 82% to 92%) to predict obesity. Surprisingly, the sensitivity of obesity at age 18 years to predict later obesity or overweight was lower. Specificity increased less with age, but generally the highest specificities were achieved at age 10 years (compared with younger ages); at this age, the specificity of childhood obesity for obesity and for overweight/obesity at age 18 years was 90% or more in boys, girls, black children and white children, whereas that for childhood overweight was lower, at around 80%. Thus, non-obesity in childhood accurately predicts non-obesity in adulthood. This study's findings were consistent with the findings of the meta-analyses.

The analysis of the British birth cohort by Cheung *et al.* (2004)¹¹⁸ reported AUC data that could not be included in the meta-analysis (*Table 13*). These authors' analysis of the British birth cohort data found that the AUC for the prediction of adult obesity from childhood obesity was slightly higher than that for predicting adult overweight from childhood overweight/obesity. Neither varied with sex but both increased slightly with childhood age.

The sensitivities and specificities reported by Cheung *et al.* (2004)¹¹⁸ for overweight and obesity at age 11 years indicate that the sensitivity of overweight (BMI) for adult obesity was low (7.7% in boys and 6.9% in girls), as was its sensitivity for adult overweight (13.9% in boys and 23.0% in girls). The sensitivity of childhood obesity for adult obesity was higher but still 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). The specificities of overweight and obesity were high for both adult overweight and adult obesity in both boys and girls (ranging from 92.7% to 99.3%). The PPVs for childhood obesity in predicting adult obesity or overweight were low, ranging from 42% to 56%; those for childhood overweight were higher (68% to 83%). The NPVs for childhood obesity were high at around 90%, but those for childhood overweight were lower (52% to 70%).

The study by Juhola *et al.* (2011)¹²⁵ reported summary data; these findings reflect that of the meta-analysis. Obesity across all ages of childhood (3–18 years) had very low sensitivity (15.8%) but high specificity (97.9%) for adult (age 30–45 years) obesity. This finding was not modified by age of child, but sensitivity was increased when boys (30.9%) and girls (22.9%) were analysed separately. The PPV and NPV were 61.5% and 84.7% respectively. PPV did tend to improve with increasing age, being 91.7% at age 15 years, whereas NPV remained roughly constant.

The cohort studied by Liddle *et al.* (2012)¹²⁷ and Mamun *et al.* (2005)¹²⁸ was followed from age 5 years and therefore was not included in the meta-analysis. Data from these studies are given in *Appendix 3* and the calculated sensitivities and specificities are given in *Table 14*.

The MUSP cohort of Australian children was followed from age 5 years, first to age 14 and then to age 21 years. The sensitivity and specificity of weight status, as determined using BMI at age 5 years to predict weight status at ages 14 and 21 years, are presented in *Table 14*. The results for the prediction of overweight at age 14 years are similar to those at age 21 years. The sensitivity of overweight or obesity at age 5 years to predict either obesity or overweight/obesity at age 21 years is low, and the sensitivity of

TABLE 13 Area under the curve data from Cheung *et al.* (2004)¹¹⁸

	Population	Timing of first measure	Cut-off point	Total N	AUC	Upper CI	Lower CI
Childhood obesity (age 11 years) to adult obesity (age 33 years)	Male	7	ROC curve BMI = 17.9	2174	0.72	0.68	0.76
		11		2085	0.78	0.75	0.81
		16		1903	0.82	0.78	0.85
	Female	7	ROC curve BMI = 18.3	2174	0.69	0.65	0.72
		11		2085	0.8	0.77	0.83
		16		1903	0.83	0.8	0.86
Childhood overweight/obesity (age 11 years) to adult overweight (age 33 years)	Male	7	ROC curve BMI = 17.9	2174	0.66	0.64	0.68
		11		2085	0.73	0.71	0.75
		16		1903	0.75	0.73	0.77
	Female	7	ROC curve BMI = 18.3	2174	0.66	0.63	0.68
		11		2085	0.75	0.72	0.77
		16		1903	0.79	0.77	0.81

TABLE 14 Mater-University Study of Pregnancy cohort results of following weight status from age 5 years

Weight status categories		Sensitivity	95% CI		Specificity	95% CI	
			Upper	Lower		Upper	Lower
Liddle (2012)¹²⁷ MUSP cohort from age 5 years to age 21 years							
BMI	Obesity at age 5 years to predict obesity at age 21 years	8.7	4.86	12.53	98.32	97.68	98.96
	Obesity at age 5 years to predict overweight or obesity at age 21 years	5.69	3.8	7.57	99.06	98.51	99.61
	Overweight or obesity at age 5 years to predict obesity at age 21 years	41.06	34.36	47.76	87.79	86.16	89.42
	Overweight or obesity at age 5 years to predict overweight or obesity at age 21 years	31.9	28.1	35.69	92.43	90.91	93.94
SFT	Obesity at age 5 years to predict obesity at age 21 years	4.83	1.91	7.75	97.55	96.77	98.32
	Obesity at age 5 years to predict overweight or obesity at age 21 years	4.48	2.8	6.17	98.13	97.35	98.9
	Overweight or obesity at age 5 years to predict obesity at age 21 years	30.92	24.62	37.21	85.66	83.91	87.4
	Overweight or obesity at age 5 years to predict overweight or obesity at age 21 years	25.86	22.3	29.43	88.43	86.6	90.25
Mamun (2005)¹²⁸ MUSP cohort from age 5 years to age 14 years							
BMI	Overweight or obesity at age 5 years to predict overweight or obesity at age 14 years	42.23	38.57	45.88	91.73	90.55	92.91

obesity at age 5 years is particularly low. These results reflect those of the meta-analysis for older age ranges, although they might suggest that diagnosis of obesity at age 5 years does not track to adult obesity. The findings from the study by Liddle *et al.* (2012)¹²⁷ on the predictive ability of triceps SFT reflect those for BMI, except that the sensitivity and specificity results are slightly poorer. This study does not provide evidence that SFT might be a better measure in children than BMI.

Conclusions of the tracking review

This review identified 23 studies^{117–139} which tracked childhood obesity or overweight into adolescence or adulthood. Of these, 20 were included in the meta-analyses. These studies were very diverse, including studies from Europe, the USA and Asia, with widely differing sample sizes. The age at which childhood assessment was carried out ranged from 7 to 18 years. Most studies included in the meta-analysis were at an unclear risk of attrition bias and confounding was considered only in terms of age and sex, if at all. BMI was measured at various ages in childhood, adolescence and adulthood, and in various populations. As a result of this diversity, very few studies were included in each specific meta-analysis, leading to considerable uncertainty in the results and wide CIs. This uncertainty should be considered when interpreting the results.

The analysis found a strong association between childhood obesity and adult obesity, with obese children being about five times more likely to be obese as adults than similar, non-obese children. This strong association is reflected in the high PPVs: just under 80% of obese adolescents go on to be obese adults. This drops to 70% when only adults over age 30 years are considered, so consequently around 30% of obese adolescents will not be obese 20 years later. Tracking of obesity from childhood to adolescence was generally good, with around 60% of obese adolescents having been obese as children, and around half of obese children still being obese in adolescence.

By contrast, most obese adults were not obese as children or adolescents: just 30% of obese adults were obese in adolescence, and around 60% of obese adults were of healthy weight during childhood and adolescence. Using childhood obesity to predict adult obesity will therefore fail to identify most adult obesity.

No data were available for tracking beyond age 40 years, but given the available data it seems that many obese children will not be obese by their forties or later (when obesity-related morbidities are most common), and most people who are obese at later ages will not have been obese in childhood.

Review of diagnostic accuracy of childhood measures of obesity

Of the 794 full papers screened, 375 were potential includes for the diagnostic accuracy review. Of these, 341 were excluded, primarily because they were correlation studies and therefore reported only associations rather than diagnostic accuracy.

Quality of the evidence for diagnostic accuracy of childhood measures of obesity

Thirty-four studies met the inclusion criteria for the review of diagnostic accuracy.¹⁷³⁻²⁰⁶ The full results of the quality assessment, along with the guidance for scoring each criterion, are given in *Appendix 4*. There were some duplicate papers for some cohorts, where more than one paper provided unique data. Three papers reported data from the NHANES study,^{101,103,180} data were extracted from the one that provided 5 × 5 data in the largest population ($n = 7356$) for both BMI and SFT using DEXA as the reference standard.¹⁸⁰ The other two NHANES papers were not extracted; one reported only PPV for BMI,¹⁰³ and the other 3 × 3 tables using cut-off points < 5th, 5th–85th and > 85th internally derived centiles, so providing 2 × 2 data for overweight only, for a small subgroup of children ($n = 58$) with cerebral palsy and ‘reference children’ ($n = 6754$).¹⁰¹ Three papers were identified from the Stockholm Weight Development Study.^{102,192,193} One of these was a summary of the results presented in the other two papers, and was therefore excluded.¹⁰² Data were extracted from both of the other studies; one provided data for BMI, WC and hip circumference (HC),¹⁹³ and the other for a further three classification systems of BMI.¹⁹² Two studies reported results from the Pediatric Rosetta Body Composition study.^{179,190} Both studies were included in the review as one reported sensitivity and specificity for BMI of the entire population, along with SFT for boys and girls separately and for the entire population,¹⁹⁰ and the other reported a contingency table for boys and girls separately for BMI only, from which summary measures were calculated for those subgroups.¹⁷⁹

All 34 studies avoided differential verification bias and incorporation bias; only one study was subject to partial verification bias, with the results of DEXA being imputed for some children.¹⁸⁰ Only two studies used the gold standard, a multicomponent model;^{175,182} the other studies used an imperfect reference standard. Of the 32 using an imperfect reference standard, three used D₂O,^{173,204,205} one used ADP¹⁹³ and four used underwater (hydrostatic) weighting,^{186,187,189,197} but most used the least reliable of the eligible reference standards, DEXA.^{174,176–181,183–185,188,190–192,194–196,198–203,206} Brief study details are provided in *Table 15*.

Eighteen studies recruited either consecutive or randomly selected children from populations representative of the UK population who would be eligible for the test in clinical practice.^{173,177–181,186,189–195,201,202,205,206} One study recruited a population representative of the country in which the study was conducted.¹⁸⁸ Thirteen studies did not recruit a representative population, for either the country in which the study was conducted or the UK;^{174–176,184,185,187,196–200,203,204} these studies generally focused on specific subgroups of children. The representativeness of the population was unclear in two studies.^{182,183}

TABLE 15 Brief study characteristics

Study details	Population details	Tests conducted
Alvero-Cruz (2010) ¹⁷³	<i>n</i> = 150	Index tests
Escola study	Age (years): mean 14.8 years (range 12–18 years)	<ul style="list-style-type: none"> • BMI • fat mass
Europe	Sex: male 50%	Reference standard
Study dates October–December 2006	Ethnicity: NR	<ul style="list-style-type: none"> • D₂O
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • PPV/NPV • LR+/- • AUC
Bartok (2011) ¹⁷⁴	<i>n</i> = 197 at baseline; 160 at final follow-up	Index tests
USA/Canada	Age: 9–15 years	<ul style="list-style-type: none"> • BMI
Study dates 2000–7	Sex: male 0%	Reference standard
	Ethnicity: white 100%	<ul style="list-style-type: none"> • DEXA
	Weight distribution: overweight 30–42% depending on age; obese 17–29% depending on age	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • AUC
Bray (2002) ¹⁷⁵	<i>n</i> = 131 at baseline; 114 at final follow-up	Index tests
USA/Canada	Age: mean 12.7 years (SD 0.11 years)	<ul style="list-style-type: none"> • BMI • sum SFT
Study dates NR	Sex: male 53.5%	Reference standard
	Ethnicity: white 48.2%; black 51.8%	<ul style="list-style-type: none"> • multicomponent <ul style="list-style-type: none"> ○ fat ○ bone mineral ○ water ○ body weight and density
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec
Dung (2006) ¹⁷⁶	<i>n</i> = 393	Index tests
Europe	Age: mean 12 years (range 0.4–18 years)	<ul style="list-style-type: none"> • BMI
Study dates April 1998–September 2003	Sex: male 48.6%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • contingency table

continued

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Ellis (1999) ¹⁷⁷	<i>n</i> = 979	Index tests
USA/Canada	Age: 3–18 years	<ul style="list-style-type: none"> BMI
Study dates 1994–8	Sex: male 41.5%	Reference standard
	Ethnicity: white 44.7%; black 28.9%; Hispanic 26.4%	<ul style="list-style-type: none"> DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> contingency table
Field (2003) ¹⁷⁸	<i>n</i> = 596	Index tests
USA/Canada	Age: mean 10 years (SD 2.2 years)	<ul style="list-style-type: none"> BMI
Study dates NR	Sex: male 39.8%	Reference standard
	Ethnicity: white 55.4%; AA 40.1%; Hispanic, Asian and other 4.5%	<ul style="list-style-type: none"> DEXA
	Weight distribution: healthy weight 36.7%; overweight 12.3%; obese 51%	Outcomes reported
		<ul style="list-style-type: none"> sens/spec PPV
Freedman (2009) ¹⁷⁹	<i>n</i> = 1196	Index tests
Pediatric Rosetta Body Composition study	Age: 5–18 years	<ul style="list-style-type: none"> BMI
USA/Canada	Sex: male 52.3%	Reference standard
Study dates 1995–2000	Ethnicity: white 25%, Asian 30%, black 23%, Hispanic 14%, unclassified 8%	<ul style="list-style-type: none"> DEXA
	Weight distribution: healthy weight 67%, overweight 17%, obese 16%	Outcomes reported
		<ul style="list-style-type: none"> contingency table
Freedman (2013) ¹⁸⁰	<i>n</i> = 7365	Index tests
NHANES	Age: mean 13.9 years (range 9.8–18.2 years)	<ul style="list-style-type: none"> BMI SFT
USA/Canada	Sex: male 61%	Reference standard
Study dates 1999–2004	Ethnicity: white 61.5%, black 14.5%, Hispanic 11%	<ul style="list-style-type: none"> DEXA
	Weight distribution: overweight 16.5%, obese 17.5%	Outcomes reported
		<ul style="list-style-type: none"> contingency table
Fujita (2011) ¹⁸¹	<i>n</i> = 466 at baseline; 422 at final follow-up	Index tests
UK	Age: mean 10 years	<ul style="list-style-type: none"> BMI WC WHtR
Study dates 2008–10	Sex: male 53.6%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> sens/spec AUC

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Fuller (2001) ¹⁸²	<i>n</i> = 41 at baseline; 38 in analysis	Index tests
UK	Age: mean 9.4 years (SD 1.4 years)	<ul style="list-style-type: none"> • sum SFT • NIR
Study dates NR	Sex: male 50%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • multicomponent <ul style="list-style-type: none"> ○ bone mineral ○ water ○ fat-free dry tissue ○ body density (kg/l)
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • contingency table (tertiles)
Fuller (2002) ¹⁸³	<i>n</i> = 41 at baseline; 37 in analysis	Index tests
UK	Age: mean 9.4 years (range 8–12 years)	<ul style="list-style-type: none"> • BIA
Study dates NR	Sex: male 48.6%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • DEXA
	Weight distribution: 32.4% in upper tertile	Outcomes reported
		<ul style="list-style-type: none"> • contingency table (tertiles)
Guntsche (2010) ¹⁸⁴	<i>n</i> = 108	Index tests
Argentina	Age: mean 11 years (range 6–16 years)	<ul style="list-style-type: none"> • BMI • sum SFT • WC • WHtR • WHR
Study dates 2005–7	Sex: male 63%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • DEXA
	Weight distribution: healthy weight 36%, overweight 13.0%, obese 50.9%	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • AUC
Harrington (2013) ¹⁸⁵	<i>n</i> = 423 at baseline; 369 at final follow-up	Index tests
USA/Canada	Age: 5–18 years	<ul style="list-style-type: none"> • BMI
Study dates NR	Sex: male 46.9%	Reference standard
	Ethnicity: white 48%, black 52%	<ul style="list-style-type: none"> • DEXA
	Weight distribution: obese 33%	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • AUC

continued

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Himes (1989) ¹⁸⁶	<i>n</i> = 316	Index tests
USA/Canada	Age: 8.4–18.99 years	<ul style="list-style-type: none"> • BMI • sum SFT
Study dates NR	Sex: male 50.3%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • Underwater (hydrostatic) weighting
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • PPV
Johnston (1985) ¹⁸⁷	<i>n</i> = 235	Index tests
USA/Canada	Age: 12–17 years	<ul style="list-style-type: none"> • SFT • relative weight
Study dates NR	Sex: male 71.9%	Reference standard
	Ethnicity: white 97.4%, black 2.6%	<ul style="list-style-type: none"> • Underwater (hydrostatic) weighting
	Weight distribution: obese 20.4%	Outcomes reported
		<ul style="list-style-type: none"> • contingency table
Khadgawat (2013) ¹⁸⁸	<i>n</i> unclear at baseline; 1640 at final follow-up	Index tests
Asia	Age: 7–17 years	<ul style="list-style-type: none"> • BMI
Study dates NR	Sex: male 50.3%	Reference standard
	Ethnicity: Asian 100% (presumed)	<ul style="list-style-type: none"> • DEXA
	Weight distribution: healthy weight 81.8%, overweight 13.8%, obese 4.5%	Outcomes reported
		<ul style="list-style-type: none"> • contingency table
Marshall (1991) ¹⁸⁹	<i>n</i> = 600 at baseline; 540 at final follow-up	Index tests
Canadian Fitness Survey 1985	Age: mean 10.9 years (range 7–14 years)	<ul style="list-style-type: none"> • BMI • sum SFT • relative weight
USA/Canada	Sex: male 49.3%	Reference standard
Study start date 1981	Ethnicity: NR	<ul style="list-style-type: none"> • Underwater (hydrostatic) weighting
	Weight distribution: obese 14.1%	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • PPV/NPV

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Mei (2006) ¹⁹⁰	<i>n</i> = 1208 at baseline; 1196 at final follow-up	Index tests
Pediatric Rosetta Body Composition study	Age: mean 12 years (range 5–18 years)	<ul style="list-style-type: none"> • BMI • SFT
USA/Canada	Sex: male 52.3%	Reference standard
Study dates 1995–2000	Ethnicity: white 25.3%, Asian 29.9%, black 22.5%, Hispanic 20.9%	<ul style="list-style-type: none"> • DEXA
	Weight distribution: healthy weight 25.6%, overweight 33.9%, obese 40.5%	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • AUC
Moreno (2006) ¹⁹¹	<i>n</i> = 348 at baseline; 286 in analysis	Index tests
AVENA study	Age: 13–17.9 years	<ul style="list-style-type: none"> • BMI
Europe	Sex: male 40.6%	Reference standard
Study dates NR	Ethnicity: NR	<ul style="list-style-type: none"> • DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec
Neovius (2004) ¹⁹²	<i>n</i> = 481 at baseline; 474 had data available	Index tests
Stockholm Weight Development Study	Age: mean 16.9 years (SD 0.4 years)	<ul style="list-style-type: none"> • BMI
Europe	Sex: male 42.2%	Reference standard
Study dates NR	Ethnicity: NR	<ul style="list-style-type: none"> • ADP
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • LR+/- • AUC
Neovius (2005) ¹⁹³	<i>n</i> = 481 at baseline; 474 had data available	Index tests
Stockholm Weight Development Study	Age: mean 16.8 years (SD 0.4 years)	<ul style="list-style-type: none"> • BMI • WC • WHR
Europe	Sex: male 42.2%	Reference standard
Study dates NR	Ethnicity: NR	<ul style="list-style-type: none"> • ADP
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • LR+/- • AUC

continued

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Pandit (2009) ¹⁹⁴	<i>n</i> = 566	Index tests
Asia	Age: 6–17 years	<ul style="list-style-type: none"> • BMI
Study dates NR	Sex: male 55.8%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • DEXA
	Weight distribution: overweight 38.5% of boys and 54% of girls	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec • PPV/NPV • AUC
Reilly (2010) ¹⁹⁵	<i>n</i> = 7779 at baseline; 7722 had data available	Index tests
ALSPAC	Age: mean 9.9 years (SD 0.5 years)	<ul style="list-style-type: none"> • BMI • WC
UK	Sex: male 49.3%	Reference standard
Study dates NR	Ethnicity: NR	<ul style="list-style-type: none"> • DEXA
	Weight distribution: overweight 25.5%, obese 13%	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec
Sardinha (1999) ¹⁹⁶	<i>n</i> = 328	Index tests
USA/Canada	Age: 10–15 years	<ul style="list-style-type: none"> • BMI • SFT
Study dates NR	Sex: male 50.3%	Reference standard
	Ethnicity: white 100%	<ul style="list-style-type: none"> • DEXA
	Weight distribution: obese 27.3% of boys and 44.8% of girls	Outcomes reported
		<ul style="list-style-type: none"> • AUC
Sarria (2001) ¹⁹⁷	<i>n</i> = 175 (173 with WC measurements)	Index tests
Europe	Age: 7.2–16.9 years	<ul style="list-style-type: none"> • BMI • SFT • WC
Study dates NR	Sex: male 100%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> • Underwater (hydrostatic) weighting
	Weight distribution: overweight 21.1%	Outcomes reported
		<ul style="list-style-type: none"> • sens/spec

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Sproule (2009) ¹⁹⁸	<i>n</i> = 25 (with spinal muscular atrophy)	Index tests
USA/Canada	Age: mean 9.1 years (range 5–18 years)	<ul style="list-style-type: none"> BMI
Study dates NR	Sex: male 56%	Reference standard
	Ethnicity: NR	<ul style="list-style-type: none"> DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> sens/spec
Taylor (2000) ¹⁹⁹	<i>n</i> = 580	Index tests
Australia/New Zealand	Age: mean 12.2 years (range 3.1–19.9 years)	<ul style="list-style-type: none"> WC WHR conicity index
Study dates NR	Sex: male 52.1%	Reference standard
	Ethnicity: white 100%	<ul style="list-style-type: none"> DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> sens/spec LR+/- AUC
Taylor (2003) ²⁰⁰	<i>n</i> = 368	Index tests
Australia/New Zealand	Age: mean 11.9 years (range 8.5–15.5 years)	<ul style="list-style-type: none"> BMI
Study dates NR	Sex: male 48.6%	Reference standard
	Ethnicity: white 100%	<ul style="list-style-type: none"> DEXA
	Weight distribution: obese 25%	Outcomes reported
		<ul style="list-style-type: none"> sens/spec AUC
Telford (2008) ²⁰¹	<i>n</i> = 741	Index tests
Commonwealth Institute LOOK	Age: mean 8 years (SD 0.3 years)	<ul style="list-style-type: none"> BMI
Australia/New Zealand	Sex: male 50.7%	Reference standard
Study dates NR	Ethnicity: NR	<ul style="list-style-type: none"> DEXA
	Weight distribution: NR	Outcomes reported
		<ul style="list-style-type: none"> sens/spec

continued

TABLE 15 Brief study characteristics (continued)

Study details	Population details	Tests conducted
Vitolo (2007) ²⁰²	<i>n</i> = 427 at baseline; 418 at final follow-up	Index tests
Brazil	Age: mean 13.4 years (range 10–19 years)	• BMI
Study start date 1998	Sex: male 52.4%	Reference standard
	Ethnicity: NR	• DEXA
	Weight distribution: overweight approximately 25%	Outcomes reported
		• sens/spec
		• PPV/NPV
Warner (1997) ²⁰³	<i>n</i> = 143	Index tests
UK	Age: mean 13.5 years (SD 2.7 years)	• BMI
Study dates NR	Sex: male 55.2%	Reference standard
	Ethnicity: NR	• DEXA
	Weight distribution: NR	Outcomes reported
		• sens/spec
Wickramasinghe (2005) ²⁰⁴	<i>n</i> = 138	Index tests
Australia/New Zealand	Age: mean 9.4 years (range 5–14.99 years)	• BMI
Study dates NR	Sex: male 51.4%	Reference standard
	Ethnicity: white 69.6%, Asian 30.4%	• D ₂ O
	Weight distribution: obese 51.4%	Outcomes reported
		• sens/spec
Wickramasinghe (2009) ²⁰⁵	<i>n</i> = 282	Index tests
Asia	Age: mean 9.8 years (range 5–15 years)	• BMI
Study dates September 2004–April 2005	Sex: male 56%	• WC
	Ethnicity: NR	• WHR
	Weight distribution: NR	Reference standard
		• D ₂ O
		Outcomes reported
		• sens/spec
Zhang (2004) ²⁰⁶	<i>n</i> = 1068 at baseline; 751 at final follow-up	Index tests
Asia	Age: 9–14 years	• BMI
Study dates NR	Sex: male 15.3%	Reference standard
	Ethnicity: Asian 100%	• DEXA
	Weight distribution: obese 28%	Outcomes reported
		• contingency table

AA, African American; ALSPAC, Avon Longitudinal Study of Parents and Children; AVENA, *Alimentacion y Valoracion del Estado Nutricional en Adolescentes*; LOOK, lifestyle of our kids; LR+/-, positive/negative likelihood ratio; NR, not reported; sens, sensitivity; spec, specificity.

Most of the studies were single-gate diagnostic cohort studies undertaken specifically to determine the accuracy of a simple anthropomorphic measure (the index test).^{173,175–179,181–184,186–189,193,194,196–205} Although the time lag between the index test and reference standard test was not stated, it is unlikely that this was sufficiently long for progression bias to be present. Five studies were cross-sectional, with aims beyond the determination of the diagnostic accuracy of an index test, and had either a prospective^{185,190,191,206} or retrospective/post-hoc¹⁸⁰ analysis; these were also considered to have a low likelihood of progression bias. Three studies were longitudinal, and the timing of the index and reference standard tests was not specifically reported; therefore, the potential for progression bias was unclear.^{174,192,195}

The description of the index tests was adequate in most studies; the details provided for the reference standards were generally more poorly reported, making reproducibility of the reference standard tests more difficult. Most of the studies apparently had no uninterpretable results and no withdrawals. The number and expertise of the assessors for both the index tests and reference standards were unclear in most studies.

Owing to the poorer accuracy of DEXA compared with the other reference standards, none of the studies using DEXA was considered to be of high quality. Of the 10 studies that used a reference standard other than DEXA, eight were considered to be high quality,^{173,186,187,189,193,197,204,205} one did not explain withdrawals¹⁷⁵ and another excluded withdrawals from the study.¹⁸²

Diagnostic accuracy of body mass index

A total of 30 diagnostic accuracy studies evaluated BMI. The study and population characteristics varied across these studies. In clinical practice, weight status is commonly defined using the cut-off points of 85th centile for overweight and 95th centile for obesity. In addition, the measures tend to be used in a diverse population of children. Several of the studies did not report the thresholds used, used other thresholds to define overweight and obesity or conducted the study in a population that was not representative of the UK child population. This section therefore concentrates on the 11 diagnostic accuracy studies of BMI that used the 85th centile for diagnosing overweight and the 95th centile for diagnosing obesity (regardless of the reference population used to standardise the measure for age) in unselected boys, girls or children of both sexes reflective of the UK child population (see *Table 16*). Results for the other studies of BMI are presented in *Appendix 3*, which includes the findings of all the included diagnostic accuracy studies.

The sensitivities and specificities of the 11 BMI studies are presented in *Table 16*. Of these, only one study was considered to be of high quality (results shown in italics in *Table 16*).¹⁸⁶ Sensitivity varied considerably across these studies, ranging from 23% to 96% for diagnosing obesity and 19% to 94% for diagnosing overweight. Specificity was less variable, ranging from 89.4% to 100% for diagnosing obesity and 82% to 100% for diagnosing overweight. Data were available as 2 × 2 contingency tables for eight studies diagnosing overweight^{177,179,180,188,191,192,197,203} and six studies diagnosing obesity;^{177,179,180,186,188,195} 2 × 2 tables were not available for two studies.^{181,190}

Using the 2 × 2 data, the pooled sensitivity, specificity, positive likelihood ratio (LR+) and negative likelihood ratio (LR–) were calculated using the HSROC model (*Figure 28*); analyses were conducted for boys and girls separately and combined (*Table 17*). Two analyses were conducted for boys and girls combined; one used the separate boy and girl subgroups,^{177,179,180,186,188,191,192,195,197} adding data for the one study that did not report for girls and boys separately,²⁰³ and in the other, data from the within-study boy and girl subgroups were combined to create 'all children' populations prior to analysis.^{177,179,180,186,188,191,192,203} The former included the one study that reported results for boys only;¹⁹⁷ this study was excluded from the latter analysis.

TABLE 16 Sensitivities and specificities (including 95% CIs where reported or calculated) of the diagnostic accuracy studies that evaluated BMI using the 85th and 95th centiles in unselected populations of boys, girls or both sexes

Study	Population	Age at assessment (years)	Index test details	Index test point (centile)	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity									
Himes (1989) ¹⁸⁶	All children	8.4–18.99	NR	85th	Underwater (hydrostatic) weighing	90th centile	316	25 (16 to 37)	100 (98 to 100)
Freedman (2013) ¹⁸⁰	All children	8–19	CDC	95th	DEXA	NR	7365	76 (73 to 78)	95 (94 to 95)
Reilly (2010) ¹⁹⁵	All children	Mean 9.9	UK90	95th	DEXA	90th centile	7722	95 (94 to 97)	95 (95 to 96)
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	95th	DEXA	95th centile	1640	66 (53 to 77)	98 (97 to 99)
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	95th	DEXA	Prevalence matched to BMI	1640	72 (60 to 82)	99 (98 to 99)
Freedman (2009) ¹⁷⁹	All children	5–18	CDC	95th	DEXA	95th centile	1196	77 (70 to 83)	96 (94 to 97)
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	95th	DEXA (adjusted for sex and ethnicity)	95th centile	979	72 (58 to 84)	91 (89 to 93)
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	95th	DEXA (adjusted for sex)	95th centile	979	82 (69 to 91)	92 (90 to 93)
Field (2003) ¹⁷⁸	Unselected	Mean 10 (SD 2.2)	NR	95th	DEXA	90th centile	596	65 (NR)	99 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–18	CDC	95th	DEXA	95th centile	1196	92.5 (NR)	89.4 (NR)
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	NR	85th	Underwater (hydrostatic) weighing	90th centile	159	29 (11 to 51)	99 (96 to 100)
Freedman (2013) ¹⁸⁰	Boys	8–19	CDC	95th	DEXA	NR	4518	75 (72 to 78)	95 (94 to 95)
Reilly (2010) ¹⁹⁵	Boys	9.9	UK90	95th	DEXA	90th centile	3809	96 (94 to 98)	95 (94 to 95)
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	95th	DEXA	95th centile	825	85 (65 to 96)	97 (95 to 98)
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	95th	DEXA	Prevalence matched to BMI	825	67 (52 to 80)	98 (97 to 99)
Freedman (2009) ¹⁷⁹	Boys	5–18	CDC	95th	DEXA	95th centile	626	75 (65 to 83)	95 (93 to 97)

Study	Population	Age at assessment (years)	Index test details	Index test point (centile)	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	95th	DEXA (adjusted for sex and ethnicity)	95th centile	406	76 (53 to 92)	91 (88 to 94)
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	95th	DEXA (adjusted for sex)	95th centile	406	71 (48 to 89)	91 (88 to 94)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	NR	85th	Underwater (hydrostatic) weighing	90th centile	157	23 (10 to 40)	100 (99 to 100)
Freedman (2013) ¹⁸⁰	Girls	8–19	CDC	95th	DEXA	NR	2847	76 (72 to 80)	95 (94 to 96)
Reilly (2010) ¹⁹⁵	Girls	9.9	UK90	95th	DEXA	90th centile	3913	94 (91 to 96)	96 (96 to 97)
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	95th	DEXA	95th centile	815	54 (37 to 69)	100 (99 to 100)
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	95th	DEXA	Prevalence matched to BMI	815	81 (61 to 93)	99 (99 to 100)
Freedman (2009) ¹⁷⁹	Girls	5–18	CDC	95th	DEXA	95th centile	570	80 (70 to 88)	97 (94 to 98)
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	95th	DEXA (adjusted for sex and ethnicity)	95th centile	573	69 (49 to 85)	91 (88 to 93)
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	95th	DEXA (adjusted for sex)	95th centile	573	90 (73 to 98)	92 (90 to 94)

continued

TABLE 16 Sensitivities and specificities (including 95% CIs where reported or calculated) of the diagnostic accuracy studies that evaluated BMI using the 85th and 95th centiles in unselected populations of boys, girls or both sexes (*continued*)

Study	Population	Age at assessment (years)	Index test details	Index test point (centile)	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Overweight									
Neovius (2004) ¹⁹²	All children	Mean 16.9 (SD 0.4)	Göteborg, Sweden	85th	ADP	25% BF boys; 30% BF girls	474	48 (40 to 57)	95 (92 to 97)
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	WHO	85th	ADP	25% BF boys; 30% BF girls	474	28 (20 to 36)	99 (97 to 100)
Freedman (2009) ¹⁷⁹	All children	5–18	CDC	85th	DEXA	85th centile	1196	83 (79 to 87)	92 (90 to 94)
Moreno (2006) ¹⁹¹	All children	13–17.9	AVENA	85th	DEXA	85th centile	286	67 (53 to 78)	90 (86 to 94)
Moreno (2006) ¹⁹¹	All children	13–17.9	IOTF	85th	DEXA	85th centile	286	73 (60 to 84)	88 (84 to 92)
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	85th	DEXA	85th centile	1640	72 (66 to 77)	93 (91 to 94)
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	85th	DEXA	Prevalence matched to BMI	1640	72 (67 to 77)	94 (93 to 95)
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	85th	DEXA (adjusted for sex and ethnicity)	85th centile	979	92 (86 to 96)	83 (80 to 85)
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	85th	DEXA (adjusted for sex)	85th centile	979	93 (87 to 96)	83 (80 to 85)
Warner (1997) ²⁰³	All children	?	SD scores	85th/1 SD	DEXA	US 85th centile	143	66 (52 to 78)	94 (86 to 98)
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Göteborg, Sweden	85th	ADP	25% BF	200	92 (NR)	93 (NR)
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	WHO	85th	ADP	25% BF	200	68 (NR)	98 (NR)
Freedman (2013) ¹⁸⁰	Boys	8–19	CDC	85th	DEXA	NR	4518	83 (81 to 84)	91 (90 to 92)
Freedman (2009) ¹⁷⁹	Boys	5–18	CDC	85th	DEXA	85th centile	626	84 (78 to 88)	92 (89 to 95)
Moreno (2006) ¹⁹¹	Boys	13–17.9	AVENA	85th	DEXA	85th centile	116	53 (28 to 77)	88 (79 to 94)
Moreno (2006) ¹⁹¹	Boys	13–17.9	IOTF	85th	DEXA	85th centile	116	71 (44 to 90)	86 (77 to 92)
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	85th	DEXA	85th centile	825	78 (71 to 85)	91 (89 to 93)
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	85th	DEXA	Prevalence matched to BMI	825	77 (70 to 83)	94 (92 to 95)

Study	Population	Age at assessment (years)	Index test details	Index test point (centile)	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	85th	DEXA (adjusted for sex and ethnicity)	85th centile	406	92 (82 to 97)	84 (79 to 87)
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	85th	DEXA (adjusted for sex)	85th centile	406	90 (80 to 96)	83 (79 to 87)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Göteborg, Sweden	85th	ADP	30% BF	274	39 (NR)	97 (NR)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	WHO	85th	ADP	30% BF	274	19 (NR)	100 (NR)
Freedman (2013) ¹⁸⁰	Girls	8–19	CDC	85th	DEXA	?	2847	80 (77 to 82)	90 (88 to 91)
Freedman (2009) ¹⁷⁹	Girls	5–18	CDC	85th	DEXA	85th centile	570	83 (77 to 88)	92 (89 to 94)
Moreno (2006) ¹⁹¹	Girls	13–17.9	AVENA	85th	DEXA	85th centile	170	79 (58 to 93)	92 (86 to 96)
Moreno (2006) ¹⁹¹	Girls	13–17.9	IOTF	85th	DEXA	85th centile	170	75 (53 to 90)	90 (84 to 95)
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	85th	DEXA	85th centile	815	64 (55 to 72)	94 (92 to 96)
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	85th	DEXA	Prevalence matched to BMI	815	65 (56 to 73)	94 (92 to 96)
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	85th	DEXA (adjusted for sex and ethnicity)	85th centile	573	92 (84 to 97)	82 (78 to 85)
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	85th	DEXA (adjusted for sex)	85th centile	573	94 (87 to 98)	83 (79 to 86)

AVENA, *Alimentación y Valoración del Estado Nutricional en Adolescentes*; BF, body fat; NR, not reported. The study by Mei et al. (2006)¹⁹⁰ did not contribute to the HSROC analysis as 2 × 2 data were not available. Italics denote high-quality study.

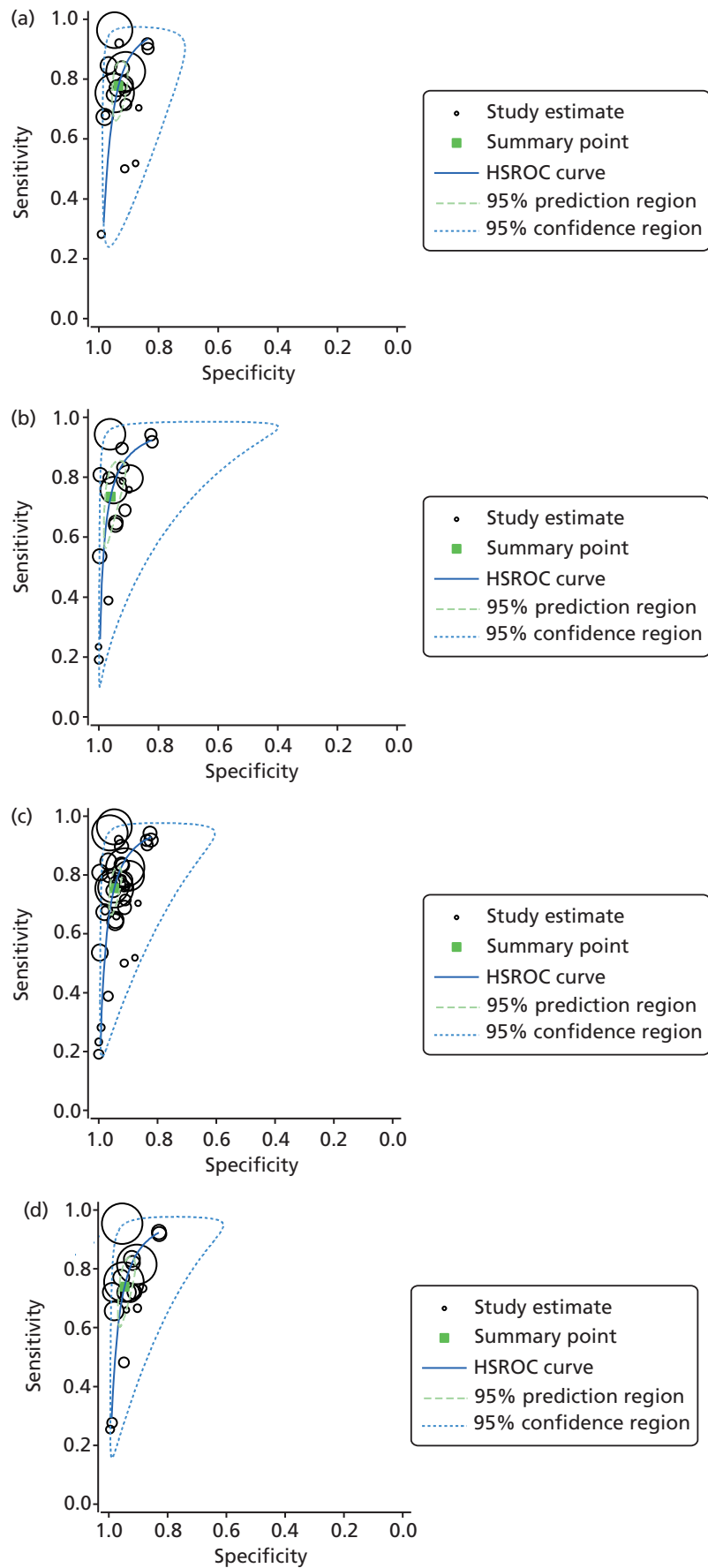


FIGURE 28 Hierarchical summary ROC curves for BMI for (a) unselected boys; (b) unselected girls; (c) all children (boy and girl subgroups kept separate); and (d) all children (within-study boy and girl subgroups combined prior to analysis).

TABLE 17 Results from the HSROC analysis for BMI using 85th and 95th centile cut-off points in unselected populations

Population	<i>n</i> studies/ data sets	Sensitivity (95% CI), %	Specificity (95% CI), %	LR+ (95% CI)	LR– (95% CI)
Boys	8/19	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	8/18	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	10/38	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	9/19	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)

The results of these analyses (see *Table 17*) show that BMI has a relatively low sensitivity, but a high specificity, across the different subgroups for diagnosing overweight/obesity. With such high specificities, there are few false-positive results; therefore, BMI is better at ruling obesity in than ruling it out, hence the moderately high LR+ but poorer LR–. These summary estimates should be treated with caution, as they are based on a subset of the BMI studies, and heterogeneity was substantial (see *Figure 28*); there were insufficient studies to investigate the impact of this heterogeneity. The analyses also combined data from the same population using different thresholds from some studies. As a result, the uncertainty surrounding the pooled estimates (95% prediction region) is large.

Two studies provided insufficient data to derive 2 × 2 tables. Of these, one reported sensitivity of 92.5% and specificity of 89.4% for diagnosing obesity (95th centile, CDC 2000²¹⁹),¹⁹⁰ and the other reported an AUC of 0.983 (95% CI 0.968 to 0.999) for boys and 0.981 (95% CI 0.961 to 1.00) for girls for diagnosing obesity (95th centile, reference population unclear).¹⁸¹

Diagnostic accuracy of skinfold thickness

Of the 34 included studies, 10^{175,180,182,184,186,187,189,190,196,197} evaluated SFT. Where reported, the most commonly used cut-off point was the 85th centile. Most of the studies used the measure to diagnose obesity; data for diagnosing overweight were more limited. Four studies reported the sensitivity and specificity of triceps SFT, or data to calculate these outcomes, for the diagnosis of overweight or obesity (*Table 18*);^{186,187,189,190} of these, three were considered to be high quality (results shown in italics in *Table 18*).^{186,187,189} Sensitivity ranged from 23% to 98.5%, and specificity from 78% to 100%, across the populations and thresholds.

TABLE 18 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of triceps SFT for the diagnosis of obesity or overweight

Study	Population	Age at assessment (years)	Index test cut-off point (centile)	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity								
<i>Himes (1989)¹⁸⁶</i>	Boys	8.4–18.99	85 th	<i>Underwater (hydrostatic) weighting</i>	90 th centile	159	24 (8 to 45)	100 (99 to 100)
<i>Himes (1989)¹⁸⁶</i>	Girls	8.4–18.99	85 th	<i>Underwater (hydrostatic) weighting</i>	90 th centile	157	23 (10 to 40)	97 (93 to 99)
<i>Marshall (1991)¹⁸⁹</i>	Unselected	7–14	85 th	<i>Underwater (hydrostatic) weighting</i>	20% BF boys; 25% BF girls	540	65.8 (NR)	94 (NR)
<i>Marshall (1991)¹⁸⁹</i>	Girls	7–14	85 th	<i>Underwater (hydrostatic) weighting</i>	25% BF	274	67.7 (NR)	93.4 (NR)
<i>Marshall (1991)¹⁸⁹</i>	Boys	7–14	85 th	<i>Underwater (hydrostatic) weighting</i>	20% BF	266	64.4 (NR)	94.6 (NR)
<i>Mei (2006)¹⁹⁰</i>	Unselected	5–18	95 th	DEXA	95 th centile	1196	89.6 (NR)	93.2 (NR)
<i>Johnston (1985)¹⁸⁷</i>	Boys	12–17	NR	<i>Underwater (hydrostatic) weighting</i>	25% BF	169	48 (30 to 67)	96 (91 to 98)
<i>Johnston (1985)¹⁸⁷</i>	Girls	12–17	NR	<i>Underwater (hydrostatic) weighting</i>	30% BF	66	24 (7 to 50)	100 (93 to 100)
<i>Johnston (1985)¹⁸⁷</i>	All children	12–17	NR	<i>Underwater (hydrostatic) weighting</i>	25% BF boys; 30% BF girls	235	40 (26 to 55)	97 (93 to 99)
Overweight								
<i>Mei (2006)¹⁹⁰</i>	Unselected	5–18	85 th	DEXA	95 th centile	1196	98.5 (NR)	78 (NR)

BF, body fat; NR, not reported.
Italics denote high-quality study.

Two studies evaluated subscapular SFT.^{186,190} Sensitivity ranged from 30% to 98.5%, and specificity from 79.1% to 99% across the two studies (*Table 19*). Six studies evaluated sum SFT (*Table 20*), where more than one site was measured and an overall percentage body fat was determined.^{175,180,184,186,189,197} As with the single-site SFT measurements, sensitivity varied across the six studies, but was, on the whole, higher than that for triceps and subscapular SFT individually, ranging from 57% to 98% across populations and thresholds. Most had a sensitivity of 80% or over. Specificity was more variable for the sum SFT than for the individual SFT measures, ranging from 47% to 96%, but was still reasonably high for most population and threshold combinations (see *Table 20*).

Diagnostic accuracy of waist circumference

Four studies reported sensitivity and specificity for WC for diagnosing obesity,^{181,193,195,205} and four studies for diagnosing overweight^{184,193,197,199} (*Table 21*); of these, three were considered to be of high quality (results shown in italics in *Table 21*).^{193,197,205} As with BMI, there was substantial variation in sensitivity across the studies, ranging from 34.7% to 100% for diagnosing obesity and 53% to 90.9% for diagnosing overweight. Specificity was less variable, ranging from 81% to 100% for diagnosing obesity and 92% to 100% for diagnosing overweight.

Diagnostic accuracy of waist-to-hip ratio and waist-to-height ratio

Three studies evaluated WHR^{184,193,199} and two evaluated WHtR.^{181,184} Sensitivity for WHR across the studies was relatively poor, ranging from 0% to 78.8% across populations and thresholds; specificities were generally high, ranging from 70.6% to 100% (*Table 22*). Sensitivity for WHtR was high, ranging from 90.9% to 100% across populations and thresholds, with specificities also high, ranging from 95% to 100% (*Table 23*).

Diagnostic accuracy of bioelectrical impedance analysis

The only diagnostic accuracy study to evaluate BIA used the test to distinguish between children who were fat and those who were not, using different models to calculate the level of adiposity.¹⁷⁵ The study characteristics and results are presented in *Table 24*. No cut-off values were reported; therefore, it is unclear whether 'fat' means obese or overweight/obese. This study used the gold-standard 4-C model to confirm adiposity. The results are mixed across the different models. Where sensitivity is 100%, this is at the expense of specificity, which is very low (45% and 11%). Two of the models give similar sensitivities and specificities of between 80% and 90%. The Deurenberg model has the highest specificity (93%), but as expected, this is at the expense of sensitivity (65%). The choice of model would therefore depend on whether it was more important to rule in (high specificity) or rule out (high sensitivity) being fat or whether neither extreme was desirable (a closer balance between sensitivity and specificity).

TABLE 19 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of subscapular SFT for the diagnosis of obesity and overweight

Study	Population	Age at assessment (years)	Index test cut-off point (centile)	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity								
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	85 th	<i>Underwater (hydrostatic) weighting</i>	90 th	159	38 (18 to 61)	99 (97 to 100)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	85 th	<i>Underwater (hydrostatic) weighting</i>	90 th	157	30 (15 to 48)	99 (96 to 100)
Mei (2006) ¹⁹⁰	Unselected	5–18	95 th	DEXA	95 th	1196	89.6 (NR)	94 (NR)
Overweight								
Mei (2006) ¹⁹⁰	Unselected	5–18	85 th	DEXA	95 th	1196	98.5 (NR)	79.1 (NR)

NR, not reported.
Italics denote high-quality study.

TABLE 20 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of sum SFT for the diagnosis of obesity, overweight or 'fat'

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity									
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Sum	85th centile	Underwater (hydrostatic) weighting	90th centile	159	57 (35 to 78)	85 (78 to 90)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Sum	85th centile	Underwater (hydrostatic) weighting	90th centile	157	80 (63 to 92)	82 (75 to 88)
Marshall (1991) ¹⁸⁹	Unselected	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	20% BF boys; 25% BF girls	540	86.8 (NR)	90.1 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	25% BF	274	96.8 (NR)	90.5 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	20% BF	266	80 (NR)	89.6 (NR)
Freedman (2013) ¹⁸⁰	Boys	8–19	Sum	Elevated – prevalence matched to BMI	DEXA	NR	4519	80 (77 to 83)	96 (95 to 96)
Freedman (2013) ¹⁸⁰	Girls	8–19	Sum	Elevated – prevalence matched to BMI	DEXA	NR	2846	79 (75 to 83)	96 (95 to 96)
Freedman (2013) ¹⁸⁰	All children	8–19	Sum	Elevated – prevalence matched to BMI	DEXA	NR	7365	80 (77 to 82)	96 (95 to 96)

continued

TABLE 20 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of sum SFT for the diagnosis of obesity, overweight or 'fat' (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Overweight									
Sarría (2001) ¹⁹⁷	Girls	7–16.9	Sum	85th centile	Underwater (hydrostatic) weighing	85th centile	175	58 (37 to 77)	93 (87 to 96)
Freedman (2013) ¹⁸⁰	Boys	8–19	Sum	Slightly elevated – prevalence matched to BMI	DEXA	NR	4519	85 (83 to 87)	92 (91 to 93)
Freedman (2013) ¹⁸⁰	Girls	8–19	Sum	Slightly elevated – prevalence matched to BMI	DEXA	NR	2846	81 (78 to 83)	90 (89 to 92)
Freedman (2013) ¹⁸⁰	All children	8–19	Sum	Slightly elevated – prevalence matched to BMI	DEXA	NR	7365	83 (82 to 85)	91 (91 to 92)
Guntzsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – pubertal	6–16	5-site SF Index	1.26	DEXA	10 kg/m ²	58	75 (NR)	77.3 (NR)
Guntzsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – prepubertal	6–16	5-site SF Index	1.07	DEXA	10 kg/m ²	50	57.6 (NR)	76.5 (NR)
Fat or not fat									
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Ellis	NR	4-C model	NR	114	96 (NR)	47 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Pennington	NR	4-C model	NR	114	94 (NR)	82 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Slaughter	NR	4-C model	NR	114	98 (NR)	71 (NR)

AA, African American; BF, body fat; NR, not reported; SF, skinfold. Italics denote high-quality study.

TABLE 21 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of WC for diagnosing obesity and overweight

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity									
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	85th centile	ADP	95th centile	274	64 (NR)	98 (NR)
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	95th centile	ADP	95th centile	200	50 (NR)	98 (NR)
Reilly (2010) ¹⁹⁵	Boys	9.9	UK 1988 reference	95th centile	DEXA	90th centile	3809	97 (95 to 99)	81 (79 to 82)
Reilly (2010) ¹⁹⁵	Girls	9.9	UK 1988 reference	95th centile	DEXA	90th centile	3913	98 (95 to 99)	81 (79 to 82)
Reilly (2010) ¹⁹⁵	All children	9.9	UK 1988 reference	95th centile	DEXA	90th centile	7722	98 (96 to 99)	81 (80 to 82)
Wickramasinghe (2009) ²⁰⁵	Sri Lankan boys	5–15	Smallest between ribs and iliac crest	98th centile	D ₂ O	25% BF	158	34.7 (NR)	98.8 (NR)
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	WC smallest between ribs and iliac crest	98th centile	D ₂ O	30% BF	124	38.4 (NR)	100 (NR)
Wickramasinghe (2009) ²⁰⁵	All Sri Lankan children	5–15	WC smallest between ribs and iliac crest	98th centile	D ₂ O	25% BF boys; 30% BF girls	282	37 (30 to 45)	99 (95 to 100)
Fujita (2011) ¹⁸¹	Boys	10	WC umbilical	76.5	DEXA	95th centile	226	100 (NR)	97 (NR)
Fujita (2011) ¹⁸¹	Girls	10	WC umbilical	73	DEXA	95th centile	196	100 (NR)	96 (NR)

continued

TABLE 21 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of WC for diagnosing obesity and overweight (*continued*)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Overweight									
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – prepubertal	6–16	Mid-point between ribs and iliac crest	66.5	DEXA	10 kg/m ²	50	84.8 (NR)	100 (NR)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – prepubertal	6–16	WC umbilical	72	DEXA	10 kg/m ²	50	90.9 (NR)	100 (NR)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – pubertal	6–16	Mid-point between ribs and iliac crest	77	DEXA	10 kg/m ²	58	88.9 (NR)	95.5 (NR)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – pubertal	6–16	WC umbilical	85	DEXA	10 kg/m ²	58	88.9 (NR)	100 (NR)
Neovius (2005) ¹⁹³	Girls	17	<i>WC smallest between ribs and iliac crest</i>	73.3	ADP	30% BF	274	53 (NR)	89 (NR)
Neovius (2005) ¹⁹³	Boys	17	<i>WC smallest between ribs and iliac crest</i>	85.9	ADP	25% BF	200	68 (NR)	99 (NR)
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	278	89 (77 to 96)	94 (91 to 97)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	302	87 (74 to 95)	92 (88 to 95)
Sarria (2001) ¹⁹⁷	Boys	7–16.9	<i>WC smallest between ribs and iliac crest</i>	85th centile	<i>Underwater (hydrostatic) weighing</i>	85th centile	175	58 (37 to 77)	93 (87 to 96)

BF, body fat; NR, not reported. Italics denote high-quality study.

TABLE 22 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of WHR for the diagnosis of obesity and overweight

Study	Population	Age at assessment (years)	Site of WC measurement	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity									
Neovius (2005) ¹⁹³	Boys	17	Smallest between ribs and iliac crest	0.9	ADP	95th centile	200	40 (NR)	97 (NR)
Neovius (2005) ¹⁹³	Girls	17	Smallest between ribs and iliac crest	1.02	ADP	95th centile	274	0 (NR)	100 (NR)
Overweight									
Neovius (2005) ¹⁹³	Girls	17	Smallest between ribs and iliac crest	0.84	ADP	30% BF	274	17 (NR)	98 (NR)
Neovius (2005) ¹⁹³	Boys	17	Smallest between ribs and iliac crest	0.9	ADP	25% BF	200	24 (NR)	98 (NR)
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	Smallest between ribs and iliac crest	80th centile	DEXA	1 SD	278	47 (32 to 62)	85 (80 to 90)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	Smallest between ribs and iliac crest	80th centile	DEXA	1 SD	302	46 (31 to 61)	85 (80 to 89)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – pubertal	6–16	Mid-point between ribs and iliac crest	0.91	DEXA	10 kg/m ²	58	72.2 (NR)	90.9 (NR)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – pubertal	6–16	Umbilical	0.98	DEXA	10 kg/m ²	58	77.8 (NR)	95.5 (NR)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – prepubertal	6–16	Mid-point between ribs and iliac crest	0.92	DEXA	10 kg/m ²	50	78.8 (NR)	70.6 (NR)
Guntsche (2010) ¹⁸⁴	Obesity centre referrals and siblings – prepubertal	6–16	Umbilical	0.99	DEXA	10 kg/m ²	50	66.7 (NR)	94.1 (NR)

BF, body fat; NR, not reported.
Italics denote high-quality study.

TABLE 23 Sensitivity and specificity from the studies evaluating the accuracy of WHtR for the diagnosis of obesity and overweight

Study	Population	Age at assessment (years)	Site of WC measurement	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity									
Fujita (2011) ¹⁸¹	Boys	10	Umbilical	0.519	DEXA	95th	226	100 (NR)	95 (NR)
Fujita (2011) ¹⁸¹	Girls	10	Umbilical	0.499	DEXA	95th	196	100 (NR)	95 (NR)
Overweight									
Guntsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	Mid-point between ribs and iliac crest	0.49	DEXA	10 kg/m ²	50	90.9 (NR)	100 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	Mid-point between ribs and iliac crest	0.5	DEXA	10 kg/m ²	58	97.2 (NR)	100 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	Umbilical	0.54	DEXA	10 kg/m ²	58	97.2 (NR)	100 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	Umbilical	0.54	DEXA	10 kg/m ²	50	93.9 (NR)	100 (NR)

NR, not reported.

TABLE 24 Sensitivity and specificity from the studies evaluating the accuracy of BIA for the diagnosis of fat or not fat as reported in Bray *et al.* (2002)¹⁷⁵

Population	Age at assessment (years)	Index test model	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
White and AA children	12	Deurenberg	NR	4-C	NR	114	65 (NR)	93 (NR)
White and AA children	12	Goran	NR	4-C	NR	114	100 (NR)	45 (NR)
White and AA children	12	Pennington	NR	4-C	NR	114	87 (NR)	84 (NR)
White and AA children	12	Schaefer	NR	4-C	NR	114	89 (NR)	84 (NR)
White and AA children	12	Suprasongsin	NR	4-C	NR	114	100 (NR)	11 (NR)

AA, African American; NR, not reported.

Other childhood measures

There were a small number of studies that evaluated some less common simple measures of childhood obesity: the conicity index,¹⁹⁹ relative BMI,¹⁸⁹ relative weight^{187,189} and FMI.¹⁷³ The results for FMI appeared good, with sensitivity of 100% and specificity of over 90%, but these were derived from only one study of only 150 children.¹⁷³ As with the childhood measures discussed in the previous section, specificity of these tests is generally high, with sensitivity being more variable (*Table 25*).

Direct comparisons of the diagnostic accuracy of simple childhood measures of obesity

The studies of diagnostic accuracy were extremely heterogeneous, assessing different populations, measurements at a range of different ages, different cut-off points for the index tests and different reference standards with different cut-off points. Several studies made direct comparisons, with each index test conducted in all study participants along with the reference standard; these are more robust when determining relative accuracy than indirect comparisons.

Diagnosing obesity

Eleven studies reported direct comparisons of childhood measures for diagnosing obesity.^{178,180,181,186,187,189,190,193,195,204,205} Different reference standards were used to determine the adiposity of the children in the studies. One used ADP (*Table 26*),¹⁹³ two used D₂O (*Table 27*),^{204,205} three used underwater (hydrostatic) weighting (*Table 28*)^{186,187,189} and five used DEXA (*Table 29*).^{178,180,181,190,195} Of the 11 studies, six were considered to be of high quality (results are shown in italics within the tables).^{186,187,189,193,204,205}

Where SFT was measured in the same children as BMI, sum SFT consistently had higher sensitivity than BMI with similar specificity (see *Tables 28* and *29*); measuring SFT at only a single location seemed to be less accurate than using the sum of several locations. When comparing the use of different BMI reference data, results were variable, with no one reference source being consistently better (see *Tables 27* and *29*). In studies comparing WC with BMI, the sensitivity of WC was generally better than or similar to that of BMI; specificity was similar for the two measures (see *Tables 26*, *27* and *29*). One study showed a substantial difference between boys and girls; sensitivity was higher with BMI in girls and with WC in boys.¹⁹³ This difference was not seen in the other studies where data for boys and girls were reported separately.

The results of these studies are presented graphically, with results plotted in ROC space in *Figure 29* and the DOR shown in *Figure 30* for each test for which 2 × 2 tables of test performance were available.

TABLE 25 Sensitivity and specificity (including 95% CI where reported) from the studies evaluating the accuracy of relative BMI, relative weight, FMI and the conicity index for diagnosing obesity or overweight

Study	Population	Age at assessment (years)	Index test	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Obesity									
Marshall (1991) ¹⁸⁹	Unselected	7–14	Relative BMI	≥ 120%	Underwater (hydrostatic) weighting	20% BF boys; 25% BF girls	540	71.1 (NR)	91.6 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	Relative BMI	≥ 120%	Underwater (hydrostatic) weighting	25% BF	274	74.2 (NR)	90.5 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	Relative BMI	≥ 120%	Underwater (hydrostatic) weighting	20% BF	266	68.9 (NR)	92.8 (NR)
Marshall (1991) ¹⁸⁹	Unselected	7–14	Relative weight	≥ 120%	Underwater (hydrostatic) weighting	20% BF boys; 25% BF girls	540	51.6 (NR)	95 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	Relative weight	≥ 120%	Underwater (hydrostatic) weighting	25% BF	274	58.1 (NR)	95.1 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	Relative weight	≥ 120%	Underwater (hydrostatic) weighting	20% BF	266	48.9 (NR)	95 (NR)
Johnston (1985) ¹⁸⁷	Boys	12–17	Relative weight	NR	Underwater (hydrostatic) weighting	25% BF	169	52 (33 to 70)	86 (79 to 92)
Johnston (1985) ¹⁸⁷	Girls	12–17	Relative weight	NR	Underwater (hydrostatic) weighting	30% BF	66	29 (10 to 56)	94 (83 to 99)
Johnston (1985) ¹⁸⁷	All children	12–17	Relative weight	NR	Underwater (hydrostatic) weighting	25% BF boys; 30% BF girls	235	44 (29 to 59)	88 (83 to 92)
Overweight									
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	Conicity index	80th centile	DEXA	1 SD	278	57 (42 to 72)	88 (83 to 92)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	Conicity index	80th centile	DEXA	1 SD	302	61 (45 to 75)	88 (83 to 91)
Alvero-Cruz (2010) ¹⁷³	Boys	12–18	FMI	4.58	D ₂ O	NR	75	100 (89.3 to 100)	90.5 (77.4 to 97.3)
Alvero-Cruz (2010) ¹⁷³	Girls	12–18	FMI	7.76	D ₂ O	NR	75	100 (66.2 to 100)	97 (89.5 to 99.5)

BF, body fat; NR, not reported.

TABLE 26 Sensitivity and specificity from the direct comparison of BMI, WHR and WC using ADP as the reference standard for the diagnosis of obesity

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Sensitivity (%)			Specificity (%)		
					BMI (optimal)	WHR (WC smallest between ribs and iliac crest)	WC (smallest between ribs and iliac crest)	BMI (minimising misclassifications/maximising sensitivity/specificity)	WHR (WC smallest between ribs and iliac crest)	WC (smallest between ribs and iliac crest)
<i>Neovius (2005)¹⁹³</i>	Boys	17	95th centile	200	40	40	50	98	97	98
<i>Neovius (2005)¹⁹³</i>	Girls	17	95th centile	274	86	0	64	98	100	98

Italics denote high-quality study.

TABLE 27 Sensitivity and specificity from the direct comparison of BMI and WC using D₂O as the reference standard for the diagnosis of obesity

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Sensitivity (%)				Specificity (%)			
					BMI (IOTF)	BMI (CDC/WHO)	BMI (z-/SD scores)	WC (mid-point between ribs and iliac crest)	BMI (IOTF)	BMI (CDC/WHO)	BMI (z-/SD scores)	WC (mid-point between ribs and iliac crest)
<i>Wickramasinghe (2005)^{2,04}</i>	Sri Lankan boys	5–14.99	20% BF	27	0	12.5	12.5	–	100	100	100	–
<i>Wickramasinghe (2005)^{2,04}</i>	Sri Lankan girls	5–14.99	30% BF	15	0	14.3	14.3	–	100	100	100	–
<i>Wickramasinghe (2009)^{2,05}</i>	Sri Lankan boys	5–15	25% BF	158	12.5	19.5	23.6	34.7	100	100	100	98.8
<i>Wickramasinghe (2009)^{2,05}</i>	Sri Lankan girls	5–15	30% BF	124	0	16.2	16.2	38.4	100	100	100	100
<i>Wickramasinghe (2005)^{2,04}</i>	White boys	5–14.99	20% BF	44	0	3.5	6.9	–	100	100	93	–
<i>Wickramasinghe (2005)^{2,04}</i>	White girls	5–14.99	30% BF	52	0	20	5.2	–	100	100	100	–

BF, body fat.
Italics denote high-quality study.

TABLE 28 Sensitivity and specificity (including 95% CI where reported or calculated) from the direct comparison of BMI, relative BMI, SFT and relative weight using underwater (hydrostatic) weighting as the reference standard for the diagnosis of obesity

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total n	Sensitivity (95% CI), %					Specificity (95% CI), %						
					BMI (reference data NR)	Relative BMI	SFT (sum)	SFT (triceps)	SFT (subscapular)	Relative weight	BMI (reference data NR)	Relative BMI	SFT (sum)	SFT (triceps)	SFT (subscapular)	Relative weight
Marshall (1991) ¹⁸⁹	Boys	7–14	20% BF	266	–	68.9	80	64.4	–	48.9	–	92.8	89.6	94.6	–	95
Marshall (1991) ¹⁸⁹	Girls	7–14	25% BF	274	–	74.2	96.8	67.7	–	58.1	–	90.5	90.5	93.4	–	95.1
Marshall (1991) ¹⁸⁹	Unselected	7–14	20% BF boys; 25% BF girls	540	–	71.1	86.8	65.8	–	51.6	–	91.6	90.1	94	–	95
Johnston (1985) ¹⁸⁷	Boys	12–17	25% BF	169	–	–	–	48 (30 to 67)	–	52 (33 to 70)	–	–	–	96 (91 to 98)	–	86 (79 to 92)
Johnston (1985) ¹⁸⁷	Girls	12–17	30% BF	66	–	–	–	24 (7 to 50)	–	29 (10 to 56)	–	–	–	100 (93 to 100)	–	94 (83 to 99)
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	90th centile	159	29 (11 to 51)	–	57 (35 to 78)	24 (8 to 45)	38 (18 to 61)	–	99 (96 to 100)	–	85 (78 to 90)	100 (99 to 100)	99 (97 to 100)	–
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	90th centile	157	23 (10 to 40)	–	80 (63 to 92)	23 (10 to 40)	30 (15 to 48)	–	100 (99 to 100)	–	82 (75 to 88)	97 (93 to 99)	99 (96 to 100)	–

BF, body fat; NR, not reported.
Italics denote high-quality study.

TABLE 29 Sensitivity and specificity (95% CI where reported or calculated) from the direct comparison of BMI, SFT, WHtR and WC using DEXA as the reference standard for the diagnosis of obesity

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %							
					BMI (reference data NR)	BMI (z-/SD scores)	BMI (UK90)	BMI (CDC/WHO)	BMI (optimal)	SFT (sum)	SFT (triceps)	SFT (subscapular)
Freedman (2013) ¹⁸⁰	Boys	8–19	?	4518	–	–	–	75 (72 to 78)	–	80 (77 to 83)	–	–
Freedman (2013) ¹⁸⁰	Girls	8–19	?	2847	–	–	–	76 (72 to 80)	–	79 (75 to 83)	–	–
Reilly (2010) ¹⁹⁵	Boys	9.9	90th centile	3809	–	–	96 (94 to 98)	–	–	–	–	–
Reilly (2010) ¹⁹⁵	Girls	9.9	90th centile	3913	–	–	94 (91 to 96)	–	–	–	–	–
Field (2003) ¹⁷⁸	Unselected	10	90th centile	596	65	51	–	–	–	–	–	–
Mei (2006) ¹⁹⁰	Unselected	5–18	95th centile	1196	–	–	–	92.5	–	–	89.6	89.6
Fujita (2011) ¹⁸¹	Boys	10	95th centile	226	–	–	–	–	100	–	–	–
Fujita (2011) ¹⁸¹	Girls	10	95th centile	196	–	–	–	–	100	–	–	–

NR, not reported.

			Specificity (95% CI), %											
WHtR (WC umbilical)	WC (umbilical)	WC (UK 1988 reference)	BMI (reference data NR)	BMI (z-/SD scores)	BMI (UK90)	BMI (CDC/WHO)	BMI (optimal)	SFT (sum)	SFT (triceps)	SFT (subscapular)	WHtR (WC umbilical)	WC (umbilical)	WC (UK 1988 reference)	
-	-	-	-	-	-	95 (94 to 95)	-	96 (95 to 96)	-	-	-	-	-	
-	-	-	-	-	-	95 (94 to 96)	-	96 (95 to 96)	-	-	-	-	-	
-	-	97 (95 to 99)	-	-	95 (94 to 95)	-	-	-	-	-	-	-	81 (79 to 82)	
-	-	98 (95 to 99)	-	-	96 (96 to 97)	-	-	-	-	-	-	-	81 (79 to 82)	
-	-	-	99	100	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	89.4	-	-	93.2	94	-	-	-	
100	100	-	-	-	-	-	96	-	-	-	95	97	-	
100	100	-	-	-	-	-	92	-	-	-	95	96	-	

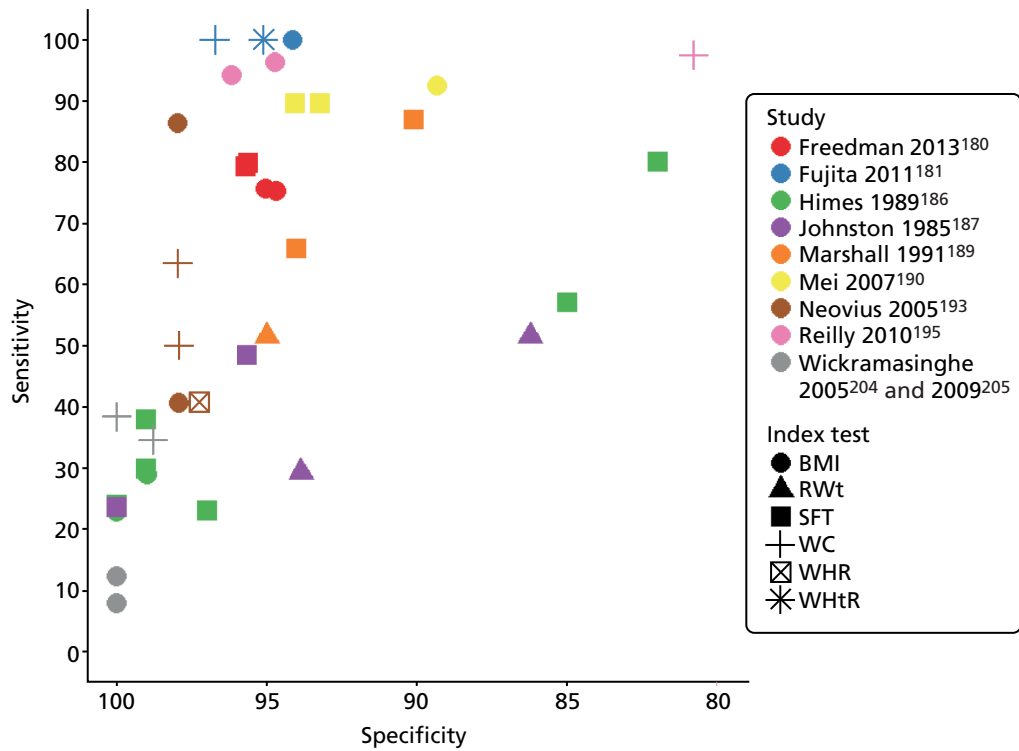


FIGURE 29 Results of the tests reported in the direct comparisons plotted in ROC space. RWt, relative weight.

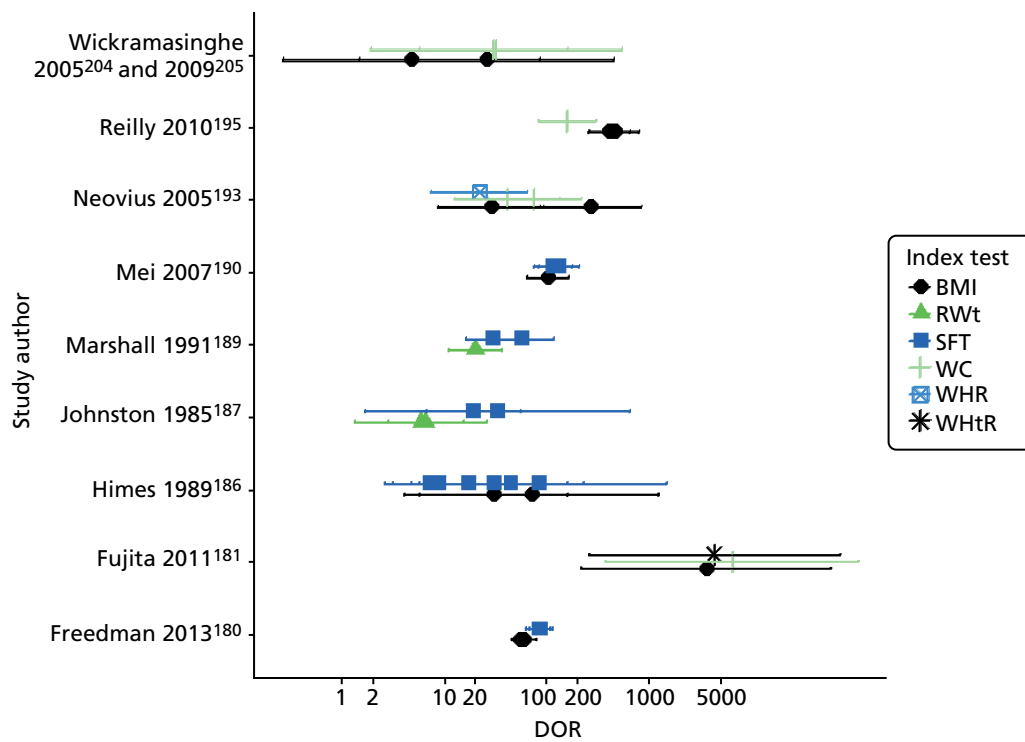


FIGURE 30 Diagnostic OR for the tests in the studies reporting direct comparisons. RWt, relative weight.

Figure 29 demonstrates the difficulty in comparing BMI with other obesity measures, because of the trade-off between sensitivity and specificity. In the Freedman *et al.* (2013)¹⁸⁰ study (in red), for example, SFT has a marginally higher sensitivity and specificity than BMI, so may be better at diagnosing obesity. Himes *et al.* (1989)¹⁸⁶ (green) used several forms of SFT measurement (the green squares). These vary considerably in their sensitivity and specificity, with some having much higher sensitivity, but at a cost of reduced specificity.

The DOR provides a simpler means of comparing obesity measures, as a higher DOR indicates better diagnostic performance. As seen in Figure 30, the DORs vary enormously across studies, from 3 to nearly 4000, demonstrating the considerable heterogeneity across studies. Both Freedman *et al.* (2013)¹⁸⁰ and Mei *et al.* (2006)¹⁹⁰ suggest that SFT may be more accurate than BMI, but Himes *et al.* (1989)¹⁸⁶ does not show that SFT is better. There is no evidence that WC, WHtR or WHR have better diagnostic performance than BMI.

Diagnosing overweight

Ten studies reported direct comparisons of childhood measures for diagnosing obesity.^{173,175,180,184,191–193,197,199,202} A range of reference standards were used across the studies; one used a gold-standard 4-C model (Table 30),¹⁷⁵ two used ADP (Table 31),^{192,193} one used D₂O (Table 32),¹⁷³ one used underwater (hydrostatic) weighting (Table 33)¹⁹⁷ and five used DEXA (Tables 34 and 35).^{180,184,191,199,202} Of the 10 studies, three were considered to be high quality (results shown in italics within the tables).^{173,193,197}

The difference between BMI and SFT was less pronounced for diagnosing overweight than for diagnosing obesity; one study reported a higher sensitivity with BMI,¹⁸⁴ but most reported similar accuracy (see Tables 33–35). In one study,¹⁷³ FMI outperformed BMI in boys and girls for both sensitivity and specificity (see Table 32). On the whole, BIA and SFT had similar, relatively high, sensitivity. Specificity was more variable; tests with the highest sensitivities had poorer specificity. The two tests with relatively high sensitivity and specificity were BIA using the Schaefer model and sum SFT using the Pennington optimal SFT model (see Table 30). WHR seemed to perform poorly compared with BMI or WC alone (see Tables 31, 34 and 35); WHtR seemed to outperform WHR for both sensitivity and specificity, and WC alone in terms of sensitivity (see Tables 34 and 35).

RESULTS

TABLE 30 Sensitivity and specificity from the direct comparison of BIA and SFT using a 4-C gold standard for the diagnosis of fat or not fat

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Sensitivity (%)					
					BIA Deurenberg	BIA Goran	BIA Pennington	BIA Schaefer	BIA Suprasongsin	SFT (sum Ellis)
Bray (2002) ¹⁷⁵	White and AA children	12	?	114	65	100	87	89	100	96

AA, African American.

TABLE 31 Sensitivity and specificity from the direct comparison of BMI, WHR and WC using ADP as the reference standard for the diagnosis of overweight

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Sensitivity (%)		
					BMI (IOTF)	BMI (CDC/WHO)	BMI (optimal)
<i>Neovius (2005)¹⁹³</i>	<i>Boys</i>	<i>17</i>	<i>25% BF</i>	<i>200</i>	–	–	72
<i>Neovius (2005)¹⁹³</i>	<i>Girls</i>	<i>17</i>	<i>30% BF</i>	<i>274</i>	–	–	65
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	25% BF	200	80	68	92
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	30% BF	274	24	19	77

BF, body fat.
Italics denote high-quality study.

TABLE 32 Sensitivity and specificity (including 95% CI) from the direct comparison of BMI and FMI using D₂O as the reference standard for the diagnosis of overweight

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>
<i>Alvero-Cruz (2010)¹⁷³</i>	<i>Boys</i>	<i>12–18</i>	?	75
<i>Alvero-Cruz (2010)¹⁷³</i>	<i>Girls</i>	<i>12–18</i>	?	75

NR, not reported.
Italics denote high-quality study.

TABLE 33 Sensitivity and specificity (including 95% CI) from the direct comparison of BMI, SFT and WC using underwater (hydrostatic) weighting as the reference standard for the diagnosis of overweight

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>
<i>Sarria (2001)¹⁹⁷</i>	<i>Boys</i>	<i>7–16.9</i>	<i>85th centile</i>	175

Italics denote high-quality study.

		Specificity (%)							
SFT (sum Pennington)	SFT (sum Slaughter)	BIA Deurenberg	BIA Goran	BIA Pennington	BIA Schaefer	BIA Suprasongsin	SFT (sum Ellis)	SFT (sum Pennington)	SFT (sum Slaughter)
94	98	93	45	84	84	11	47	82	71

		Specificity (%)						
BMI (Göteborg, Sweden)	WHR (WC smallest between ribs and iliac crest)	WC (smallest between ribs and iliac crest)	BMI (IOTF)	BMI (CDC/WHO)	BMI (optimal)	BMI (Göteborg, Sweden)	WHR (WC smallest between ribs and iliac crest)	WC (smallest between ribs and iliac crest)
–	24	68	–	–	98	–	98	99
–	17	53	–	–	88	–	98	89
92	–	–	95	98	92	93	–	–
39	–	–	100	100	76	97	–	–

Sensitivity (95% CI), %		Specificity (95% CI), %	
BMI (reference data NR)	FMI	BMI (reference data NR)	FMI
75.8 (57.7 to 88.9)	100 (89.3 to 100)	83.3 (68.6 to 93)	90.5 (77.4 to 97.3)
88.9 (51.7 to 98.2)	100 (66.2 to 100)	77.3 (65.3 to 86.7)	97 (89.5 to 99.5)

Sensitivity (95% CI), %			Specificity (95% CI), %		
BMI (z-/SD scores)	SFT (sum)	WC: smallest between ribs/iliac crest	BMI (z-/SD scores)	SFT (sum)	WC: smallest between ribs/iliac crest
50 (30 to 70)	58 (37 to 77)	58 (37 to 77)	91 (85 to 95)	93 (87 to 96)	93 (87 to 96)

TABLE 34 Sensitivity (including 95% CI where reported or calculated) from the direct comparison of BMI, SFT, WHR, WHtR, WC and the conicity index using DEXA as the reference standard for the diagnosis of overweight

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %				
					BMI (IOTF)	BMI (CDC/WHO)	BMI (Conde and Monteiro)	BMI (AVENA)	BMI (z-/SD scores)
Freedman (2013) ¹⁸⁰	Boys	8–19	?	4518	–	83 (81 to 84)	–	–	–
Freedman (2013) ¹⁸⁰	Girls	8–19	?	2847	–	80 (77 to 82)	–	–	–
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	1 SD	278	–	–	–	–	–
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	1 SD	302	–	–	–	–	–
Guntsche (2010) ¹⁸⁴	Pubertal obese and siblings	6–16	10 kg/m ²	58	–	–	–	–	97.2
Guntsche (2010) ¹⁸⁴	Prepubertal obese and siblings	6–16	10 kg/m ²	50	–	–	–	–	96.9
Vitolo (2007) ²⁰²	Boys	10–19	25% BF	219	79.5	–	84.1	–	–
Vitolo (2007) ²⁰²	Boys	10–14	25% BF	128	84.2	–	84.2	–	–
Vitolo (2007) ²⁰²	Boys	15–19	25% BF	91	50	–	83.3	–	–
Vitolo (2007) ²⁰²	Girls	10–19	30% BF	199	26.6	–	34.5	–	–
Vitolo (2007) ²⁰²	Girls	10–14	30% BF	132	32.6	–	44.2	–	–
Vitolo (2007) ²⁰²	Girls	15–19	30% BF	67	17	–	18.9	–	–
Moreno (2006) ¹⁹¹	Boys	13–17.9	85th centile	116	71 (44 to 90)	–	–	53 (28 to 77)	–
Moreno (2006) ¹⁹¹	Girls	13–17.9	85th centile	170	75 (53 to 90)	–	–	79 (58 to 93)	–

AVENA, *Alimentacion y Valoracion del Estado Nutricional en Adolescentes*; BF, body fat.

SFT (sum)	WHR (WC smallest between ribs and iliac crest)	WHR (umbilical)	WHR (WC mid-point between ribs and iliac crest)	WHtR (WC umbilical)	WHtR (WC mid-point between ribs and iliac crest)	WC (smallest between ribs and iliac crest)	WC (mid-point between ribs and iliac crest)	WC (umbilical)	Conicity index
85 (83 to 87)	-	-	-	-	-	-	-	-	-
81 (78 to 83)	-	-	-	-	-	-	-	-	-
-	47 (32 to 62)	-	-	-	-	89 (77 to 96)	-	-	57 (42 to 72)
-	46 (31 to 61)	-	-	-	-	87 (74 to 95)	-	-	61 (45 to 75)
75	-	77.8	72.2	97.2	97.2	-	88.9	88.9	-
57.6	-	66.7	78.8	93.9	90.9	-	84.8	90.9	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

TABLE 35 Specificity (95% CI where reported or calculated) from the direct comparison of BMI, SFT, WHR, WHtR, WC and the conicity index using DEXA as the reference standard for the diagnosis of overweight

Study	Population	Age at assessment (years)	Reference standard cut-off point	Total <i>n</i>	Specificity (95% CI), %				
					BMI (IOTF)	BMI (CDC/WHO)	BMI (Conde and Monteiro)	BMI (AVENA)	BMI (z-/SD scores)
Freedman (2013) ¹⁸⁰	Boys	8–19	?	4518	–	91 (90 to 92)	–	–	–
Freedman (2013) ¹⁸⁰	Girls	8–19	?	2847	–	90 (88 to 91)	–	–	–
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	1 SD	278	–	–	–	–	–
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	1 SD	302	–	–	–	–	–
Guntsche (2010) ¹⁸⁴	Pubertal obese and siblings	6–16	10 kg/m ²	58	–	–	–	–	100
Guntsche (2010) ¹⁸⁴	Prepubertal obese and siblings	6–16	10 kg/m ²	50	–	–	–	–	100
Vitolo (2007) ²⁰²	Boys	10–19	25% BF	219	86.9	–	84.6	–	–
Vitolo (2007) ²⁰²	Boys	10–14	25% BF	128	86.7	–	82.2	–	–
Vitolo (2007) ²⁰²	Boys	15–19	25% BF	91	87.1	–	87.1	–	–
Vitolo (2007) ²⁰²	Girls	10–19	30% BF	199	96.7	–	98.3	–	–
Vitolo (2007) ²⁰²	Girls	10–14	30% BF	132	95.7	–	97.8	–	–
Vitolo (2007) ²⁰²	Girls	15–19	30% BF	67	100	–	100	–	–
Moreno (2006) ¹⁹¹	Boys	13–17.9	85th centile	116	86 (77 to 92)	–	–	88 (79 to 94)	–
Moreno (2006) ¹⁹¹	Girls	13–17.9	85th centile	170	90 (84 to 95)	–	–	92 (86 to 96)	–

AVENA, *Alimentacion y Valoracion del Estado Nutricional en Adolescentes*; BF, body fat.

SFT (sum)	WHR (WC smallest between ribs and iliac crest)	WHR (umbilical)	WHR (WC mid-point between ribs and iliac crest)	WHtR (WC umbilical)	WHtR (WC mid-point between ribs and iliac crest)	WC (smallest between ribs and iliac crest)	WC (mid-point between ribs and iliac crest)	WC (umbilical)	Conicity index
92 (91 to 93)	-	-	-	-	-	-	-	-	-
90 (89 to 92)	-	-	-	-	-	-	-	-	-
-	85 (80 to 90)	-	-	-	-	94 (91 to 97)	-	-	88 (83 to 92)
-	85 (80 to 89)	-	-	-	-	92 (88 to 95)	-	-	88 (83 to 91)
77.3	-	95.5	90.9	100	100	-	95.5	100	-
76.5	-	94.1	70.6	100	100	-	100	100	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

The results of these studies are presented graphically, with results plotted in ROC space in *Figure 31* and the DOR shown in *Figure 32* for each test for which 2 × 2 tables of test performance were available.

The results are similar to those seen for diagnosing obesity. From *Figure 32*, two studies [Freedman *et al.* (2013),¹⁸⁰ Sarria *et al.* (2001)¹⁹⁷] suggest that SFT may have better diagnostic performance than BMI, but results cannot be considered to be statistically significant. Neovius *et al.* (2004)¹⁹² found SFT to have the worst diagnostic performance of any measure. There is no evidence to suggest that any other measure can improve on BMI.

Comparisons of predictive and diagnostic accuracy

In order to understand why one childhood measure of obesity had a better predictive accuracy than another, we planned to compare the estimates of predictive accuracy from the tracking and adult morbidity reviews with estimates of diagnostic accuracy in similar studies from the diagnostic accuracy review. Unfortunately, the vast majority of data from the two predictive accuracy reviews were for BMI. Only one study in the review of tracking and two in the review of adult morbidities used a measure other than BMI: triceps SFT in the tracking review,¹²⁷ and WC,¹¹⁷ and WC, sum SFT and WHR,¹⁷¹ in the studies from the adult morbidity review. There were therefore insufficient predictive accuracy data for us to make such comparisons.

Summary of the diagnostic accuracy data

In terms of diagnostic accuracy, there was little evidence to suggest that any obesity measure has better diagnostic performance than BMI. Direct comparisons suggest that sum SFT may have promise as an alternative to BMI, especially for the diagnosis of obesity. Generally, BMI has a similar level of accuracy to SFT for the diagnosis of overweight. With the limited data available, WHR seems to be a poor measure, and does not improve on BMI, with WC alone or WHtR being more promising. These relationships need to be confirmed with a full evaluation of the available diagnostic accuracy data, including searching for studies using magnetic resonance imaging (MRI) to determine abdominal fat in order to investigate the impact of the distribution of fat more fully, and contacting authors to retrieve tables of test performance for those studies where this could not be extracted or derived. Further well-designed primary studies are likely to be required for some of the measures once the full systematic review has identified the most promising diagnostic measures.

We considered a model with at least four components as the gold standard for determining actual adiposity in children; this requires the conduct of a range of tests to determine the contribution of the different components of body composition. ADP, underwater (hydrostatic) weighting, D₂O and DEXA were all considered imperfect reference standards compared with four- or more-component models. Several studies have been published that have highlighted the shortcomings of these tests as reference standards, but DEXA may be a poorer reference standard than the others.^{55–57,227–235} The majority of the diagnostic studies considered used DEXA as a reference standard, and we note that the diagnostic performance of all the obesity measures may be poorer if a 4-C model is used as the reference standard. Therefore, any future primary studies should ideally use a four- or more-component model to determine weight status.

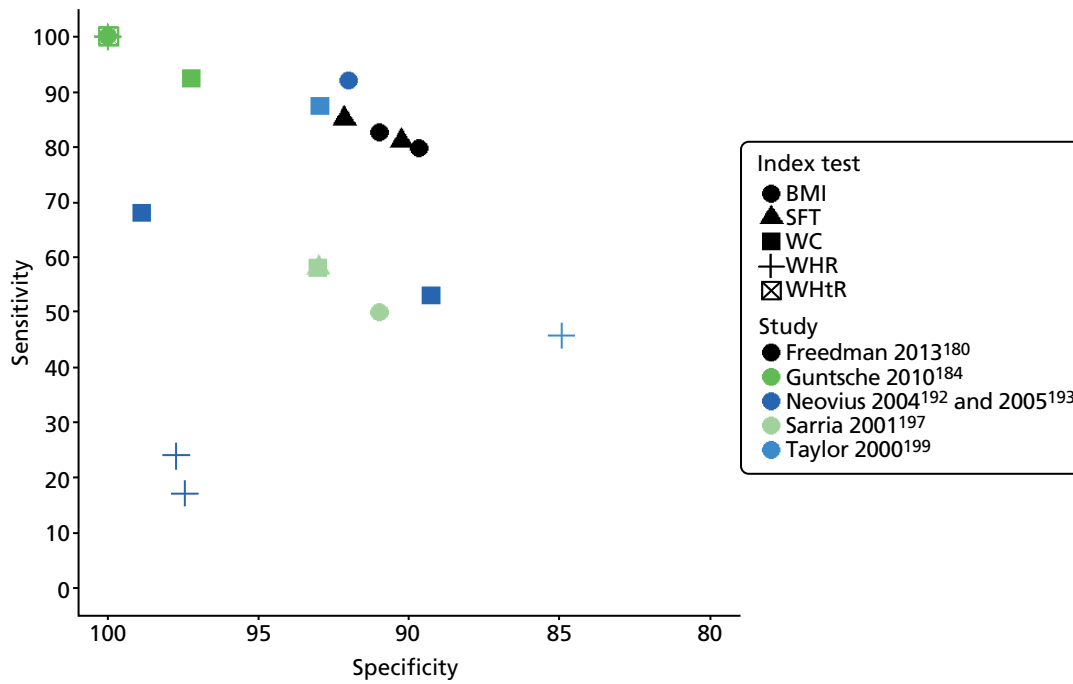


FIGURE 31 Results of the tests from studies of direct comparisons plotted in ROC space.

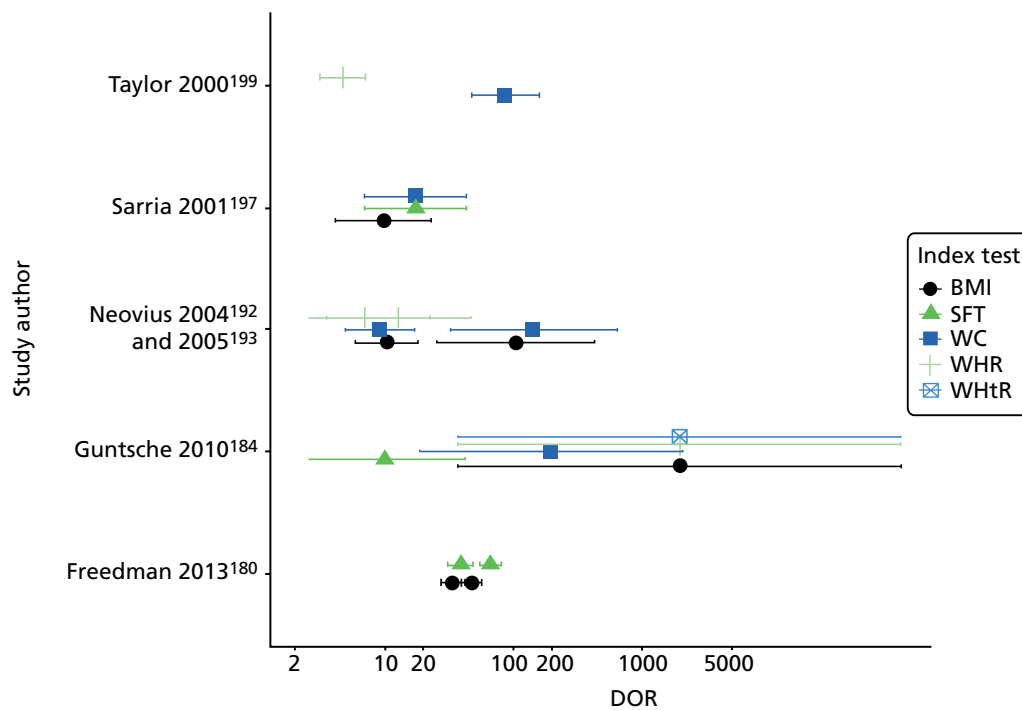


FIGURE 32 Diagnostic OR of the tests from studies that report direct comparisons.

Review of acceptability and ease of use of childhood measures of obesity

Children's assessment of acceptability and ease of use

No previous studies of the opinions of children regarding simple measures of childhood obesity were identified.

The de novo study conducted as part of this review is presented here. This took the form of an elicitation exercise conducted by colleagues at Leeds Metropolitan University, during a weight management summer camp for children. A total of 72 (out of 147) children completed the questionnaire (see *Appendix 3*). All children who attended the summer camp were overweight or obese (> 85th centile using UK90). The characteristics of the children who completed the questionnaire are given in *Table 36*. As can be seen from *Table 37*, the vast majority of the children said that they had previously had their height and weight measured, but only 58% said they had experienced BMI being measured; this is likely to be a result of a lack of feedback of the result of the height and weight measurement, or a lack of understanding of what BMI is. The other measures were, as expected, less commonly experienced, with SFT being the least common.

For the survey of children, it was considered most appropriate to obtain information on a child's reaction to the individual components of the four measures being evaluated, as it is the conduct of these individual components that will elicit a response, good or bad, from the child. Responses to the individual components of the simple childhood measures of interest were mixed (*Table 38*). The vast majority of children had no problem with having their height measured, but a significant proportion had a negative reaction to being weighed [either embarrassment (39%) or a more extreme negative reaction such as anger or crying]. Of those who had experienced the measurement of WC, HC and/or SFT, similar proportions of children were embarrassed by WC and HC, although fewer were embarrassed by SFT (*Table 39*).

TABLE 36 Population characteristics of overweight or obese children attending summer camp ($n = 72$)

Age (years)	School year	Sex	Are you concerned about your weight?	Do you feel it is important to measure your growth?
Mean 12.6	Range 4–13	Male: 51.4%	Yes: 79.2%	Yes: 81.9%
Range 9–17	4: 2.8%	Female: 48.6%	No: 19.4%	No: 16.7%
9: 8.3%	5: 6.9%		NR: 1.4%	NR: 1.4%
10: 5.6%	6: 4.2%			
11: 25.0%	7: 16.7%			
12: 13.9%	8: 13.9%			
13: 13.9%	9: 12.5%			
14: 9.7%	10: 8.3%			
15: 11.1%	11: 9.7%			
16: 6.9%	12: 4.2%			
17: 5.6%	13: 2.8%			
	Other: 4.2%			
	NR: 13.9%			

NR, not reported.

TABLE 37 The proportion of overweight or obese children attending summer camp who have experienced different simple measures of childhood obesity ($n = 72$)

Measure	Yes (%)	No (%)	Don't know (%)	NR (%)
Height	91.7	6.9	1.4	0
Weight	93.1	5.6	1.4	0
BMI	58.3	23.6	16.7	1.4
WC	58.3	31.9	8.3	1.4
HC	34.7	48.6	15.3	1.4
WHtR	25.0	52.8	20.8	1.4
WHR	18.1	58.3	20.8	0
SFT	9.7	66.7	20.8	2.8

NR, not reported.

TABLE 38 The proportion of the children who reported experiencing a particular emotion/reaction to the different simple measures of childhood obesity ($n = 72$)

Measure	Never had this (%)	Hurt (%)	Embarrassed (%)	Liked it/fun (%)	Did not let them do it (%)	Did not have a problem (%)	Angry (%)	Cried (%)
Height	1.4	2.8	6.9	29.2	0	63.9	0	0
Weight	0	2.8	38.9	11.1	2.8	43.1	5.6	1.4
WC	37.5	1.4	19.4	13.9	2.8	26.4	1.4	0
HC	59.7	1.4	12.5	6.9	2.8	12.5	0	0
SFT	80.6	0	1.4	4.2	2.8	6.9	0	0

TABLE 39 The number and proportion of children who had reported experiencing the measurement of WC, HC and/or SFT who did not have a problem, experienced embarrassment or reported a positive response

Measure	Had measure (n)	Embarrassed, n (%)	Liked it/fun, n (%)	Did not have a problem, n (%)
WC	45	14 (31)	10 (22)	19 (42)
HC	29	9 (31)	5 (17)	9 (31)
SFT	14	1 (7)	3 (10)	5 (36)

Over 50% of children considered a weight measurement to accurately reflect their weight status, and approximately 30% thought BMI and WC did so. Similar, smaller proportions (ranging from 11% to 19% of the overall population) considered HC, WHR, WHtR and SFT to be accurate (Table 40). Of those who had actually reported experiencing the measurement of HC, WHR, WHtR and/or SFT, between 31% and 46% considered the measure to accurately reflect their weight status; the majority of the remaining children reported either not understanding the measure or never being told about it (Table 41).

Parents' and caregivers' assessment of acceptability and ease of use

Three previous studies were identified that elicited opinions about BMI from guardians (parents in two studies^{74,75} and mothers and grandparents in one study²⁰⁷). All three studies were generally considered to be of good quality; all had clearly stated aims, appropriate methodology, research designs and recruitment strategies, data that were collected and analysed appropriately, clear statements of findings, appropriate ethical considerations and the research was considered to be of value. Brief study details are given in Table 42; the full data extraction is presented in Appendix 3. None of the studies considered the relationship between researcher and participants.

One study sent questionnaires to 1186 parents whose children attended school between kindergarten and Grade 6.⁷⁴ Of the 790 parents who returned questionnaires, 78% thought it was very (39%) or somewhat (39%) important for schools to screen height and weight (with parents of girls being less likely to think height/weight screening was important); 78% of parents wanted to receive results of such screening every year. Approximately 50% of the parents had received a letter informing them of their child's BMI, of which 79% read the entire letter and 16% most of the letter; 55% of these parents did not discuss the letter with their child. Parents who worked full time were less likely to think screening was important than those who worked part time or stayed at home, and parents of older students and girls were less likely to want information than parents of younger students or boys. Most parents were either not uncomfortable (68%) or only slightly uncomfortable (12%) with their child's BMI results; most thought their children were also either not uncomfortable (68%) or only slightly uncomfortable (15%). Parents found the results of weight/BMI measurements more helpful than information on physical activity, nutrition, screen time, health-related websites and community resources. Of the parents who expressed a concern for their child's weight after receiving a BMI letter, 8% planned to seek medical services, 8% to make diet-related changes, 27% to increase exercise and/or sign up their child for sports and 24% to sign up to other physical activity.⁷⁴

A second study used videotaped focus groups to elicit opinions about BMI screening from 71 parents whose children attended school between kindergarten and Grade 6.⁷⁵ This may be a subset of the parents who were sent questionnaires in the larger study by Kibik *et al.*⁷⁴ Nearly 50% of the parents were unaware that annual health screening was done at school; however, of the parents familiar with the screening process, most were supportive of height and weight screening. Several parents queried the value of such screening when the results were not shared with them; most felt that the results of screening should be reported to the parents, and several parents thought that this would aid with the early detection of important health conditions.⁷⁵ Some parents expressed concerns about the screening process for height and weight. These included the maintenance of privacy and confidentiality, the children's behaviour during screening – particularly the potential for teasing – and the accuracy of the results. Parents also expressed opinions as to who should be screened. Several said that screening was more important where there was a lack of health insurance or limited access to health care, and others felt that screening was less important in younger children as overweight usually resolves as children age.⁷⁵

Opinions of the 71 parents about BMI specifically were generally positive. Many parents felt that BMI was a more meaningful indicator of a child's weight status than height and weight alone; age- and sex-adjusted BMI were considered valuable as parents felt that they could not easily calculate these themselves. Several parents thought that BMI would be a 'wake-up call' or 'warning sign' for parents of an emerging weight problem that needed attention, and others thought that children overly concerned about

TABLE 40 The proportion of children who thought that a particular measure did or did not accurately reflect their weight status ($n = 72$)

Measure	Never had this (%)	Overestimated (%)	Underestimated (%)	About right (%)	Do not understand (%)	Never been told (%)
Weight	1.4	12.5	11.1	54.2	11.1	1.4
BMI	25.0	8.3	9.7	29.2	13.9	5.6
WC	30.6	4.2	5.6	31.9	12.5	5.6
HC	51.4	2.8	4.2	19.4	8.3	5.6
WHtR	55.6	1.4	5.6	13.9	6.9	6.9
WHR	59.7	1.4	2.8	13.9	6.9	5.6
SFT	66.7	0	0	11.1	8.3	5.6

TABLE 41 The number and proportion of children who had reported experiencing the measurement of WC, HC, WHR, WHtR and/or SFT who thought that the measure overestimated or underestimated their weight status, or got it about right

Measure	Had measure (n)	Overestimated, n (%)	Underestimated, n (%)	About right, n (%)
WC	50	3 (6)	4 (8)	23 (46)
HC	35	2 (6)	3 (9)	14 (40)
WHtR	32	1 (3)	4 (12.5)	10 (31)
WHR	29	1 (3)	2 (7)	10 (35)
SFT	24	0	0	8 (33)

TABLE 42 Brief details of the elicitation studies in parents and caregivers

Study details	Population characteristics	Children's details
Cloutier (2013) ²⁰⁷ Country in which study conducted: USA/Canada Study dates: start October 2009, finish March 2010	Whose opinion?: 83% mothers; 17% grandparents Source of sample: primary care clinics; family centres; head start and child care centres Method of obtaining opinion: focus groups ($n = 27$); interview ($n = 251$) Method of recording opinions: paper questionnaire; videotapes in focus groups	Simple childhood measure: BMI (CDC growth chart); 'My weight ruler' School grade of children: 2–4 Sex of children: NR Weight status of children: NR
Kubik (2006) ⁷⁴ Country in which study conducted: USA/Canada Study dates: start 2004, finish 2005	Whose opinion?: parents Source of sample: elementary school Method of obtaining opinion: self-administered survey Method of recording opinions: paper questionnaire	School grade of children: kindergarten to Grade 6 Sex of children: male 54% Weight status of children: normal weight 73%; overweight/obese 27%
Kubik (2007) ⁷⁵ Country in which study conducted: USA/Canada Study dates: start 2004, finish 2005	Whose opinion?: parents Source of sample: elementary school Method of obtaining opinion: focus groups Method of recording opinions: videotapes	School grade of children: kindergarten to Grade 6 Sex of children: NR Weight status of children: NR
NR, not reported.		

weight issues could be reassured if they were within the normal weight range. Most parents wanted to be notified about the BMI results, although some suggested that only parents of children with BMI values outside a healthy weight range need receive notification, to keep costs down. The preferred method of feedback to parents varied; most preferred results to be mailed directly, whereas others preferred feedback at teacher–parent conferences, parents calling the school nurse or the child bringing the information home in a sealed envelope. Few wanted the information via e-mail or the child’s report card.⁷⁵

The third study elicited opinions of caregivers (the mother or grandparent) on the ease of use of the CDC growth charts and a new presentation of BMI called ‘My Weight Ruler’.²⁰⁷ The ruler was designed to simplify the presentation of results of BMI. There were two parts to this study. The first was to obtain opinions about the My Weight Ruler from 27 Hispanic and African American caregivers in order to decide descriptors for the different categories during videotaped focus groups. The Hispanic participants decided on the terms ‘underweight’, ‘healthy weight’, ‘slightly overweight’ and ‘unhealthy weight’; the African American participants decided on the terms ‘too little’, ‘just right’, ‘big’ and ‘too big’ (Figure 33). All participants of the focus groups preferred the My Weight Ruler to the CDC growth charts.²⁰⁷

The second part of the study involved 251 caregivers who completed a questionnaire which asked them to interpret two plots on the My Weight Ruler and the CDC BMI growth chart. One plot was equivalent to the 50th centile and the other to the 97th centile. Of the 251 participants, 92% had previously seen a CDC BMI growth chart; none had seen the My Weight Ruler.

More respondents correctly classified both plotted measurements on the My Weight Ruler (92%) than on the CDC growth chart (37%); significantly more participants provided incorrect answers to both measurements on the CDC growth chart (32%) than on the My Weight Ruler (1%); and significantly more responded ‘I don’t know’ to the CDC growth chart (12% compared with 0.5%). Those who correctly interpreted the CDC BMI growth chart plots were more likely to have a higher level of education and higher household incomes; there were no significant trends for level of education, household income, ethnicity or first language for the My Weight Ruler. The need to take action when the result was at the 97th centile was understood by 61% of participants on the My Weight Ruler compared with 1% on the CDC growth chart. Overall, 79% of participants preferred the My Weight Ruler and 17% preferred the CDC BMI growth chart.²⁰⁷

Leeds Metropolitan University’s de novo study of overweight or obese children attending summer camp

To supplement the information identified for the systematic review, the parents of the children attending the obesity management summer camp reported in *Children’s assessment of acceptability and ease of use* were also asked to give their opinion about simple measures of childhood obesity. Sixty-four parents completed a questionnaire. The opinions of the parents can only be generalised to those with an overweight or obese child, owing to the setting in which the survey was undertaken. The characteristics of the parents who completed the questionnaire are given in Table 43.

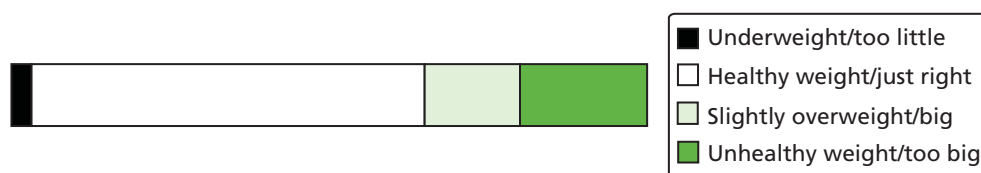


FIGURE 33 The ‘My Weight Ruler’.

Most of the parents said that their child had experienced height and weight measurements (*Table 44*). A proportion of these did not believe that their children had experienced their BMI being calculated, possibly as a consequence of the result not being fed back to them. Nearly 50% were aware that their children had had their WC measured, although, again, far fewer said that their children had experienced the composite measures that utilise WC. Only a small proportion of parents/caregivers were aware that their child had experienced SFT measurements, and one parent said that their child had undergone a measurement of muscle mass, although how this was measured is uncertain (see *Table 44*). When considering the usefulness of a measure, responses were generally positive, although the value of HC and SFT was uncertain for a large proportion of parents (*Table 45*). Nearly all of the parents were happy for their children to undergo any of the measures (see *Table 45*), although a large proportion considered the measurement of weight to be embarrassing for their child (*Table 46*).

The measure that parents considered most useful was a child's weight, with BMI and WC considered to be useful by over 40% of parents. Parents were less certain about the usefulness of HC, WHtR, WHR and SFT; most were either unfamiliar with the measure, or had not had the results fed back to them in order to form an opinion (*Table 47*).

TABLE 43 Population characteristics (64 parents with a total of 69 children)

Parents			Children	
Age (years)	Sex (%)	Concerned about child's weight? (%)	Age (years)	Sex (%)
Mean 40.7	Male: 17.2	Yes: 89.1	Mean 12	Male: 40.6
Range 20–69	Female: 79.7	No: 4.7	Range 9–17	Female: 59.4
	NR: 3.1	NR: 3.1		
		Sort of/slightly: 3.1		

NR, not reported.

TABLE 44 The proportion of parents who said that their children had experience of the different simple childhood measures of obesity ($n = 64$)

Measure	Yes (%)	No (%)	Don't know (%)	NR (%)
Height	87.5	3.1	7.8	1.6
Weight	92.2	3.1	3.1	1.6
BMI	67.2	15.6	15.6	1.6
WC	48.4	26.6	23.4	1.6
HC	26.6	40.6	31.3	1.6
WHtR	25.0	40.6	32.8	1.6
WHR	23.4	43.8	31.3	1.6
SFT	14.1	45.3	34.4	6.3
Muscle mass	1.6	0	0	0

NR, not reported.

RESULTS

TABLE 45 The proportion of parents who considered that a particular measure was useful, and whether or not they were happy for their child to undergo the measure ($n = 64$)

Do you think the measure is useful?					
Measure	Yes (%)	No (%)	Don't know (%)	NR (%)	What is it? (%)
Height	85.9	1.6	10.9	1.6	0
Weight	89.1	0	7.8	3.1	0
WC	73.4	1.6	21.9	3.1	0
HC	57.8	1.6	35.9	3.1	1.6
SFT	48.4	4.7	40.6	4.7	1.6
Are you happy for your child to have the measure?					
Measure	Yes (%)	No (%)	Don't know (%)	NR (%)	What is it? (%)
Height	98.4	0	1.6	0	0
Weight	98.4	0	1.6	0	0
WC	98.4	0	1.6	0	0
HC	96.9	0	3.1	0	0
SFT	96.9	0	3.1	0	0

NR, not reported.

TABLE 46 The proportion of parents who said that their children experienced a certain emotion/reaction to a simple childhood measure of obesity ($n = 64$)

Measure	Not had measure (%)	I don't know (%)	Physical pain (%)	Embarrassed (%)	Fun/liked it (%)	Opted out (%)	Didn't have a problem (%)	Anger (%)	Crying (%)	Other (%)
Height	3.1	17.2	0	1.6	12.5	0	60.9	0	0	0
Weight	1.6	15.6	0	31.3	6.3	0	29.7	3.1	9.4	3.1
WC	23.4	26.6	0	7.8	6.3	0	25.0	1.6	0	0
HC	42.2	25.0	0	3.1	3.1	0	17.2	0	0	0
SFT	46.9	26.6	0	0	3.1	0	10.9	0	0	0

Note
Total percentages do not necessarily add to 100% as some parents may not have answered all questions.

TABLE 47 The proportion of parents who thought that a particular measure did or did not accurately reflect their child's weight status ($n = 64$)

Measure	Child had not had measure (%)	Agreed that measure was accurate (%)	Measure overestimated child's weight (%)	Measure underestimated child's weight (%)	Didn't understand the information (%)	Didn't receive any information (%)
Weight	4.7	68.8	7.8	1.6	0	10.9
BMI	12.5	46.9	12.5	1.6	0	20.3
WC	25.0	40.6	1.6	0	1.6	20.3
HC	45.3	17.2	3.1	0	4.7	17.2
WHtR	48.4	17.2	1.6	0	4.7	17.2
WHR	50.0	12.5	3.1	0	4.7	17.2
SFT	54.7	9.4	3.1	0	6.3	15.6

Note
Total percentages do not necessarily add to 100% as some parents may not have answered all questions.

Health professionals' assessment of acceptability and ease of use

Two previous studies were identified that elicited opinions about BMI from health-care professionals, one of school nurses⁷³ and the other of family doctors and paediatricians.²⁰⁸ Both of the studies were generally considered to be of good quality; both had clear aims and appropriate methodology, research designs and recruitment strategies, findings were clearly stated and the research was considered to be of value. One study had data that were collected and analysed appropriately; the other was only an abstract, and therefore data relating to analysis were limited. Neither study considered the relationship between researcher and participants or stated that ethical approval was gained. Brief study details are given in *Table 48*; the full data extraction is given in *Appendix 3*.

The study of school nurses was an online survey.⁷³ Of the 2629 school nurses who completed the survey (97% of whom were female), 67% said that BMI should be measured in school, with 62% believing that BMI results should be sent home to parents. Most respondents stated that school nurses should be designing programmes to help overweight children (81%), that BMI helped create awareness of a problem (73%) and that BMI provided evidence to change policies to reduce obesity levels (72%). There were some concerns expressed over the use of BMI, with 31% believing that measuring BMI could be psychologically or socially damaging to the child.⁷³ A number of barriers to the use of BMI were highlighted, the most common of which was inadequate school resources (57.6%). Other barriers included inadequate or inappropriate parental responses (55.2%) and insufficient time for the measure (42%). Most of the school nurses were confident or very confident in measuring height and weight (94%), calculating BMI (74%) and helping parents interpret BMI results (93%). Over 50% of nurses agreed or strongly agreed that tracking BMI would help administrators to address the childhood overweight/obesity issue.⁷³

The study of family doctors and paediatricians took the form of a questionnaire aimed at eliciting opinions on the use of BMI in preschool children aged 2–5 years; 267 completed the survey.²⁰⁸ Of the 267 respondents, 37% generally did not use BMI charts for children between 2 and 5 years old; 24% did generally use BMI charts for this age group and 39% endorsed the use of BMI charts for selected 2- to 5-year-olds. Of the 39% who used BMI charts for selected children, 87% indicated that this was for children who appear overweight from height and weight curves, 72% for children who appear overweight by visual inspection and 68% for children who have crossed upwards between weight centiles.²⁰⁸

TABLE 48 Brief details of the elicitation studies conducted in health professionals

Study details	Population characteristics	Children's details
Hendershot (2008) ⁷³	Whose opinion?: school nurses	School grade of children: NR
Country in which study conducted: USA	Source of sample: National Association of School Nurses database	Sex of children: NR
Study dates: NR	Method of obtaining opinion: electronic survey	Weight status of children: NR
	Method of recording opinions: electronic/online	
Woolford (2008) ²⁰⁸	Whose opinion?: GPs, paediatricians	School grade of children: preschool (age 2–5 years)
Country in which study conducted: USA/Canada	Source of sample: American Medical Association Masterfile	Sex of children: NR
Study dates: start 2006, finish 2006	Method of obtaining opinion: self-administered survey (12-item Likert scales and multiple-choice questions)	Weight status of children: NR
	Method of recording opinions: paper questionnaire	

GP, general practitioner; NR, not reported.

Barriers to the use of BMI included the time taken to calculate and plot BMI (65% of all respondents; 75% of those who did not use BMI or who used it selectively); the time and complexity of explaining the findings to parents (70% of all respondents; 76% of those who did not use BMI or who used it selectively); and parental familiarity with height and weight curves (57% of all respondents; 59% of those who did not use BMI or who used it selectively). Physicians who did not use BMI charts were more likely to report these as major barriers than physicians who did use BMI charts generally or selectively. Colour-coded charts were considered by 60%, and the inclusion of management recommendations on BMI charts by 61%, as strong influences in increasing the likelihood of using BMI charts at preschool well-child visits; 35% considered that computerised calculation and plotting of results would also improve use. Recommendations for addressing obesity were workshops at national and regional medical conferences (47%), online websites (45%) and DVD training (43%); 30% said they would participate in a 2-day behaviour management course, with paediatricians significantly more likely than family physicians to endorse this option (38% vs. 17%). Just 5% indicated that they probably would not participate in any training activities related to behaviour management skills to address obesity.²⁰⁸

In order to supplement the information identified in the systematic review, we attempted to elicit the opinions of school nurses on the simple childhood measures most commonly used during screening in schools. We have no responses from school nurses to report.

Summary of acceptability and ease of use

The evidence identified from the systematic searches was limited. Three studies elicited opinions about BMI from parents/grandparents, one from school nurses and one from family doctors and paediatricians; no studies were identified that elicited the opinions of children on BMI or any other measure. The opinion of parents regarding the usefulness of BMI was generally positive; on the whole, parents considered height and weight screening useful and wanted to be made aware of the results of the screening of their children, although probably in a more user-friendly format than CDC growth charts, which were evaluated in one of the studies. School nurses were also generally positive about the usefulness of BMI, and most agreed with parents that the results of screening should be fed back to the child's parent. The usefulness of measuring BMI in preschool children was less well accepted among doctors; however, it was considered by many to be useful for selected children aged 2–5 years who appear overweight from height and weight curves or visual inspection, or who have crossed upwards between weight centiles.

From the elicitation exercise, it seems that parents are generally unfamiliar with measurements such as WHR, WHtR and SFT, and therefore their potential accuracy and usefulness. This highlights the need to increase parents' awareness of these measures if they are to be introduced as screening tools for school-aged children. The children who completed a questionnaire were most familiar with measurements of height and weight. Although most did not seem to have a problem with their height being measured, a large proportion were embarrassed by, or had other adverse reactions to, being weighed. This was, however, a small sample of children who were attending a weight management summer camp, and may not be representative of a more diverse population of children. Of those who experienced WC, HC and SFT measurements, a large proportion were also embarrassed when WC and HC were measured.

Chapter 4 Discussion

Summary of findings

This review sought to answer the question ‘What is the best simple measure, or combination of simple measures, of obesity in children for predicting the development of obesity-related health problems in adulthood?’ To answer this question, the review focused on four areas: the prediction of adult morbidity from childhood obesity; the tracking of obesity from childhood into adolescence and adulthood; the diagnosis of obesity in childhood; and the acceptability and ease of use of obesity measures. The review identified 37 studies on the prediction of adult morbidities, 23 studies on the tracking of obesity into adolescence and adulthood, 34 relevant diagnostic accuracy studies and five studies on acceptability, along with the elicitation exercise performed as part of the review.

Prediction of adult obesity-related morbidities

Thirteen existing systematic reviews were identified, of which four were judged to be of direct relevance to this review. These reviews generally concluded that there was a positive association between childhood BMI and adult obesity-related morbidities, with high BMI leading to greater incidence of diabetes, CHD and hypertension. One review found that the association between childhood obesity and morbidity was a consequence of obese children becoming obese adults and that childhood obesity was not an independent predictor of morbidity once adult obesity had been accounted for.¹⁸

A total of 37 studies representing 22 distinct cohorts met the inclusion criteria for this review. Of these, 26 studies (13 cohorts) were included in meta-analyses. All studies included BMI. Three measured WC, and one used WHR and sum SFT. No evidence was found for other simple childhood measures.

In general, elevated childhood BMI was found to be modestly associated with an increased risk of adult morbidity. The association between a 1-SD increase in BMI and adult diabetes had an OR of 1.7 (95% CI 1.30 to 2.22), approximately equivalent to a 24% increase in risk per BMI unit in an adolescent. The association between a 1-SD increase in BMI and adult CHD had an OR of 1.2 (95% CI 1.20 to 1.31), approximately equivalent to obese children having an odds of CHD 44% higher than normal-weight children. There was no convincing evidence of an association between childhood obesity and stroke. Across a range of cancers, there was evidence that childhood obesity was associated with a higher risk of cancer in adulthood. Increases in odds were generally around 20% per SD of BMI. However, there was no evidence of an association between childhood BMI and breast cancer.

Despite the positive association between childhood BMI and morbidities, childhood BMI was not found to be a good predictor of adult disease. Given the associations identified, only 40% of adult diabetes and only 20% of CHD and cancers would occur in overweight or obese children (above the 85th centile for BMI). Hence, the majority of adult morbidity occurs in people who were of normal weight as children. This poor predictive accuracy is a consequence of the comparatively small magnitude of the association between childhood BMI and morbidities. As noted above, a large association would be required for BMI to be a useful predictor of adult morbidity.

In the narrative review, childhood obesity was found to be associated with adult metabolic syndrome, and there was some very limited evidence that BMI had poor sensitivity to predict adult metabolic syndrome. The existence and nature of metabolic syndrome remains controversial, with no standard definition. Most definitions of metabolic syndrome include obesity measurement, so the strong association between childhood BMI and metabolic syndrome may be a consequence of tracking of obesity into adulthood. Evidence on the association

between childhood BMI and hypertension and hypercholesterolaemia was very limited. The number of studies was too small to draw conclusions about the effect of variables such as age and sex on adult morbidity.

Evidence was too limited to draw any firm conclusions about other childhood measures of obesity.

The studies included in the review tended to focus on older cohorts of children, who were born before the modern obesity epidemic in most cases. Earlier obesity onset and more extreme forms of childhood obesity are more common in contemporary populations than in the recent past.²³⁶ This should be considered when interpreting the findings of this review.

Tracking of childhood obesity into adulthood

Two directly relevant systematic reviews of the tracking of overweight/obesity into adulthood had already been conducted prior to our review. Both reviews looked at correlations or associations between childhood and adult weight status. One of these reviews¹⁶ found that there was strong evidence of moderate persistence of overweight in both overweight and obese children, and that this association was possibly stronger for adolescent than for childhood overweight or obesity. The other, which focused on early childhood, found that childhood obesity (at age 5 years or earlier) was a probable marker of adult obesity.¹⁷

From existing systematic reviews and searches for primary studies, a total of 23 studies from 16 cohorts met the inclusion criteria for this review. Only one study evaluated a childhood measure other than BMI (SFT). The association between childhood obesity (≥ 95 th centile) and obesity in adults (age ≥ 20 years) was strong, with obese children being more than five times more likely to be obese as adults than non-obese children (pooled RR 5.21, 95% CI 4.50 to 6.02). There was no apparent difference in this RR between younger and older age groups.

Obesity tracked moderately well from childhood into adolescence; around half of obese children were still obese in adolescence. Obesity tracked well from adolescence to adulthood; about 80% of obese adolescents were still obese in adulthood and 70% were still obese after age 30 years. No data were available for tracking beyond the age of 40 years.

Body mass index was less effective at identifying those who would be obese in adulthood; 70% of obese adults were not obese as children or in adolescence, and 80% of obese people aged over 30 years were not obese in adolescence, so childhood BMI has poor sensitivity to detect adult obesity. Analyses of the tracking of childhood overweight (≥ 85 th centile) to adult obesity or overweight gave broadly similar results.

Four studies reported data that could not be included in the meta-analyses; the results of these studies were broadly consistent with the findings of the meta-analyses. There were insufficient data on any simple measure other than BMI to suggest that any might improve the ability of childhood obesity to predict adult obesity.

Diagnostic accuracy of simple measures for childhood obesity

Thirty-four studies met the inclusion criteria for the review of diagnostic accuracy, of which 30 assessed the diagnostic accuracy of BMI, 10 of SFT, seven of WC, four of WHR, two of WHtR, one of BIA and five of other childhood measures of obesity. Sixteen studies reported direct comparisons of two or more childhood measures. Most of the studies used DEXA, which is the least reliable of the eligible reference standards. Of the 34 studies, only eight were considered to be high quality.

Overall, the sensitivity of BMI for diagnosing both obesity and overweight varied considerably; specificity was less variable. The most homogeneous subset of studies evaluating BMI were meta-analysed, that is those using the cut-off points most commonly used in clinical practice (85th centile for overweight and 95th centile for obesity), in a population of children representative of the UK child population who would receive the measure in practice. The resulting pooled sensitivity was approximately 74% (95% CI 64.2% to 81.8%) and pooled specificity was approximately 95% (95% CI 92.2% to 96.4%) for diagnosing overweight or obesity.

Data on other measures of obesity were more limited, with insufficient numbers of studies that were sufficiently homogeneous to undertake a meta-analysis. The most commonly evaluated non-BMI test was SFT. Sensitivity ranged from 23% to 98.5% and specificity from 78% to 100% across the populations and thresholds for triceps SFT (four studies). Sensitivity ranged from 30% to 98.5% and specificity from 79.1% to 99% for subscapular SFT (two studies). Sensitivity ranged from 57% to 98% and specificity from 47% to 96% for sum SFT (six studies). Several studies evaluated WC, either alone or in association with HC or height. Across populations and thresholds, sensitivity ranged from 34.7% to 100% and specificity from 81% to 100% for WC alone, sensitivity from 0% to 78.8% and specificity from 70.6% to 100% for WHR, and sensitivity from 90.9% to 100% and specificity from 95% to 100% for WHtR.

Using the studies reporting direct comparisons, there was little evidence to suggest that any measure that reported 2 × 2 tables of test performance to allow plotting into ROC would have substantially better diagnostic performance than BMI. FMI was evaluated alongside BMI in one study and looks promising, but would require further research. Sum SFT also shows potential as an alternative or supplementary measure to BMI. Of the measures that incorporate a WC measurement, it seems that WHtR was more accurate than WC alone or WHR, although WHtR was evaluated in fewer studies.

Acceptability and ease of use of simple measures for childhood obesity

Five studies were identified for the review of acceptability and ease of use, all eliciting opinions about BMI. None of the studies elicited the opinions of children; three elicited the opinions of caregivers/guardians, and two those of health professionals (one of school nurses and one of family doctors and paediatricians). The opinion of parents regarding the usefulness of BMI was generally positive. Most parents considered height and weight screening useful and wanted to be made aware of the results for their children, although in a more user-friendly format than CDC growth charts. School nurses were also generally positive about the usefulness of BMI, and most agreed with parents that the results of screening should be fed back to the child's parent. The usefulness of measuring BMI in preschool children was less well accepted among doctors; however, it was considered by many to be useful for selected children aged 2–5 years who appear overweight from height and weight curves or visual inspection, or who have crossed upwards between weight centiles.

An elicitation exercise was conducted to obtain the views of children, parents/guardians and school nurses on four of the measures of childhood obesity: BMI, SFT, WHR and WHtR. The 72 children questioned, who were attending a weight management summer camp, were most familiar with height and weight measurement. Although most did not seem to have a problem with their height being measured, a large proportion were embarrassed by, or had other adverse reactions to, being weighed. Of those who experienced measurements of WC, HC and SFT, a large proportion were also embarrassed when WC and HC were measured. The 71 parents/caregivers questioned were generally unfamiliar with measures of WHR, WHtR and SFT, and therefore their potential accuracy and usefulness. Many felt that BMI was a more meaningful indicator of a child's weight status than height and weight alone; age- and sex-adjusted BMI were considered valuable as parents/caregivers felt that they could not easily calculate these themselves. We had no data to report from school nurses.

Strengths and limitations of the review

Strengths

This review was conducted according to the PRISMA guidelines and provided a comprehensive analysis of the link between childhood obesity and adult obesity and morbidity by considering the four review areas described above. For each subreview, extensive searching was undertaken to identify published and unpublished studies, so that all relevant, appropriately powered studies were included.

Most previous systematic reviews in this field have been narrative reviews; this is the first review to combine results across studies in meta-analyses. In addition, unlike previous systematic reviews, this review has focused on the accuracy of childhood obesity to predict adult obesity or morbidity, rather than on estimating correlations or associations between test results and outcomes, and has used meta-analysis to calculate estimates of predictive accuracy for the ability of childhood obesity/overweight to predict adult morbidities and obesity/overweight. This is particularly important as an association between obesity and adult morbidity or obesity does not imply that childhood obesity will be a useful predictor of adult morbidity or obesity. In general, the association between a risk factor (such as obesity) and a subsequent medical condition has to be substantial before the risk factor can usefully be used to predict the future incidence of the condition.^{70,237}

The results of this review complement the findings of previous reviews rather than superseding them.

Limitations

Despite a large number of studies being identified for the morbidity and tracking review questions, the number from which the necessary data could be obtained was small. Furthermore, the limited reporting of most studies and the diversity in the reporting of morbidities, assessments of BMI and ages at which obesity was measured further reduced the number of studies that could be combined in any particular meta-analysis. This meant that most results have a high degree of uncertainty, with wide CIs, and it also limited the ability of the analyses to test for the impact of important confounders such as age and sex.

The diversity of reporting across studies also meant that most meta-analyses required a number of assumptions to be made to permit analysis. This was particularly the case for the prediction of morbidities, especially the assumption of normality for BMI, which is acknowledged to be inaccurate. Without individual patient data, there was no way for us to transform the BMI to meet the assumption of a normal distribution. This will have limited the reliability of the pooled estimate, and so the results should be taken as indicating general trends rather than providing precise estimates of association or predictive accuracy.

The number of studies of the prediction of adult morbidities or adult obesity that used a childhood measure of weight status other than BMI was surprisingly low: only four studies. This greatly hampered the review's ability to address the original review question.

The cohort studies of the association between childhood obesity and adult morbidities included in the review were, of necessity, long-term studies, with recruitment often occurring in the 1960s or earlier. As this was before the rise in general obesity, it is unclear whether or not the findings from this part of the review apply to present-day children, among whom obesity is more prevalent.

Very few studies compared simple measures of obesity with our 'gold standard' measurement tool. In addition, several studies included in the review of diagnostic tools used internally derived, distribution-based cut-off points rather than set thresholds of adiposity. This limited the extent to which our third objective (to answer the question 'how accurately do simple measures of obesity reflect actual adiposity in children?') could be addressed.

Our review on the acceptability of simple measures of childhood obesity identified gaps in the evidence regarding the views of children, parents and health professionals. The elicitation exercise did contribute to filling some of these gaps. However, we acknowledge that this primary study only included a small, self-selected sample of children and parents, and did not include the views of health-care professionals. Therefore, the applicability of its findings to the broader population of children, parents and health professionals is unclear.

Chapter 5 Conclusions

In general, the review found that childhood obesity (when measured using BMI) was associated with moderately increased risks of adult obesity-related morbidity, but the increase in risk was not large enough for childhood BMI to be a good predictor of the incidence of adult morbidities; the majority of adult obesity-related morbidity occurs in adults who were of healthy weight in childhood.

Owing to lack of data, the review was unable to determine whether or not other simple measures of obesity might improve the prediction of adult morbidities.

The review of tracking studies found that obese children, and particularly obese adolescents, are likely to become obese adults. This is because childhood obesity (again when measured using BMI) is strongly associated with adult obesity. This strong association was matched by a strong persistence of childhood obesity into adulthood. However, childhood BMI is not a good predictor of the incidence of adult obesity or overweight; most obese adults were not obese in childhood, so overall adult obesity is not primarily determined by childhood obesity.

No information was available on tracking of obesity into later adulthood, when most obesity-related morbidities are likely to occur.

The usefulness of BMI as a screening tool therefore depends upon the objectives of screening. It may be useful for identifying a group of obese or overweight children who may benefit from intervention, but does not identify all children who will go on to be obese or to develop obesity-related morbidities in adulthood.

Body mass index was found to be reasonably good at diagnosing obesity during childhood, with around 75% of genuinely adipose children being classified as obese using BMI, and around 95% of non-obese children also being correctly classified. This result was, however, based mostly on studies using DEXA, which is not generally regarded as a gold standard for diagnosing obesity.

There is a lack of evidence to help determine whether or not any simple measure is better or worse than BMI for assessing childhood weight status, either for diagnosing obesity in childhood or for predicting adult obesity or obesity-related morbidities. If a simple childhood measure of obesity is to be introduced as a screening tool, its usefulness will depend upon the objectives of screening. If the objective is to identify a group of children who will benefit from intervention, then screening would be useful, as long as there are efficacious interventions available. If, however, the objective is to identify all children who will go on to become obese adults, then screening in childhood using one of these measures is unlikely to be useful.

When considering the acceptability and ease of use of the childhood measures of obesity, the opinion of parents and nurses on the usefulness of BMI was generally positive; however, its usefulness in preschool children was less well accepted among doctors, although it was considered useful for selected young children. From the elicitation exercise, the acceptability to children and their carers of BMI or other common simple measures was generally good, although adverse reactions were not uncommon when children had their weight measured. Parents were unfamiliar with measurements such as WHR, WHtR and SFT and therefore their potential usefulness, highlighting the need to increase the awareness of these measures if they are to be introduced as screening tools for school-aged children.

Implications for practice

This review has found evidence that childhood obesity (when measured using BMI) is strongly associated with increased adult obesity, but more weakly associated with increased adult obesity-related morbidity. Childhood overweight and obesity is therefore a genuine public health problem, and reducing the overall prevalence of obesity and overweight in childhood should reduce obesity and morbidities in later life.

Most obese children (when measured using BMI) will still be obese in early adulthood, so BMI is useful for identifying that group of children at higher risk of adult obesity. Whether or not this obesity persists into later adulthood (> 30 years) is uncertain.

However, most obese adults were of healthy weight in childhood, and the substantial majority of obesity-related morbidities occur in adults who were of healthy weight in childhood. Using BMI to identify obese children as being at risk of later obesity or morbidity, and targeting weight-reduction interventions specifically at these obese children, is therefore unlikely to have a meaningful impact on reducing the overall morbidity or obesity burden in adulthood.

This review suggests that, given the modest size of the association between childhood obesity and later morbidity, it may not be appropriate to categorise obese children as being at 'high risk' of later adult morbidity.

The evidence on measures of obesity other than BMI was too limited to draw any conclusions regarding whether such measures are better or worse than BMI when used to assess childhood obesity.

Issues around applicability may be considered alongside the question of parental interpretation of simple measures of overweight and obesity. There is evidence to suggest that some parents may not perceive their child as being overweight or at higher risk of health problems in later life.^{238,239} Reasons for these misperceptions may be considered when communicating with parents of overweight and obese children.²³⁹

Further research

There is limited evidence of the accuracy of childhood measures of obesity to predict adult obesity and morbidity. This suggests the following areas for future research:

1. To seek to review and analyse the individual-level raw data from the identified cohort studies. This could greatly enhance understanding of the association between childhood BMI and adult obesity and obesity-related morbidity, by avoiding the limitations found when using published results and reducing the need for making inaccurate assumptions in the analyses. It may also allow for examination of other simple measures, such as WC or WHtR, that may have been recorded but not reported in publications.
2. A high research priority is to determine which childhood measure is the most accurate for diagnosing childhood obesity. A full assessment is required of the diagnostic accuracy of childhood measures of obesity, at a range of ages from 2 to 18 years, particularly of studies using MRI as the reference standard. Primary diagnostic accuracy studies may need to be undertaken for those childhood measures for which data are sparse or missing completely. Any future diagnostic accuracy studies of other simple childhood measures should include BMI as a comparator and use at least a 4-C model as the reference standard, as this is the gold standard.
3. Primary predictive accuracy studies of measures other than BMI may be appropriate once it is clear that the required data are currently unavailable, and when the most accurate simple childhood measure for diagnosing childhood obesity has been determined, as such studies would be time-consuming and expensive.
4. Cohort studies to assess tracking of obesity and incidence of obesity-related morbidities should be undertaken to investigate the effect of contemporary childhood obesity on long-term obesity and morbidity. This could be achieved through appropriate maintenance and analysis of NHS records.
5. Any future assessment of simple measures of obesity should consider assessment of acceptability and ease of use of these measures.

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Contribution of authors

Mark Simmonds contributed to the protocol development. Performed the statistical analyses in the morbidity and tracking reviews and performed some analyses for the diagnostic review; performed the data extraction for the morbidity review; wrote the sections of the report relating to the morbidity and tracking analyses, and the discussion; contributed generally to the writing of the report.

Jane Burch contributed to the protocol development. Performed the study selection for all four review questions, and the data extraction, validity assessment and most of the analyses for the diagnostic accuracy and acceptability and ease of use reviews; wrote the sections of the report relating to the diagnostic accuracy and acceptability and ease of use reviews, and the introduction; contributed generally to the writing of the report.

Alexis Llewellyn contributed to the protocol development. Performed the study selection, data extraction and validity assessment of the morbidity review; wrote sections of the report for the morbidity review; contributed generally to the writing of the report.

Claire Griffiths contributed to the protocol development. Was responsible for the conduct of the elicitation exercise, and provided comments on drafts of the report.

Huiqin Yang contributed to the protocol development. Performed the study selection and data extraction for the tracking and diagnostic accuracy reviews.

Christopher Owen contributed to the protocol development. Provided the team with advice throughout the project and commented on drafts of the report.

Steven Duffy contributed to the protocol development. Information specialist responsible for developing the search strategies, conducting a range of searches to locate studies and writing the methodological sections relating to the search.

Nerys Woolcott contributed to the protocol development. Took overall managerial responsibility for the project, contributed to all aspects of the project and provided comments on drafts of the report.

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Appendix 1 Literature searches

Review of adult morbidities: search for systematic reviews

Cochrane Database of Systematic Reviews (Wiley Online Library)

2013: Issue 6/12. Searched 11 June 2013. Retrieved four records.

- #1 Medical subject heading (MeSH) descriptor: [Obesity] explode all trees (6452)
- #2 MeSH descriptor: [Overweight] this term only (1072)
- #3 MeSH descriptor: [Weight Gain] this term only (1416)
- #4 MeSH descriptor: [Weight Loss] this term only (2918)
- #5 obes*:ti,ab,kw (9909)
- #6 (overweight or (over next weight)):ti,ab,kw (3234)
- #7 ((weight next gain) or (weight next loss)):ti,ab,kw (9014)
- #8 #1 or #2 or #3 or #4 or #5 or #6 or #7 (15,983)
- #9 MeSH descriptor: [Adiposity] explode all trees (203)
- #10 MeSH descriptor: [Body Composition] explode all trees (2773)
- #11 MeSH descriptor: [Body Weight] explode all trees (14,255)
- #12 (adiposity or adipose):ti,ab,kw (2114)
- #13 (body near/2 (composition or fat or weight)):ti,ab,kw (18,126)
- #14 fatness:ti,ab,kw (86)
- #15 #8 or #9 or #10 or #11 or #12 or #13 or #14 (30,161)
- #16 MeSH descriptor: [Child] explode all trees (64)
- #17 MeSH descriptor: [Infant] explode all trees (12,099)
- #18 MeSH descriptor: [Adolescent] this term only (69,925)
- #19 MeSH descriptor: [Young Adult] this term only (112)
- #20 (child* or infant* or pediat* or paediat* or schoolchild* or (school next age*) or schoolage*):ti,ab,kw (83,102)
- #21 (adolescen* or juvenile* or youth* or teenage* or youngster*):ti,ab,kw (83,300)

- #22 (girl or girls or boy or boys or kid or kids):ti,ab,kw (3932)
- #23 ((young next people) or (young next person) or (young next persons) or (young next adult*)):ti,ab,kw (21,801)
- #24 #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 (149,550)
- #25 MeSH descriptor: [Body Mass Index] this term only (5044)
- #26 MeSH descriptor: [Skinfold Thickness] this term only (269)
- #27 MeSH descriptor: [Waist Circumference] this term only (261)
- #28 MeSH descriptor: [Waist-Hip Ratio] this term only (158)
- #29 MeSH descriptor: [Electric Impedance] this term only (313)
- #30 (("body mass" near/3 (index* or indices)) or bmi or quetelet*):ti,ab,kw (11,870)
- #31 (("fat mass" near/3 (index* or indices)) or fmi):ti,ab,kw (49)
- #32 (("fat free mass" near/3 (index* or indices)) or fmi):ti,ab,kw (35)
- #33 ("body adipos*" near/3 (index* or indices)):ti,ab,kw (1)
- #34 ("body fat" near/2 percentage*):ti,ab,kw (328)
- #35 (("skin fold" or skinfold) near/3 (thickness* or test* or measure*)):ti,ab,kw (590)
- #36 ((waist or hip or neck) near/3 circumference*):ti,ab,kw (1244)
- #37 ((waist-to-hip or waist-hip or "waist to hip" or "waist hip") near/3 ratio*):ti,ab,kw (542)
- #38 ((waist-to-height or waist-height or "waist to height" or "waist height") near/3 ratio*):ti,ab,kw (16)
- #39 (((bioelectric* or electric*) near/3 (impedance or resistance)) or bia):ti,ab,kw (598)
- #40 ("near infrared interactance" or NIR):ti,ab,kw (49)
- #41 ((benn* or rohrer* or ponderal or corpulence) near/3 (index* or indices)):ti,ab,kw (32)
- #42 ("sagittal abdominal diameter*" or "supine abdominal diameter*"):ti,ab,kw (8)
- #43 #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 (13,412)
- #44 #15 and #24 and #43 (2163)
- #45 MeSH descriptor: [Cardiovascular Diseases] explode all trees (68,582)
- #46 ((cardiovascular or cardio or vascular or peripheral) near/3 (disease* or disorder* or failure*)):ti,ab,kw (11,739)

- #47 ((heart or cardiac or myocardial) near/3 (disease* or disorder* or failure* or attack* or arrest*)):ti,ab, kw (19,972)
- #48 (coronary near/3 (disease* or disorder* or failure* or attack* or arrest* or syndrome*)):ti,ab, kw (14,665)
- #49 (circulatory near/3 (disease* or disorder* or failure*)):ti,ab,kw (139)
- #50 CVD or CHD:ti,ab,kw (2049)
- #51 (myocardial near/3 (infarc* or disease* or disorder* or failure* or attack* or arrest*)):ti,ab, kw (13,949)
- #52 (ami or mi):ti,ab,kw (3681)
- #53 (angina* or "atrial fibril*"):ti,ab,kw (11,114)
- #54 MeSH descriptor: [Stroke] explode all trees (4414)
- #55 (stroke* or poststroke*):ti,ab,kw (18,467)
- #56 (cerebrovascular or (cerebral next vascular)):ti,ab,kw (4312)
- #57 ((brain* or cerebral* or lacunar) near/3 (accident* or infarc*)):ti,ab,kw (2049)
- #58 (apoplexy or CVA):ti,ab,kw (305)
- #59 MeSH descriptor: [Hypertension] this term only (12,874)
- #60 MeSH descriptor: [Blood Pressure] explode all trees (21,914)
- #61 (hypertens* or (blood next pressure*) or bloodpressure* or diastolic or systolic):ti,ab,kw (55,771)
- #62 MeSH descriptor: [Cholesterol] this term only (5091)
- #63 MeSH descriptor: [Hypercholesterolemia] this term only (2311)
- #64 (cholesterol or hypercholesterol?emia* or hypercholester?emia*):ti,ab,kw (16,019)
- #65 #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 (134,104)
- #66 MeSH descriptor: [Diabetes Mellitus, Type 2] explode all trees (7712)
- #67 (diabetes near/2 "type 2"):ti,ab,kw (9307)
- #68 (diabetes near/2 "type II"):ti,ab,kw (599)
- #69 (diabetes near/2 ("non insulin" or noninsulin)):ti,ab,kw (1744)
- #70 (NIDDM or T2DM):ti,ab,kw (1353)

- #71 MeSH descriptor: [Metabolic Syndrome X] explode all trees (689)
- #72 ((metabolic or dysmetabolic or reaven or insulin resistance) near/2 syndrome*):ti,ab,kw (1211)
- #73 #66 or #67 or #68 or #69 or #70 or #71 or #72 (11,163)
- #74 MeSH descriptor: [Neoplasms] explode all trees (46,049)
- #75 (cancer* or neoplas* oncolog* or malignan* or tumo?r* or carcinoma* or adenocarcinoma*):ti,ab,kw (62,530)
- #76 #74 or #75 (74,856)
- #77 #65 or #73 or #76 (210,175)
- #78 #44 and #77 (712)

Database of Abstracts of Reviews of Effects (Centre for Reviews and Dissemination public interface)

7 June 2013. Searched 11 June 2013. Retrieved 56 records.

1. MeSH DESCRIPTOR Obesity EXPLODE ALL TREES (685)
2. MeSH DESCRIPTOR Overweight EXPLODE ALL TREES (698)
3. MeSH DESCRIPTOR Weight Gain EXPLODE ALL TREES (108)
4. MeSH DESCRIPTOR Weight Loss EXPLODE ALL TREES (310)
5. (obes* or overweight or "over weight" or "weight gain" or "weight loss") (1772)
6. MeSH DESCRIPTOR Adiposity EXPLODE ALL TREES (11)
7. MeSH DESCRIPTOR Body Composition EXPLODE ALL TREES (72)
8. MeSH DESCRIPTOR Body Weight EXPLODE ALL TREES (1005)
9. (adiposity or adipose or fatness) (70)
10. ((body NEAR2 (composition or fat or weight))) (723)
11. (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10) (2222)
12. MeSH DESCRIPTOR Body Mass Index EXPLODE ALL TREES (220)
13. MeSH DESCRIPTOR Skinfold Thickness EXPLODE ALL TREES (4)
14. MeSH DESCRIPTOR Waist Circumference EXPLODE ALL TREES (14)
15. MeSH DESCRIPTOR Waist-Hip Ratio EXPLODE ALL TREES (0)
16. MeSH DESCRIPTOR Electric Impedance EXPLODE ALL TREES (14)
17. (((("body mass" NEAR3 (index* or indices)) or bmi or quetelet*)) (927)
18. (((("fat mass" NEAR3 (index* or indices)) or fmi)) (5)
19. (((("fat free mass" NEAR3 (index* or indices)) or ffm)) (0)
20. ((("body adipos*" NEAR3 (index* or indices))) (1)
21. ((("body fat" NEAR2 percentage*)) (9)
22. (((("skin fold" or skinfold) NEAR3 (thickness* or test* or measure*)) (48)
23. (((waist or hip or neck) NEAR3 circumference*)) (66)
24. (((waist-to-hip or waist-hip) NEAR3 ratio*)) (22)
25. (((waist-to-height or waist-height) NEAR3 ratio*)) (2)
26. (((bioelectric* or electric*) NEAR3 (impedance or resistance)) or bia)) (28)
27. (((benn* or rohrer* or ponderal or corpulence) NEAR3 (index* or indices))) (6)
28. ((("infrared interactance" or NIR)) (7)
29. ((("sagittal abdominal diameter*" or "supine abdominal diameter*")) (0)

30. (#12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29) (983)
31. MeSH DESCRIPTOR Child EXPLODE ALL TREES (3665)
32. MeSH DESCRIPTOR Infant EXPLODE ALL TREES (2258)
33. MeSH DESCRIPTOR Adolescent EXPLODE ALL TREES (3456)
34. MeSH DESCRIPTOR Young Adult EXPLODE ALL TREES (1124)
35. ((child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*)) (9033)
36. ((adolescen* or juvenile* or youth* or teenage* or youngster*)) (4300)
37. ((girl or girls or boy or boys or kid or kids)) (278)
38. (("young people" or "young person" or "young persons" or "young adult*)) (1492)
39. (#31 or #32 or #33 or #34 or #35 or #36 or #37 or #38) (11,234)
40. MeSH DESCRIPTOR Cardiovascular Diseases EXPLODE ALL TREES (7964)
41. (((cardiovascular or cardio or vascular or peripheral) NEAR3 (disease* or disorder* or failure*)) (1837)
42. (((heart or cardiac or myocardial) NEAR3 (disease* or disorder* or failure* or attack* or arrest*)) (2805)
43. ((coronary NEAR3 (disease* or disorder* or failure* or attack* or arrest* or syndrome*)) (1970)
44. ((circulatory NEAR3 (disease* or disorder* or failure*)) (4)
45. (CVD or CHD) (351)
46. ((myocardial NEAR3 (infarc* or disease* or disorder* or failure* or attack* or arrest*)) (2211)
47. ((ami or mi)) (838)
48. ((angina* or "atrial fibril*") (1288)
49. MeSH DESCRIPTOR Stroke EXPLODE ALL TREES (909)
50. (stroke* or poststroke*) (2514)
51. (cerebrovascular or "cerebral vascular") (479)
52. (((brain* or cerebral* or lacunar) NEAR3 (accident* or infarc*)) (94)
53. ((apoplexy or CVA) (31)
54. MeSH DESCRIPTOR Hypertension EXPLODE ALL TREES (687)
55. MeSH DESCRIPTOR Blood Pressure EXPLODE ALL TREES (384)
56. ((hypertens* or "blood pressure*" or bloodpressure* or diastolic or systolic) (2854)
57. MeSH DESCRIPTOR Cholesterol EXPLODE ALL TREES (301)
58. MeSH DESCRIPTOR Hypercholesterolemia EXPLODE ALL TREES (149)
59. ((cholesterol or hypercholesterol?emia* or hypercholester?emia*)) (962)
60. MeSH DESCRIPTOR Diabetes Mellitus, Type 2 EXPLODE ALL TREES (0)
61. ((diabetes NEAR2 "type 2") or (diabetes NEAR2 "type II") or (diabetes NEAR2 ("non insulin" or noninsulin)) or NIDDM or T2DM) (890)
62. MeSH DESCRIPTOR Metabolic Syndrome X EXPLODE ALL TREES (34)
63. (((metabolic or dysmetabolic or reaven or insulin resistance) NEAR2 syndrome*)) (88)
64. MeSH DESCRIPTOR Neoplasms EXPLODE ALL TREES (8227)
65. ((cancer* or neoplas* or oncolog* or malignan* or tumo?r* or carcinoma* or adenocarcinoma*)) (9628)
66. #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 OR #56 OR #57 OR #58 OR #59 OR #60 OR #61 OR #62 OR #63 OR #64 OR #65 (22,000)
67. #11 AND #30 AND #39 AND #66 (66)
68. * IN DARE (31,884)
69. #67 AND #68 (56)

Database of Abstracts of Reviews of Effects (Centre for Reviews and Dissemination internal administration database)

7 June 2013. Searched 11 June 2013. Retrieved 149 records.

	Search term	Number retrieved
#1	MeSH DESCRIPTOR Obesity	333
#2	MeSH DESCRIPTOR Overweight	69
#3	MeSH DESCRIPTOR Weight Gain	97
#4	obes* or overweight or over weight or weight gain or weight loss	10,755
#5	MeSH DESCRIPTOR Adiposity	10
#6	MeSH DESCRIPTOR Body Composition	51
#7	MeSH DESCRIPTOR Body Weight	118
#8	adiposity or adipose or fatness	646
#9	(body NEAR2 composition)	438
#10	(body NEAR2 fat) or (body NEAR2 weight)	1634
#11	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10	11,151
#12	MeSH DESCRIPTOR Body Mass Index	126
#13	MeSH DESCRIPTOR Skinfold Thickness	3
#14	MeSH DESCRIPTOR Waist Circumference	13
#15	MeSH DESCRIPTOR Waist-Hip Ratio	2
#16	MeSH DESCRIPTOR Electric Impedance	3
#17	(body mass NEAR3 index*) or (body mass NEAR3 indices) or bmi or quetelet* "fat mass index*" or "fat free mass index*" or adiposity index*	2306
#18	fat mass index* or fat free mass index* or adiposity index*	2
#19	body fat NEAR3 percentage*	16
#20	skinfold or skin fold	62
#21	waist circumference or hip circumference or neck circumference	222
#22	waist-to-hip or waist-hip	112
#23	waist-to-height or waist-height	10
#24	bioelectric* impedance or bioelectric* resistance or electric* impedance or electric* resistance	51
#25	(benn* or rohrer* or ponderal or corpulence) and (index* or indices)	209
#26	infrared interactance or NIR or sagittal abdominal diameter* or supine abdominal diameter*	26
#27	#12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26	2655
#28	MeSH DESCRIPTOR Child	1756
#29	MeSH DESCRIPTOR Infant	582
#30	MeSH DESCRIPTOR Adolescent	1525
#31	MeSH DESCRIPTOR Young Adult	441
#32	child* or infant* or pediat* or paediat* or schoolchild* or school age* or schoolage*	27,579
#33	adolescen* or juvenile* or youth* or teenage* or youngster*	9836
#34	girl or girls or boy or boys or kid or kids	929

Search term	Number retrieved
#35 young people or young person or young persons or young adult*	2092
#36 #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35	31,535
#37 MeSH DESCRIPTOR Cardiovascular Diseases	471
#38 cardiovascular NEAR3 disease*	5050
#39 cardiovascular disease* or cardiovascular disorder* or cardiovascular failure*	4981
#40 cardio disease* or cardio disorder* or cardio failure*	5046
#41 vascular disease* or vascular disorder* or vascular failure*	1097
#42 peripheral disease* or peripheral disorder* or peripheral failure*	7
#43 heart disease* or heart disorder* or heart failure* or heart attack* or heart arrest*	6301
#44 cardiac disease* or cardiac disorder* or cardiac failure* or cardiac attack* or cardiac arrest*	939
#45 myocardial disease* or myocardial disorder* or myocardial failure* or myocardial attack* or myocardial arrest*	14
#46 coronary disease* or coronary disorder* or coronary failure* or coronary attack* or coronary arrest* or coronary syndrome*	2251
#47 ami or mi or angina* or atrial fibril*	5266
#48 MeSH DESCRIPTOR Stroke	554
#49 stroke* or poststroke* or cerebrovascular or cerebral vascular	7127
#50 (brain* or cerebral* or lacunar) NEAR3 (accident* or infarc*)	315
#51 MeSH DESCRIPTOR Hypertension	357
#52 MeSH DESCRIPTOR Blood Pressure	270
#53 hypertens* or blood pressure* or bloodpressure* or diastolic or systolic	8581
#54 MeSH DESCRIPTOR Cholesterol	95
#55 MeSH DESCRIPTOR Hypercholesterolemia	66
#56 cholesterol or hypercholesterol?emia* or hypercholester?emia*	2501
#57 MeSH DESCRIPTOR Diabetes Mellitus, Type 2	424
#58 (diabetes NEAR2 "type 2") or (diabetes NEAR2 "type II") or (diabetes NEAR2 ("non insulin" or noninsulin)) or NIDDM or T2DM	1314
#59 MeSH DESCRIPTOR Metabolic Syndrome X	26
#60 (metabolic or dysmetabolic or reaven or insulin resistance) NEAR2 syndrome*	895
#61 MeSH DESCRIPTOR Neoplasms	584
#62 cancer* or neoplas* or oncolog* or malignan* or tumo?r* or carcinoma* or adenocarcinoma*	31,338
#63 #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 OR #56 OR #57 OR #58 OR #59 OR #60 OR #61 OR #62	55,949
#64 #11 AND #27 AND #36 AND #63	149

MEDLINE and MEDLINE In-Process & Other Non-Indexed Citations (OvidSP)

1946–2013, May week 5. Searched 11 June 2013. Retrieved 687 records in MEDLINE and 27 records in MEDLINE In-Process & Other Non-Indexed Citations.

1. review.ab. (636,359)
2. review.pt. (1,830,463)
3. meta-analysis as topic/ (13,280)
4. meta-analysis.ab. (34,787)
5. meta-analysis.pt. (42,681)
6. meta-analysis.ti. (23,835)
7. or/1-6 (2,076,188)
8. (letter or editorial or comment).pt. (1,197,336)
9. animals/ not humans/ (3,811,795)
10. 7 not (8 or 9) (1,910,614)
11. exp Obesity/ (133,014)
12. Overweight/ (10,556)
13. Weight Gain/ (21,776)
14. Weight Loss/ (22,903)
15. obes\$.ti,ab. (152,384)
16. (overweight or over weight).ti,ab. (32,167)
17. (weight gain or weight loss).ti,ab. (82,180)
18. or/11-17 (267,262)
19. Adiposity/ or Adipose Tissue/ (63,489)
20. exp Body Composition/ (35,563)
21. Body Weight/ (159,038)
22. (adiposity or adipose).ti,ab. (56,647)
23. (body adj2 (composition or fat or weight)).ti,ab. (168,451)
24. fatness.ti,ab. (2834)
25. or/18-24 (541,557)
26. exp child/ (1,510,589)
27. exp Infant/ (916,662)
28. Adolescent/ (1,568,189)
29. Young Adult/ (310,115)
30. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,205,015)
31. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (236,539)
32. (girl or girls or boy or boys or kid or kids).ti,ab. (155,309)
33. (young people or young person or young persons or young adult\$).ti,ab. (67,202)
34. or/26-33 (3,198,543)
35. body mass index/ (75,019)
36. Skinfold Thickness/ (5476)
37. Waist Circumference/ (3842)
38. Waist-Hip Ratio/ (2713)
39. Electric Impedance/ (11,165)
40. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (113,321)
41. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (823)
42. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (343)
43. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (35)
44. (body fat adj2 percentage\$).ti,ab. (3469)
45. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$ or ratio\$)).ti,ab. (4808)
46. ((waist or hip or neck) adj3 circumference\$).ti,ab. (13,184)

47. ((waist-to-hip or waist-hip) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (6364)
48. ((waist-to-height or waist-height) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (522)
49. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (10,288)
50. (near infrared interactance or NIR).ti,ab. (4634)
51. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (999)
52. (sagittal abdominal diameter\$ or supine abdominal diameter\$).ti,ab. (108)
53. or/35-52 (168,981)
54. exp Cardiovascular Diseases/ (1,817,863)
55. ((cardiovascular or cardio or vascular or peripheral) adj3 (disease\$ or disorder\$ or failure\$)).ti,ab. (145,737)
56. ((heart or cardiac or myocardial) adj3 (disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$)).ti,ab. (257,933)
57. (coronary adj3 (disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$ or syndrome\$)).ti,ab. (116,718)
58. (CVD or CHD).ti,ab. (28,240)
59. (myocardial adj3 (infarc\$ or disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$)).ti,ab. (141,002)
60. (ami or mi).ti,ab. (37,701)
61. (circulatory adj3 (disease\$ or disorder\$)).ti,ab. (4164)
62. angina\$.ti,ab. (43,678)
63. atrial fibril\$.ti,ab. (33,386)
64. exp Stroke/ (79,531)
65. (stroke\$ or poststroke\$).ti,ab. (132,480)
66. (cerebrovascular or cerebral vascular).ti,ab. (38,448)
67. ((brain\$ or cerebral\$ or lacunar) adj3 (accident\$ or infarc\$)).ti,ab. (19,623)
68. apoplexy.ti,ab. (2150)
69. CVA.ti,ab. (1653)
70. Hypertension/ (187,947)
71. exp Blood Pressure/ (243,419)
72. hypertens\$.ti,ab. (294,407)
73. (blood pressure\$ or bloodpressure\$).ti,ab. (209,312)
74. (diastolic or systolic).ti,ab. (143,044)
75. Cholesterol/ (102,941)
76. Hypercholesterolemia/ (21,568)
77. cholesterol.ti,ab. (166,494)
78. (hypercholesterol?emia\$ or hypercholester?emia\$).ti,ab. (21,597)
79. or/54-78 (2,328,244)
80. Diabetes Mellitus, Type 2/ (81,449)
81. (diabetes adj2 type 2).ti,ab. (56,501)
82. (diabetes adj2 type II).ti,ab. (5757)
83. (diabetes adj2 (non insulin or noninsulin)).ti,ab. (9422)
84. (NIDDM or T2DM).ti,ab. (11,346)
85. Metabolic Syndrome X/ (17,954)
86. ((metabolic or dysmetabolic or reaven or insulin resistance) adj2 syndrome\$).ti,ab. (25,583)
87. or/80-86 (122,953)
88. exp Neoplasms/ (2,503,418)
89. cancer\$.ti,ab. (983,533)
90. (neoplas\$ or oncolog\$ or malignan\$ or tumo?r\$ or carcinoma\$ or adenocarcinoma\$).ti,ab. (1,593,573)
91. or/88-90 (2,907,785)
92. 79 or 87 or 91 (5,088,112)
93. 10 and 25 and 34 and 53 and 92 (687)

PubMed (National Library of Medicine)

1946–11 June 2013. Searched 11 June 2013. Retrieved 174 records.

#51 Search (#1 AND #10 AND #16 AND #29 AND #50) (174)

#50 Search (#41 or #46 or #49) (5,156,219)

#49 Search (#47 or #48) (2,973,617)

#48 Search cancer*[tiab] or neoplas*[tiab] or oncolog*[tiab] or malignan*[tiab] or tumour*[tiab] or tumor*[tiab] or carcinoma* [tiab] or adenocarcinoma*[tiab] (2,088,303)

#47 Search "Neoplasms"[Mesh] (2,448,239)

#46 Search (#42 or #43 or #44 or #45) (105,866)

#45 Search metabolic syndrome*[tiab] or dysmetabolic syndrome*[tiab] or reaven syndrome*[tiab] or insulin resistance syndrome*[tiab] (26,957)

#44 Search "Metabolic Syndrome X"[Mesh] (16,908)

#43 Search diabetes type 2[tiab] or diabetes type II[tiab] or diabetes non insulin[tiab] or diabetes noninsulin [tiab] or NIDDM [tiab] or T2DM[tiab] (12,728)

#42 Search "Diabetes Mellitus, Type 2"[Mesh] (77,427)

#41 Search (#30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40) (2,333,774)

#40 Search cholesterol[tiab] or hypercholesterolaemia*[tiab] or hypercholesteraemia*[tiab] or hypercholesterolemia*[tiab] or hypercholesteremia*[tiab] (183,386)

#39 Search "Cholesterol"[Mesh] or "Hypercholesterolemia"[Mesh] (141,654)

#38 Search hypertens*[tiab] or blood pressure*[tiab] or bloodpressure*[tiab] or diastolic[tiab] or systolic [tiab] (503,837)

#37 Search "Hypertension"[Mesh] or "Blood Pressure"[Mesh] (386,155)

#36 Search stroke*[tiab] or poststroke*[tiab] or cerebrovascular[tiab] or cerebral vascular[tiab] or brain* accident*[tiab] or cerebral* accident*[tiab] or lacunar accident*[tiab] or cerebral infarc*[tiab] or brain* infarc*[tiab] or cerebral* infarc*[tiab] or lacunar infarc*[tiab] or apoplexy[tiab] or CVA[tiab] (44,293)

#35 Search "Stroke"[Mesh] (76,757)

#34 Search CVD[tiab] or CHD[tiab] or ami[tiab] or mi[tiab] or angina*[tiab] or atrial fibril*[tiab] (144,210)

#33 Search coronary disease*[tiab] or coronary disorder*[tiab] or coronary failure*[tiab] or coronary attack*[tiab] or coronary arrest*[tiab] or coronary syndrome*[tiab] (53,502)

#32 Search heart disease*[tiab] or cardiac disease*[tiab] or myocardial disease*[tiab] or heart disorder*[tiab] or cardiac disorder*[tiab] or myocardial disorder*[tiab] or heart failure*[tiab] or cardiac failure*[tiab] or myocardial failure*[tiab] or heart failure*[tiab] or cardiac failure*[tiab] or myocardial failure*[tiab] or heart attack*[tiab] or cardiac attack*[tiab] or myocardial attack*[tiab] or heart attack*[tiab] or cardiac attack*[tiab] or myocardial attack*[tiab] or heart arrest*[tiab] or cardiac arrest*[tiab] or myocardial arrest*[tiab] or heart arrest*[tiab] or cardiac arrest*[tiab] or myocardial arrest*[tiab] (252,579)

#31 Search cardiovascular disease*[tiab] or cardio disease*[tiab] or vascular disease*[tiab] or peripheral disease*[tiab] or cardiovascular disorder*[tiab] or cardio disorder*[tiab] or vascular disorder*[tiab] or peripheral disorder*[tiab] or cardiovascular failure*[tiab] or cardio failure*[tiab] or vascular failure*[tiab] or peripheral failure*[tiab] (272,760)

#30 Search "Cardiovascular Diseases"[Mesh] (1,788,644)

#29 Search (#17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28) (168,726)

#28 Search "bioelectric impedance"[tiab] or "bioelectrical impedance"[tiab] or "electric impedance"[tiab] or "electrical impedance"[tiab] or "bioelectric resistance"[tiab] or "bioelectrical resistance"[tiab] or "electric resistance"[tiab] or "electrical resistance"[tiab] or bia[tiab] (10,600)

#27 Search "waist-to-height ratio"[tiab] or "waist-to-height ratios"[tiab] or "waist-height ratio"[tiab] or "waist-height ratios"[tiab] (600)

#26 Search "waist-to-hip ratio"[tiab] or "waist-to-hip ratios"[tiab] or "waist-hip ratio"[tiab] or "waist-hip ratios"[tiab] (6377)

#25 Search "waist circumference"[tiab] or "hip circumference"[tiab] or "neck circumference"[tiab] (13,577)

#24 Search ("skinfold thickness"[tiab] or "skinfold test"[tiab] or "skinfold tests"[tiab] or "skinfold measure"[tiab] or "skinfold measurement"[tiab] or "skinfold measures"[tiab] or "skinfold measurements"[tiab]) (3357)

#23 Search ("skin fold thickness"[tiab] or "skin fold test"[tiab] or "skin fold tests"[tiab] or "skin fold measure"[tiab] or "skin fold measurement"[tiab] or "skin fold measures"[tiab] or "skin fold measurements"[tiab]) (658)

#22 Search (("body fat percentage"[tiab] or "body fat percentages"[tiab])) (1222)

#21 Search "body adiposity index"[tiab] or "body adiposity indices"[tiab] or "body adiposie index"[tiab] or "body adipose indices"[tiab] (47)

#20 Search ("fat free mass index"[tiab] or "fat free mass indices"[tiab] or ffm[tiab]) (248)

#19 Search "fat mass index"[tiab] or "fat mass indices"[tiab] or fmi[tiab] (434)

#18 Search ("body mass index"[tiab] or "body mass indices"[tiab] or bmi[tiab] or quetelet*[tiab]) (119,706)

#17 Search (((("Body Mass Index"[Mesh]) OR "Skinfold Thickness"[Mesh]) OR "Waist Circumference"[Mesh]) OR "Waist-Hip Ratio"[Mesh]) OR "Electric Impedance"[Mesh] (86,627)

#16 Search (#11 OR #12 OR #13 OR #14 OR #15) (3,221,920)

#15 Search “young people”[tiab] or “young person”[tiab] or “young persons”[tiab] or young adult* [tiab] (69,376)

#14 Search girl[tiab] or girls[tiab] or boy[tiab] or boys[tiab] or kid[tiab] or kids[tiab] (163,334)

#13 Search adolescen*[tiab] or juvenile*[tiab] or youth*[tiab] or teenage*[tiab] or youngster* [tiab] (248,889)

#12 Search child*[tiab] or infant*[tiab] or pediat*[tiab] or paediat*[tiab] or schoolchild*[tiab] or school age*[tiab] or schoolage*[tiab] (1,254,419)

#11 Search (((“Child”[Mesh]) OR “Infant”[Mesh]) OR “Adolescent”[Mesh]) OR “Young Adult”[Mesh] (2,849,606)

#10 Search (#7 OR #8 OR #9) (583,003)

#9 Search adiposity[tiab] or adipose[tiab] or “body composition”[tiab] or “body fat”[tiab] or “body weight”[tiab] or fatness[tiab] (216,116)

#8 Search (((“Adiposity”[Mesh]) OR “Adipose Tissue”[Mesh]) OR “Body Composition”[Mesh]) OR “Body Weight”[Mesh] (386,174)

#7 Search (#2 OR #3 OR #4 OR #5 OR #6) (281,116)

#6 Search “weight gain”[tiab] or “weight loss”[tiab] (86,556)

#5 Search overweight[tiab] or “over weight*”[tiab] (34,320)

#4 Search obes*[tiab] (160,601)

#3 Search ((“Overweight”[Mesh]) OR “Weight Gain”[Mesh]) OR “Weight Loss”[Mesh] (160,439)

#2 Search “Obesity”[Mesh] (127,351)

#1 Search ((systematic review [ti] OR meta-analysis [pt] OR meta-analysis [ti] OR systematic literature review [ti] OR (systematic review [tiab] AND review [pt]) OR consensus development conference [pt] OR practice guideline [pt] OR cochrane database syst rev [ta] OR acp journal club [ta] OR health technol assess [ta] OR evid rep technol assess summ [ta] OR drug class reviews [ti] OR (clinical guideline [tw] AND management [tw]) OR ((evidence based[ti] OR evidence-based medicine [mh] OR best practice* [ti] OR evidence synthesis [tiab]) AND (review [pt] OR diseases category[mh] OR behavior and behavior mechanisms [mh] OR therapeutics [mh] OR evaluation studies[pt] OR validation studies[pt] OR guideline [pt] OR pmcbook)) OR ((systematic [tw] OR systematically [tw] OR critical [tiab] OR (study selection [tw]) OR (predetermined [tw] OR inclusion [tw] AND criteri* [tw]) OR exclusion criteri* [tw] OR main outcome measures [tw] OR standard of care [tw] OR standards of care [tw]) AND (survey [tiab] OR surveys [tiab] OR overview* [tw] OR review [tiab] OR reviews [tiab] OR search* [tw] OR handsearch [tw] OR analysis [tiab] OR critique [tiab] OR appraisal [tw] OR (reduction [tw]AND (risk [mh] OR risk [tw]) AND (death OR recurrence))) AND (literature [tiab] OR articles [tiab] OR publications [tiab] OR publication [tiab] OR bibliography [tiab] OR bibliographies [tiab] OR published [tiab] OR unpublished [tw] OR citation [tw] OR citations [tw] OR database [tiab] OR internet [tiab] OR textbooks [tiab] OR references [tw] OR scales [tw] OR papers [tw] OR datasets [tw] OR trials [tiab] OR meta-analy* [tw] OR (clinical [tiab] AND studies [tiab]) OR treatment outcome [mh] OR treatment outcome [tw] OR pmcbook)) NOT (letter [pt] OR newspaper article [pt] OR comment [pt])) (206,739)

Database of Promoting Health Effectiveness Reviews (Evidence for Policy and Practice Information and Co-ordinating Centre)

12 June 2013. Searched 12 June 2013. Retrieved 13 records.

1. Freetext: "obes*" OR overweight OR "over weight" OR "weight gain" OR "weight loss" (429)
2. Freetext: adiposity OR adipose OR fatness OR "body composition" or "body fat" or "body weight" (93)
3. 1 OR 2 (348)
4. Freetext: "body mass index*" OR "body mass indices" OR bmi OR quetelet* (85)
5. Freetext: "fat mass" NEAR "index*" OR "fat mass" NEAR "indices*" OR fmi (1)
6. Freetext: "fat free mass" NEAR "index*" OR "fat free mass" NEAR "indices*" OR ffm (1)
7. Freetext: "body adipos*" NEAR "index*" OR "body adipos*" NEAR "indices*" (1)
8. Freetext: "body fat" NEAR "percentage*" (11)
9. Freetext: "skin fold" or skinfold (10)
10. Freetext: "waist" NEAR "circumference*" OR "hip" NEAR "circumference*" OR "neck" NEAR "circumference*" (6)
11. Freetext: "waist-to-hip" OR "waist-hip" OR "waist-to-height" OR "waist-height" (4)
12. Freetext: "bioelectric*" NEAR "impedance" OR "electric*" NEAR "impedance" OR "bioelectric*" NEAR "resistance" OR "electric*" NEAR "resistance" (2)
13. Freetext: "benn*" NEAR "index*" OR "rohrer*" NEAR "index*" OR "ponderal" NEAR "index*" OR "corpulence" NEAR "index*" OR "benn*" NEAR "indices*" OR "rohrer*" NEAR "indices*" OR "ponderal" NEAR "indices*" OR "corpulence" NEAR "indices*" (2)
14. Freetext: "infrared interactance" OR NIR OR "sagittal abdominal diameter*" OR "supine abdominal diameter*" (0)
15. 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 (87)
16. Freetext: cardiovascular OR cardio OR vascular OR peripheral OR heart OR cardiac OR myocardial OR coronary OR circulatory OR CVD OR CHD OR AMI OR MI OR "angina*" OR atrial (239)
17. Freetext: "stroke*" OR "poststroke*" OR cerebrovascular OR "cerebral vascular" (21)
18. Freetext: "brain*" NEAR "accident*" OR "cerebral*" NEAR "accident*" OR "lacunar" NEAR "accident*" OR "brain*" NEAR "infarc*" OR "cerebral*" NEAR "infarc*" OR "lacunar" NEAR "infarc*" OR apoplexy OR CVA (1)
19. Freetext: "hypertens*" OR "blood pressure*" OR "bloodpressure*" OR diastolic OR systolic (114)
20. Freetext: cholesterol OR "hypercholesterolemia*" OR "hypercholesterolaemia*" OR "hypercholesteremia*" OR "hypercholesteremia*" (58)
21. Freetext: diabetes OR NIDDM OR "T2DM" (113)
22. Freetext: "metabolic" NEAR "syndrome*" OR "dysmetabolic" NEAR "syndrome*" OR "reaven" NEAR "syndrome*" OR "insulin resistance" NEAR "syndrome*" (9)
23. Freetext: "cancer*" OR "neoplas*" OR "oncolog*" OR "malignan*" OR "tumor*" OR "tumour*" OR "carcinoma*" OR "adenocarcinoma*" (180)
24. 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 (501)
25. 3 AND 15 AND 24 (40)
26. Freetext: "child*" OR "infant*" OR "pediat*" OR "paediat*" OR "schoolchild*" OR "school age*" OR "schoolage*" OR "adolescen*" OR "juvenile*" OR "youth*" OR "teenage*" OR "youngster*" OR girl OR girls OR boy OR boys OR kid OR kids OR "young people" OR "young person" OR "young persons" OR "young adult*" (1249)
27. 25 AND 26 (13)

Internet sites searched

Organisation websites were browsed (publications and/or research) and searched. Searches were conducted in June 2013.

Public Health England – Obesity Knowledge and Intelligence (previously National Obesity Observatory) (www.noo.org.uk/)

Association for the Study of Obesity (www.aso.org.uk/)

Obesity Learning Centre (www.obesitylearningcentre.org.uk/)

National Obesity Forum (www.nationalobesityforum.org.uk/)

British Dietetic Association (www.bda.uk.com/index.html)

CEDAR (www.cedar.iph.cam.ac.uk/)

The Nutrition Society (www.nutritionociety.org/)

International Association for the Study of Obesity (www.iaso.org/)

EASO (www.easoobesity.org/)

European Congress on Obesity (www.easo.org/eco2013)

ECOG (www.ecog-obesity.eu/)

CDC Division of Nutrition, Physical Activity, and Obesity (USA) (www.cdc.gov/nccdphp/dnpao/index.html)

Weight-control Information Network (USA) (<http://win.niddk.nih.gov/>)

The Obesity Society (USA) (www.obesity.org/)

myhealthywaist.org (International Chair on Cardiometabolic Risk of Université Laval – Quebec, Canada) (www.myhealthywaist.org/)

Citation searches: Web of Science and Google Scholar

1. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obesity Reviews* 2008 9(5):474-88.

WoS: 210 records (database updated 12 June 2013; searched 13 June 2013)

Google Scholar: 391 records (13 June 2013)

2. Falaschetti E, Hingorani AD, Jones A, Charakida M, Finer N, Whincup P, Lawlor DA, Davey Smith G, Sattar N, Deanfield JE. Adiposity and cardiovascular risk factors in a large contemporary population of pre-pubertal children. *European Heart Journal* 2010;31(24):3063-72.

WoS: 18 records (database updated 19 June 2013; searched 21 June 2013)

Google Scholar: 30 records (21 June 2013)

3. Okorodudu DO, Jumean MF, Montori VM, Romero-Corral A, Somers VK, Erwin PJ, Lopez-Jimenez F. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. *International Journal of Obesity* 2010;34(5):791-9.

WoS: 52 records (database updated 19 June 2013; searched 21 June 2013)

Google Scholar: 99 records (21 June 2013)

4. Nimptsch K, Giovannucci E, Willett WC, Fuchs CS, Wei EK, Wu K. Body fatness during childhood and adolescence, adult height, and risk of colorectal adenoma in women. *Cancer Prevention Research (Philadelphia, PA)* 2011;4(10):1710-8.

WoS: 3 records (database updated 21 June 2013; searched 24 June 2013)

Google Scholar: 5 records (24 June 2013)

5. Cameron AJ, Magliano DJ, Söderberg S. A systematic review of the impact of including both waist and hip circumference in risk models for cardiovascular diseases, diabetes and mortality. *Obesity Reviews* 2013;14(1):86-94.

WoS: 0 records (database updated 21 June 2013; searched 24 June 2013)

Google Scholar: 1 record (24 June 2013)

6. Clarke WR, Lauer RM. Does childhood obesity track into adulthood? *Critical Reviews in Food Science and Nutrition* 1993;33(4-5):423-30.

WoS: 110 records (database updated 21 June 2013; searched 24 June 2013)

Google Scholar: 152 records (24 June 2013)

7. Liddle K, O'Callaghan M, Mamun A, Najman J, Williams G. Comparison of body mass index and triceps skinfold at 5 years and young adult body mass index, waist circumference and blood pressure. *Journal of Paediatrics and Child Health* 2012;48(5):424-9.

WoS: 0 records (database updated 21 June 2013; searched 24 June 2013)

Google Scholar: 0 records (24 June 2013)

8. Freedman DS, Ogden CL, Blanck HM, Borrud LG, Dietz WH. The Abilities of Body Mass Index and Skinfold Thicknesses to Identify Children with Low or Elevated Levels of Dual-Energy X-Ray Absorptiometry-Determined Body Fatness. *Journal of Pediatrics* 2013 Feb 11. pii: S0022-3476(13)00005-X. [Epub ahead of print].

WoS: 0 records (database updated 21 June 2013; searched 24 June 2013)

Google Scholar: 1 record (24 June 2013)

9. Franks PW, Hanson RL, Knowler WC, Sievers ML, Bennett PH, Looker HC. Childhood obesity, other cardiovascular risk factors, and premature death. *New England Journal of Medicine* 2010;11;362(6):485-93.

WoS: 180 records (database updated 21 June 2013; searched 24 June 2013)

Google Scholar: 344 records (24 June 2013)

10. Freedman DS, Mei Z, Srinivasan SR, Berenson GS, Dietz WH. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. *Journal of Pediatrics* 2007;150(1):12-17.e2.

WoS: 30 records (database updated 21 June 2013; searched 25 June 2013)

Google Scholar: 491 records (25 June 2013)

11. Conway JM, Norris KH, Bodwell CE. A new approach for the estimation of body composition: infrared interactance. *American Journal of Clinical Nutrition* 1984;40(6):1123-30.

WoS: 221 records (database updated 21 June 2013; searched 25 June 2013)

Google Scholar: 306 records (25 June 2013)

12. Freedman DS, Kahn HS, Mei Z, Grummer-Strawn LM, Dietz WH, Srinivasan SR, Berenson GS. Relation of body mass index and waist-to-height ratio to cardiovascular disease risk factors in children and adolescents: the Bogalusa Heart Study. *American Journal of Clinical Nutrition* 2007;86(1):33-40.

WoS: 81 records (database updated 21 June 2013; searched 26 June 2013)

Google Scholar: 161 records (26 June 2013)

13. Goldhaber-Fiebert JD, Rubinfeld RE, Bhattacharya J, Robinson TN, Wise PH. The utility of childhood and adolescent obesity assessment in relation to adult health. *Medical Decision Making* 2013;33(2):163-75.

WoS: 1 record (database updated 21 June 2013; searched 26 June 2013)

Google Scholar: 2 records (26 June 2013)

14. Gunnell DJ, Frankel SJ, Nanchahal K, Peters TJ, Davey Smith G. Childhood obesity and adult cardiovascular mortality: a 57-y follow-up study based on the Boyd Orr cohort. *American Journal of Clinical Nutrition* 1998;67(6):1111-8.

WoS: 232 records (database updated 21 June 2013; searched 26 June 2013)

Google Scholar: 453 records (26 June 2013)

15. Fayter D, Nixon J, Hartley S, Rithalia A, Butler G, Rudolf M, Glasziou P, Bland M, Stirk L, Westwood M. A systematic review of the routine monitoring of growth in children of primary school age to identify growth-related conditions. *Health Technology Assessment* 2007;11(22):1-163.

WoS: 8 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 23 records (27 June 2013)

16. Juonala M, Magnussen CG, Berenson GS, Venn A, Burns TL, Sabin MA, Srinivasan SR, Daniels SR, Davis PH, Chen W, Sun C, Cheung M, Viikari JS, Dwyer T, Raitakari OT. Childhood adiposity, adult adiposity, and cardiovascular risk factors. *New England Journal of Medicine* 2011;365(20):1876-85.

WoS: 73 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 136 records (27 June 2013)

17. Lazarus R, Baur L, Webb K, Blyth F. Body mass index in screening for adiposity in children and adolescents: systematic evaluation using receiver operating characteristic curves. *American Journal of Clinical Nutrition* 1996;63(4):500-6.

WoS: 77 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 154 records (27 June 2013)

18. Li L, Law C, Power C. Body mass index throughout the life-course and blood pressure in mid-adult life: a birth cohort study. *Journal of Hypertension* 2007;25(6):1215-23.

WoS: 32 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 42 records (27 June 2013)

19. Li L, Hardy R, Kuh D, Lo Conte R, Power C. Child-to-adult body mass index and height trajectories: a comparison of 2 British birth cohorts. *American Journal of Epidemiology* 2008;168(9):1008-15.

WoS: 17 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 23 records (27 June 2013)

20. Lloyd LJ, Langley-Evans SC, McMullen S. Childhood obesity and adult cardiovascular disease risk: a systematic review. *International Journal of Obesity (London)* 2010;34(1):18-28.

WoS: 22 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 55 records (27 June 2013)

21. Lloyd LJ, Langley-Evans SC, McMullen S. Childhood obesity and risk of the adult metabolic syndrome: a systematic review. *Journal of Obesity (London)* 2012;36(1):1-11.

WoS: 10 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 21 records (27 June 2013)

22. Mei Z, Grummer-Strawn LM, Pietrobelli A, Goulding A, Goran MI, Dietz WH. Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. *American Journal of Clinical Nutrition* 2002;75(6):978-85.

WoS: 240 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 541 records (27 June 2013)

23. Nichols J, Going S, Loftin M, Stewart D, Nowicki E, Pickrel J. Comparison of two bioelectrical impedance analysis instruments for determining body composition in adolescent girls. *International Journal of Body Composition Research* 2006;4(4):153-160.

WoS: 6 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 11 records (27 June 2013)

24. Nooyens AC, Koppes LL, Visscher TL, Twisk JW, Kemper HC, Schuit AJ, van Mechelen W, Seidell JC. Adolescent skinfold thickness is a better predictor of high body fatness in adults than is body mass index: the Amsterdam Growth and Health Longitudinal Study. *American Journal of Clinical Nutrition* 2007;85(6):1533-9.

WoS: 33 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 49 records (27 June 2013)

25. Park MH, Falconer C, Viner RM, Kinra S. The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. *Obesity Reviews* 2012;13(11):985-1000.

WoS: 7 records (database updated 26 June 2013; searched 27 June 2013)

Google Scholar: 20 records (27 June 2013)

26. Power C, Lake JK, Cole TJ. Measurement and long-term health risks of child and adolescent fatness. *International Journal of Obesity and Related Metabolic Disorders* 1997;21(7):507-26.

WoS: 354 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 619 records (28 June 2013)

27. Power C, Thomas C. Changes in BMI, duration of overweight and obesity, and glucose metabolism: 45 years of follow-up of a birth cohort. *Diabetes Care* 2011;34(9):1986-91.

WoS: 8 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 13 records (28 June 2013)

28. Reilly JJ, Kelly J, Wilson DC. Accuracy of simple clinical and epidemiological definitions of childhood obesity: systematic review and evidence appraisal. *Obesity Reviews* 2010;11(9):645-55.

WoS: 20 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 35 records (28 June 2013)

29. Sardinha LB, Going SB, Teixeira PJ, Lohman TG. Receiver operating characteristic analysis of body mass index, triceps skinfold thickness, and arm girth for obesity screening in children and adolescents. *American Journal of Clinical Nutrition* 1999;70(6):1090-5.

WoS: 93 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 197 records (28 June 2013)

30. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Preventive Medicine* 1993;22(2):167-77.

WoS: 706 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 1367 records (28 June 2013)

31. Thomas C, Hyppönen E, Power C. Obesity and type 2 diabetes risk in midadult life: the role of childhood adversity. *Pediatrics* 2008 May;121(5):e1240-9.

WoS: 57 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 95 records (28 June 2013)

32. Wright CM, Parker L, Lamont D, Craft AW. Implications of childhood obesity for adult health: findings from thousand families cohort study. *BMJ* 2001;323(7324):1280-4.

WoS: 155 records (database updated 26 June 2013; searched 28 June 2013)

Google Scholar: 298 records (28 June 2013)

Review of adult morbidities: search for additional primary studies

MEDLINE and MEDLINE In-Process & Other Non-Indexed Citations (OvidSP)

1946–2013, September week 4. Searched 4 October 2013. Retrieved 2484 records in MEDLINE and 301 records in MEDLINE In-Process & Other Non-Indexed Citations.

1. exp *Obesity/ (99,951)
2. *Overweight/ (7376)
3. *Adiposity/ (2824)
4. obes\$.ti,ab. (164,847)
5. (overweight or over weight).ti,ab. (35,402)
6. adiposity.ti,ab. (13,484)
7. or/1-6 (196,646)
8. exp child/ or exp Infant/ or Adolescent/ (2,882,142)
9. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,253,562)
10. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (250,426)
11. (girl or girls or boy or boys or kid or kids).ti,ab. (161,260)
12. or/8-11 (3,152,555)
13. *body mass index/ (12,267)
14. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (123,839)
15. 13 or 14 (125,030)
16. *Skinfold Thickness/ (866)
17. *Waist Circumference/ (1108)
18. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$ or ratio\$)).ti,ab. (5000)
19. (waist adj3 circumference\$).ti,ab. (14,012)
20. or/16-19 (18,848)
21. *Waist-Hip Ratio/ or *Electric Impedance/ (2810)
22. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (915)
23. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (370)
24. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (41)
25. ((hip or neck) adj3 circumference\$).ti,ab. (3136)
26. ((waist-to-hip or waist-hip) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (6774)
27. ((waist-to-height or waist-height) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (601)
28. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (11,001)
29. (near infrared interactance or NIR).ti,ab. (5084)
30. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (1030)
31. (sagittal abdominal diameter\$ or supine abdominal diameter\$).ti,ab. (120)
32. or/21-31 (27,437)
33. exp *Cardiovascular Diseases/ (1,575,263)
34. exp *Stroke/ (63,420)
35. *Hypertension/ (139,094)
36. *Hypercholesterolemia/ or *Dyslipidemias/ (17,458)
37. ((cardiovascular or cardio or vascular or peripheral) adj3 (disease\$ or disorder\$ or failure\$)).ti,ab. (156,163)
38. ((heart or cardiac or myocardial) adj3 (disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$)).ti,ab. (270,179)
39. (coronary adj3 (disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$ or syndrome\$)).ti,ab. (121,849)
40. (CVD or CHD or IHD).ti,ab. (34,257)
41. (myocardial adj3 (infarc\$ or disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$)).ti,ab. (146,283)

42. (ami or mi).ti,ab. (39,951)
43. (circulatory adj3 (disease\$ or disorder\$)).ti,ab. (4271)
44. angina\$.ti,ab. (44,684)
45. atrial fibril\$.ti,ab. (35,395)
46. (stroke\$ or poststroke\$).ti,ab. (141,434)
47. (cerebrovascular or cerebral vascular).ti,ab. (40,112)
48. ((brain\$ or cerebral\$ or lacunar) adj3 (accident\$ or infarc\$)).ti,ab. (20,320)
49. hypertens\$.ti,ab. (306,843)
50. high blood pressure.ti,ab. (10,087)
51. high cholesterol.ti,ab. (4917)
52. (hypercholesterol?emia\$ or hypercholester?emia\$).ti,ab. (22,466)
53. (dyslipid?emia\$ or dyslipoprotein?emias\$).ti,ab. (17,481)
54. or/33-53 (1,910,195)
55. *Diabetes Mellitus, Type 2/ (69,067)
56. *Metabolic Syndrome X/ (15,189)
57. (diabetes adj2 type 2).ti,ab. (61,812)
58. (diabetes adj2 type II).ti,ab. (6078)
59. (diabetes adj2 (non insulin or noninsulin)).ti,ab. (9514)
60. (NIDDM or T2DM or T2D).ti,ab. (14,261)
61. ((metabolic or dysmetabolic or reaven or insulin resistance) adj2 syndrome\$).ti,ab. (27,945)
62. or/55-61 (121,005)
63. exp *Neoplasms/ (2,243,426)
64. cancer\$.ti,ab. (1,054,643)
65. (neoplas\$ or oncolog\$ or malignan\$ or tumor?r\$ or carcinoma\$ or adenocarcinoma\$).ti,ab. (1,673,022)
66. or/63-65 (2,819,554)
67. exp Animals/ not Humans/ (4,058,478)
68. (comment or editorial or letter).pt. (1,245,317)
69. 67 or 68 (5,253,117)
70. 7 and 12 and 15 and (54 or 62 or 66) (5576)
71. 70 not 69 (5547)
72. (2011\$ or 2012\$ or 2013\$).ed,dc,ep. (2,547,833)
73. 71 and 72 (1862)
74. 7 and 12 and 20 and (54 or 62) (1542)
75. 74 not 69 (1538)
76. (2008\$ or 2009\$ or 2010\$ or 2011\$ or 2012\$ or 2013\$).ed,dc,ep. (5,017,455)
77. 75 and 76 (1076)
78. 7 and 12 and 20 and 66 (128)
79. 78 not 69 (128)
80. 7 and 12 and 32 and (54 or 62 or 66) (817)
81. 80 not 69 (812)
82. 73 or 77 or 79 or 81 (2980)

NB: After removal of duplicate records, the final total was 2484.

EMBASE (OvidSP)

1974–2013, week 39. Searched 4 October 2013. Retrieved 3405 records.

1. exp *obesity/ (154,266)
2. obes\$.ti,ab. (229,244)
3. (overweight or over weight).ti,ab. (50,550)
4. adiposity.ti,ab. (17,157)
5. or/1-4 (282,623)
6. child/ or preschool child/ or infant/ or adolescent/ (2,386,317)
7. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,602,771)
8. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (320,105)
9. (girl or girls or boy or boys or kid or kids).ti,ab. (215,455)
10. or/6-9 (3,051,058)
11. *body mass/ (13,758)
12. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (191,016)
13. 11 or 12 (192,700)
14. *skinfold thickness/ (877)
15. *waist circumference/ (1514)
16. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$ or ratio\$)).ti,ab. (6057)
17. (waist adj3 circumference\$).ti,ab. (21,661)
18. or/14-17 (27,483)
19. *waist hip ratio/ or *waist to height ratio/ or *weight height ratio/ or *neck circumference/ (543)
20. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (1254)
21. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (537)
22. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (83)
23. ((hip or neck) adj3 circumference\$).ti,ab. (4655)
24. ((waist-to-hip or waist-hip) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (9084)
25. ((waist-to-height or waist-height) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (929)
26. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (14,541)
27. (near infrared interactance or NIR).ti,ab. (6862)
28. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (1246)
29. (sagittal abdominal diameter\$ or supine abdominal diameter\$).ti,ab. (146)
30. or/19-29 (35,697)
31. exp *cardiovascular disease/ (2,055,464)
32. exp *cerebrovascular accident/ (31,720)
33. *hypertension/ (187,647)
34. *hypercholesterolemia/ or *dyslipidemia/ (26,658)
35. ((cardiovascular or cardio or vascular or peripheral) adj3 (disease\$ or disorder\$ or failure\$)).ti,ab. (213,224)
36. ((heart or cardiac or myocardial) adj3 (disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$)).ti,ab. (376,201)
37. (coronary adj3 (disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$ or syndrome\$)).ti,ab. (171,524)
38. (CVD or CHD or IHD).ti,ab. (49,922)
39. (myocardial adj3 (infarc\$ or disease\$ or disorder\$ or failure\$ or attack\$ or arrest\$)).ti,ab. (198,567)
40. (ami or mi).ti,ab. (62,188)
41. (circulatory adj3 (disease\$ or disorder\$)).ti,ab. (5203)
42. angina\$.ti,ab. (60,695)
43. atrial fibril\$.ti,ab. (57,424)
44. (stroke\$ or poststroke\$).ti,ab. (205,519)
45. (cerebrovascular or cerebral vascular).ti,ab. (55,507)
46. ((brain\$ or cerebral\$ or lacunar) adj3 (accident\$ or infarc\$)).ti,ab. (29,059)
47. hypertens\$.ti,ab. (426,356)

48. high blood pressure.ti,ab. (14,098)
49. high cholesterol.ti,ab. (6446)
50. (hypercholesterol?emia\$ or hypercholester?emia\$).ti,ab. (30,335)
51. (dyslipid?emia\$ or dyslipoprotein?emias\$).ti,ab. (27,695)
52. or/31-51 (2,547,699)
53. *non insulin dependent diabetes mellitus/ (81,799)
54. *metabolic syndrome X/ (23,897)
55. (diabetes adj2 type 2).ti,ab. (90,512)
56. (diabetes adj2 (non insulin or noninsulin)).ti,ab. (11,127)
57. (NIDDM or T2DM or T2D).ti,ab. (22,350)
58. ((metabolic or dysmetabolic or reaven or insulin resistance) adj2 syndrome\$).ti,ab. (43,565)
59. or/53-58 (165,434)
60. exp *neoplasm/ (2,652,219)
61. cancer\$.ti,ab. (1,389,393)
62. (neoplas\$ or oncolog\$ or malignan\$ or carcinoma\$ or adenocarcinoma\$).ti,ab. (1,302,882)
63. or/60-62 (3,268,818)
64. (editorial or letter or note).pt. (1,885,479)
65. 5 and 10 and 13 and (52 or 59 or 63) (6295)
66. 65 not 64 (6277)
67. (2011\$ or 2012\$ or 2013\$).em. (3,692,841)
68. 66 and 67 (2498)
69. 5 and 10 and 18 and (52 or 59) (1997)
70. 69 not 64 (1992)
71. (2008\$ or 2009\$ or 2010\$ or 2011\$ or 2012\$ or 2013\$).em. (6,973,364)
72. 70 and 71 (1525)
73. 5 and 10 and 18 and 63 (76)
74. 73 not 64 (76)
75. 5 and 10 and 30 and (52 or 59 or 63) (845)
76. 75 not 64 (843)
77. 68 or 72 or 74 or 76 (3802)
78. limit 77 to human (3405)

Science Citation Index (Web of Science)

1900–1 October 2013. Searched 4 October 2013. Retrieved 3025 records.

Search term	Number retrieved
# 32 #25 or #26 or #29 or #31 Databases=SCI-EXPANDED Timespan=All years	3025
# 31 #30 not #23 Databases=SCI-EXPANDED Timespan=All years	882
# 30 #1 and #2 and #5 and (#16 or #21 or #22) Databases=SCI-EXPANDED Timespan=All years	898
# 29 #28 not #23 Databases=SCI-EXPANDED Timespan=All years	73
# 28 #1 and #2 and #4 and #22 Databases=SCI-EXPANDED Timespan=All years	75
# 27 #26 not #23 Databases=SCI-EXPANDED Timespan=2008-2013	1165
# 26 #1 and #2 and #4 and (#16 or #21) Databases=SCI-EXPANDED Timespan=All years	1623
# 25 #24 not #23 Databases=SCI-EXPANDED Timespan=2011-2013	1809
# 24 #1 and #2 and #3 and (#16 or #21 or #22) Databases=SCI-EXPANDED Timespan=All years	5340
# 23 (TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or pig or pigs or cats or bovine or cow or sheep or ovine or porcine or monkey)) Databases=SCI-EXPANDED Timespan=All years	3,694,533
# 22 (TS=(cancer* or neoplas* or oncolog* or malignan* or carcinoma* or adenocarcinoma*)) Databases=SCI-EXPANDED Timespan=All years	1,773,464
# 21 (#17 or #18 or #19 or #20) Databases=SCI-EXPANDED Timespan=All years	128,589
# 20 TS=((metabolic or dysmetabolic or reaven or "insulin resistance") NEAR/2 syndrome*) Databases=SCI-EXPANDED Timespan=All years	48,002
# 19 TS=(NIDDM or T2DM or T2D)) Databases=SCI-EXPANDED Timespan=All years	18,476
# 18 TS=(diabetes NEAR/2 ("non insulin" or noninsulin)) Databases=SCI-EXPANDED Timespan=All years	8853
# 17 TS=(diabetes NEAR/2 "type 2") or TS=(diabetes NEAR/2 "type II") Databases=SCI-EXPANDED Timespan=All years	76,238
# 16 (#6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15) Databases=SCI-EXPANDED Timespan=All years	1,067,535

	Search term	Number retrieved
# 15	(TS=(hypertens* or "high blood pressure" or "high cholesterol" or hypercholesterol?emia* or hypercholester?emia* or dyslipid?emia* or dyslipoprotein?emia*)) Databases=SCI-EXPANDED Timespan=All years	329,965
# 14	(TS=((brain* or cerebral* or lacunar) NEAR/3 (accident* or infarc*))) Databases=SCI-EXPANDED Timespan=All years	21,191
# 13	(TS=(stroke* or poststroke* or cerebrovascular)) Databases=SCI-EXPANDED Timespan=All years	183,819
# 12	(TS=(angina* or "atrial fibril*")) Databases=SCI-EXPANDED Timespan=All years	84,084
# 11	(TS=(circulatory NEAR/3 (disease* or disorder*))) Databases=SCI-EXPANDED Timespan=All years	1415
# 10	(TS=(myocardial NEAR/3 (infarc* or disease* or disorder* or failure* or attack* or arrest*))) Databases=SCI-EXPANDED Timespan=All years	196,005
# 9	(TS=(CVD or CHD or IHD)) Databases=SCI-EXPANDED Timespan=All years	52,225
# 8	(TS=(coronary NEAR/3 (disease* or disorder* or failure* or attack* or arrest* or syndrome*))) Databases=SCI-EXPANDED Timespan=All years	183,720
# 7	(TS=((heart or cardiac or myocardial) NEAR/3 (disease* or disorder* or failure* or attack* or arrest*))) Databases=SCI-EXPANDED Timespan=All years	336,341
# 6	(TS=((cardiovascular or peripheral) NEAR/3 (disease* or disorder* or failure*))) Databases=SCI-EXPANDED Timespan=All years	147,514
# 5	(TS=((("fat mass" NEAR/3 (index* or indices)) or fmi) or TS=((("fat free mass" NEAR/3 (index* or indices)) or ffm) or TS=(("body adiposity" NEAR/3 (index* or indices)) or TS=(("body fat" NEAR/2 percentage*) or TS=((hip or neck) NEAR/3 circumference*) or TS=((waist-to-hip or waist-hip) NEAR/3 ratio*) or TS=((waist-to-height or waist-height) NEAR/3 ratio*) or TS=((bioelectric* or electric*) NEAR/3 (impedance or resistance)) or bia) or TS=(("near infrared interactance" or NIR) or TS=((benn* or rohrer* or ponderal or corpulence) NEAR/3 (index* or indices)) or TS=(sagittal abdominal diameter* or supine abdominal diameter*)) Databases=SCI-EXPANDED Timespan=All years	58,595
# 4	(TS=((("skin fold" or skinfold) NEAR/3 (thickness* or test* or measure*)) or TS=(waist NEAR/3 circumference*)) Databases=SCI-EXPANDED Timespan=All years	16,378
# 3	(TS=((("body mass" NEAR/3 (index* or indices)) or bmi or quetelet*)) Databases=SCI-EXPANDED Timespan=All years	116,916
# 2	(TS=(child* or infant* or pediat* or paediat* or schoolchild* or "school age" or "school aged" or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boy or boys or kid or kids or "young people" or "young person" or "young persons" or "young adult" or "young adults")) AND Language=(English) Databases=SCI-EXPANDED Timespan=All years	1,281,780
# 1	(TS=(obes* or overweight or "over weight" or adiposity)) Databases=SCI-EXPANDED Timespan=All years	206,204

The Cochrane Library: Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Database of Abstracts of Reviews of Effects, Health Technology Assessment and NHS Economic Evaluation Database (Wiley Online Library)

2013: CDSR Issue 10/12, CENTRAL Issue 10/12, DARE Issue 3/4, HTA Issue 3/4 and NHS EED Issue 3/4. Searched 4 October 2013. Retrieved 2 records in CDSR, 125 records in CENTRAL, 1 record in DARE, 0 records in HTA and 0 records in NHS EED.

- #1 MeSH descriptor: [Obesity] explode all trees (6646)
- #2 MeSH descriptor: [Overweight] explode all trees (7151)
- #3 MeSH descriptor: [Adiposity] explode all trees (213)
- #4 (obes* or overweight or (over next weight) or adiposity):ti,ab,kw (11,502)
- #5 #1 or #2 or #3 or #4 (11,529)
- #6 MeSH descriptor: [Child] explode all trees (122)
- #7 MeSH descriptor: [Infant] explode all trees (12,348)
- #8 MeSH descriptor: [Adolescent] explode all trees (70,756)
- #9 child* or infant* or pediat* or paediat* or schoolchild* or (school next age*) or schoolage*:ti,ab, kw (84,824)
- #10 adolescen* or juvenile* or youth\$ or teenage* or youngster*:ti,ab,kw (84,511)
- #11 girl or girls or boy or boys or kid or kids:ti,ab,kw (3991)
- #12 #6 or #7 or #8 or #9 or #10 or #11 (141,741)
- #13 MeSH descriptor: [Cardiovascular Diseases] explode all trees (69,868)
- #14 MeSH descriptor: [Stroke] explode all trees (4580)
- #15 MeSH descriptor: [Hypertension] this term only (13,068)
- #16 MeSH descriptor: [Hypercholesterolemia] this term only (2328)
- #17 MeSH descriptor: [Dyslipidemias] explode all trees (4660)
- #18 ((cardiovascular or vascular or peripheral) near/3 (disease* or disorder* or failure*)):ti,ab,kw (12,157)
- #19 ((heart or cardiac or myocardial) near/3 (disease* or disorder* or failure* or attack* or arrest*)):ti,ab, kw (20,649)
- #20 (coronary near/3 (disease* or disorder* or failure* or attack* or arrest* or syndrome*)):ti,ab, kw (15,079)
- #21 CVD or CHD or IHD:ti,ab,kw (2325)

- #22 (myocardial near/3 (infarc* or disease* or disorder* or failure* or attack* or arrest*)):ti,ab, kw (14,322)
- #23 circulatory near/3 (disease* or disorder*):ti,ab,kw (100)
- #24 angina* or (atrial next fibril*):ti,ab,kw (11,477)
- #25 stroke* or poststroke* or cerebrovascular:ti,ab,kw (22,044)
- #26 ((brain* or cerebral* or lacunar) near/3 (accident* or infarc*)):ti,ab,kw (2104)
- #27 hypertens* or (high next blood next pressure) or (high next cholesterol):ti,ab,kw (28,550)
- #28 hypercholesterol?emia* or hypercholester?emia* or dyslipid?emia* or dyslipoprotein?emia*:ti,ab, kw (790)
- #29 #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 (113,868)
- #30 MeSH descriptor: [Diabetes Mellitus, Type 2] this term only (7914)
- #31 MeSH descriptor: [Metabolic Syndrome X] explode all trees (717)
- #32 diabetes near/2 (type next 2):ti,ab,kw (9705)
- #33 diabetes near/2 (type next II):ti,ab,kw (610)
- #34 (diabetes near/2 ("non insulin" or noninsulin)):ti,ab,kw (1755)
- #35 NIDDM or T2DM or T2D:ti,ab,kw (1468)
- #36 ((metabolic or dysmetabolic or reaven or "insulin resistance") near/2 syndrome*):ti,ab,kw (1376)
- #37 #30 or #31 or #32 or #33 or #34 or #35 or #36 (11,742)
- #38 MeSH descriptor: [Neoplasms] explode all trees (47,634)
- #39 cancer* or neoplas* or oncolog* or malignan* or carcinoma* or adenocarcinoma*:ti,ab,kw (73,437)
- #40 (#38 or #39) (78,770)
- #41 MeSH descriptor: [Body Mass Index] explode all trees (5177)
- #42 (("body mass" near/3 (index* or indices)) or bmi or quetelet*):ti,ab,kw (12,162)
- #43 #41 or #42 (12,162)
- #44 #5 and #12 and #43 and (#29 or #37 or #40) from 2011 to 2013 (65)

- #45 MeSH descriptor: [Skinfold Thickness] this term only (272)
- #46 MeSH descriptor: [Waist Circumference] this term only (278)
- #47 (("skin fold" or skinfold) near/3 (thickness* or test* or measure*)):ti,ab,kw (595)
- #48 (waist near/3 circumference*):ti,ab,kw (1260)
- #49 #45 or #46 or #47 or #48 (1804)
- #50 #5 and #12 and #49 (266)
- #51 #50 and (#29 or #37) from 2008 to 2010 (20)
- #52 #50 and #40 from 1900 to 2010 (2)
- #53 MeSH descriptor: [Waist-Hip Ratio] explode all trees (163)
- #54 MeSH descriptor: [Electric Impedance] this term only (318)
- #55 (("fat mass" near/3 (index* or indices)) or fmi):ti,ab,kw (52)
- #56 (("fat free mass" near/3 (index* or indices)) or ffmi):ti,ab,kw (28)
- #57 ("body adipos*" near/3 (index* or indices)):ti,ab,kw (2)
- #58 ("body fat" near/2 percentage*):ti,ab,kw (336)
- #59 ((hip or neck) near/3 circumference*):ti,ab,kw (239)
- #60 ((waist-to-hip or waist-hip) near/3 ratio*):ti,ab,kw (549)
- #61 ((waist-to-height or waist-height) near/3 ratio*):ti,ab,kw (18)
- #62 (((bioelectric* or electric*) near/3 (impedance or resistance)) or bia):ti,ab,kw (606)
- #63 ("near infrared interactance" or NIR):ti,ab,kw (52)
- #64 ((benn* or rohrer* or ponderal or corpulence) near/3 (index* or indices)):ti,ab,kw (32)
- #65 ("sagittal abdominal diameter*" or "supine abdominal diameter*"):ti,ab,kw (8)
- #66 #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 or #65 (1709)
- #67 #5 and #12 and #66 and (#29 or #37 or #40) (49)
- #68 #44 or #51 or #52 or #67 (127)

Review of tracking of obesity into adulthood

Searches were limited by entry date 2007–13; Singh (ENL #454) tracking systematic review searches were completed in February 2007.

MEDLINE and MEDLINE In-Process & Other Non-Indexed Citations (OvidSP)

1946–2013, June week 1. Searched 17 June 2013. Retrieved 2677 records in MEDLINE and 126 records in MEDLINE In-Process & Other Non-Indexed Citations.

1. exp Obesity/ (133,174)
2. Overweight/ (10,590)
3. Weight Gain/ (21,800)
4. Weight Loss/ (22,928)
5. obes\$.ti,ab. (152,595)
6. (overweight or over weight).ti,ab. (32,221)
7. (weight gain or weight loss).ti,ab. (82,269)
8. or/1-7 (267,570)
9. Adiposity/ or Adipose Tissue/ (63,551)
10. exp Body Composition/ (35,621)
11. Body Weight/ (159,105)
12. (adiposity or adipose).ti,ab. (56,741)
13. (body adj2 (composition or fat)).ti,ab. (37,403)
14. fatness.ti,ab. (2835)
15. or/8-14 (468,298)
16. body mass index/ (75,120)
17. Skinfold Thickness/ (5477)
18. Waist Circumference/ (3853)
19. Waist-Hip Ratio/ (2715)
20. Electric Impedance/ (11,187)
21. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$.ti,ab. (113,508)
22. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (824)
23. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (345)
24. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (35)
25. (body fat adj2 percentage\$.ti,ab. (3478)
26. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$ or ratio\$)).ti,ab. (4810)
27. ((waist or hip or neck) adj3 circumference\$.ti,ab. (13,212)
28. ((waist-to-hip or waist-hip) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (6373)
29. ((waist-to-height or waist-height) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (523)
30. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (10,305)
31. (near infrared interactance or NIR).ti,ab. (4648)
32. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (1001)
33. (sagittal abdominal diameter\$ or supine abdominal diameter\$.ti,ab. (108)
34. or/16-33 (169,256)
35. track\$.ti,ab. (65,784)
36. traject\$.ti,ab. (26,434)
37. (persistence or persistent\$.ti,ab. (199,631)
38. (observ\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (72,559)
39. (monitor\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (34,703)
40. (surveil\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (6320)

41. (measure\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (58,971)
42. ((annual\$ or regular\$ or recurr\$) adj3 (interview\$ or questionnaire\$)).ti,ab. (1252)
43. (lifespan or life span or lifecourse or life course).ti,ab. (32,271)
44. or/35-43 (482,887)
45. *Cohort Studies/ (916)
46. *Longitudinal Studies/ (1144)
47. ((cohort or panel) adj1 (study or studies or analy\$)).ti,ab. (82,658)
48. (longitudinal adj1 (study or studies or survey or surveys or analy\$ or pattern\$ or data)).ti,ab. (50,985)
49. *Follow-up Studies/ (497)
50. (follow up adj1 (study or studies or survey or surveys or analy\$ or data)).ti,ab. (50,500)
51. or/44-50 (646,777)
52. exp child/ (1,511,291)
53. exp Infant/ (917,072)
54. Adolescent/ (1,569,130)
55. Young Adult/ (311,210)
56. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,205,816)
57. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (236,753)
58. (girl or girls or boy or boys or kid or kids).ti,ab. (155,425)
59. (young people or young person or young persons or young adult\$).ti,ab. (67,269)
60. or/52-59 (3,200,696)
61. exp Adult/ (5,408,792)
62. (adult\$ or midadult\$ or middle age\$ or later life).ti,ab. (765,494)
63. 61 or 62 (5,769,283)
64. 15 and 34 and 51 and 60 and 63 (2818)
65. (relation\$ or association\$ or predict\$ or risk or risks or mortality).ti,ab. (3,350,562)
66. (obes\$ or overweight or weight status or BMI or body mass index).ti,ab. (231,751)
67. (adult\$ or middle-age\$ or men or women or later life).ti,ab. (1,444,222)
68. (((relation\$ or association\$ or predict\$ or risk or risks or mortality) adj5 (obes\$ or overweight or weight status or BMI or body mass index) adj6 (adult\$ or middle-age\$ or men or women or later life))).ti,ab. **[65 adj5 66 adj6 67]** (3566)
69. 68 and 60 (1519)
70. 64 or 69 (4012)
71. (2007\$ or 2008\$ or 2009\$ or 2010\$ or 2011\$ or 2012\$ or 2013\$).ed,dc,ep. (5,166,979)
72. 70 and 71 (2677)

PubMed (National Library of Medicine)

1946–17 June 2013. Searched 17 June 2013. Retrieved 2195 records.

#52 (#50 AND #51) (2195)

#51 2007:2013[edat] (5,408,518)

#50 (#46 OR #49) (3413)

#49 (#48 AND #42) (788)

#48 ((relation*[TI] or association*[TI] or predict*[TI] or risk[TI] or risks[TI] or mortality[TI]) AND (obes*[TI] or overweight[TI] or "weight status"[TI] or BMI[TI] or "body mass index"[TI]) AND (adult*[TI] or middle-age*[TI] or men[TI] or women[TI] or "later life"[TI])) (2583) **[Title only]**

- #47 (relation*[TIAB] or association*[TIAB] or predict*[TIAB] or risk[TIAB] or risks[TIAB] or mortality[TIAB]) AND (obes*[TIAB] or overweight[TIAB] or "weight status"[TIAB] or BMI[TIAB] or "body mass index"[TIAB]) AND (adult*[TIAB] or middle-age*[TIAB] or men[TIAB] or women[TIAB] or "later life"[tiab]) (59,518) **[without adjacency this line is too sensitive]**
- #46 (#8 AND #24 AND #36 AND #42 AND #45) (2790)
- #45 (#43 OR #44) (5,643,266)
- #44 adult*[tiab] or midadult*[tiab] or middle age*[tiab] or later life[tiab] (785,580)
- #43 "Adult"[Mesh] (5,240,400)
- #42 (#37 OR #38 OR #39 OR #40 OR #41) (3,207,673)
- #41 ("young people"[tiab] or "young person"[tiab] or "young persons"[tiab] or young adult*[tiab]) (68,922)
- #40 girl[tiab] or girls[tiab] or boy[tiab] or boys[tiab] or kid[tiab] or kids[tiab] (162,454)
- #39 adolescen*[tiab] or juvenile*[tiab] or youth*[tiab] or teenage*[tiab] or youngster*[tiab] (247,200)
- #38 child*[tiab] or infant*[tiab] or pediat*[tiab] or paediat*[tiab] or schoolchild*[tiab] or school age*[tiab] or schoolage*[tiab] (1,248,537)
- #37 (((("Child"[Mesh]) OR "Infant"[Mesh]) OR "Adolescent"[Mesh]) OR "Young Adult"[Mesh]) (2,838,299)
- #36 (#25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35) (660,605)
- #35 "follow up study"[tiab] or "follow up studies"[tiab] or "follow up survey"[tiab] or "follow up surveys"[tiab] or follow up analy*[tiab] or follow up pattern*[tiab] or "follow up data"[tiab] (50,170)
- #34 "longitudinal study"[tiab] or "longitudinal studies"[tiab] or "longitudinal survey"[tiab] or "longitudinal surveys"[tiab] or longitudinal analy*[tiab] or longitudinal pattern*[tiab] or "longitudinal data"[tiab] (51,648)
- #33 "cohort study"[tiab] or "cohort studies"[tiab] or cohort analy*[tiab] or "panel study"[tiab] or "panel studies"[tiab] or panel analy*[tiab] (79,961)
- #32 (("Cohort Studies"[Majr]) OR "Longitudinal Studies"[Majr]) OR "Follow-Up Studies"[Majr] (2993)
- #31 measure* repeat*[tiab] or measure* regular*[tiab] or measure* continu*[tiab] or measure* frequent*[tiab] or measure* period*[tiab] or measure* recurr*[tiab] or measure* perenn*[tiab] or measure* prolong*[tiab] or measure* perpetu*[tiab] or measure* long term[tiab] (78,057)
- #30 annual* interview*[tiab] or annual* questionnaire*[tiab] or regular* interview*[tiab] or regular* questionnaire*[tiab] or recurr* interview*[tiab] or recurr* questionnaire*[tiab] (8822)
- #29 lifespan[tiab] or "life span"[tiab] or lifecourse[tiab] or "life course"[tiab] (32,727)

- #28 surveil* repeat*[tiab] or surveil* regular*[tiab] or surveil* continu*[tiab] or surveil* frequent*[tiab] or surveil* period*[tiab] or surveil* recurr*[tiab] or surveil* perenn*[tiab] or surveil* prolong*[tiab] or surveil* perpetu*[tiab] or surveil* long term[tiab] (6687)
- #27 (monito* repeat*[tiab] or monito* regular*[tiab] or monito* continu*[tiab] or monito* frequent*[tiab] or monito* period*[tiab] or monito* recurr*[tiab] or monito* perenn*[tiab] or monito* prolong*[tiab] or monito* perpetu*[tiab] or monito* long term[tiab]) (29,418)
- #26 observ* repeat*[tiab] or observ* regular*[tiab] or observ* continu*[tiab] or observ* frequent*[tiab] or observ* period*[tiab] or observ* recurr*[tiab] or observ* perenn*[tiab] or observ* prolong*[tiab] or observ* perpetu*[tiab] or observ* long term[tiab] (85,510)
- #25 track*[tiab] or traject*[tiab] or persistence[tiab] or persistent*[tiab] (302,985)
- #24 (#9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23) (174,219)
- #23 (sagittal abdominal diameter*[tiab] or supine abdominal diameter*[tiab]) (114)
- #22 benn* index[tiab] or benn* indices[tiab] or rohrer* index[tiab] or rohrer* indices[tiab] or "ponderal index"[tiab] or "ponderal indices"[tiab] or "corpulence index"[tiab] or "corpulence indices"[tiab] (973)
- #21 (((("Body Mass Index"[Mesh]) OR "Skinfold Thickness"[Mesh]) OR "Waist Circumference"[Mesh]) OR "Waist-Hip Ratio"[Mesh]) OR "Electric Impedance"[Mesh]) (85,824)
- #20 ("body mass index"[tiab] or "body mass indices"[tiab] or bmi[tiab] or quetelet*[tiab]) (118,394)
- #19 "fat mass index"[tiab] or "fat mass indices"[tiab] or fmi[tiab] (430)
- #18 ("fat free mass index"[tiab] or "fat free mass indices"[tiab] or ffm[tiab]) (244)
- #17 "body adiposity index"[tiab] or "body adiposity indices"[tiab] or "body adiposie index"[tiab] or "body adipose indices"[tiab] (43)
- #16 ("body fat percentage"[tiab] or "body fat percentages"[tiab]) (1203)
- #15 ("skin fold thickness"[tiab] or "skin fold test"[tiab] or "skin fold tests"[tiab] or "skin fold measure"[tiab] or "skin fold measurement"[tiab] or "skin fold measures"[tiab] or "skin fold measurements"[tiab]) (658)
- #14 ("skinfold thickness"[tiab] or "skinfold test"[tiab] or "skinfold tests"[tiab] or "skinfold measure"[tiab] or "skinfold measurement"[tiab] or "skinfold measures"[tiab] or "skinfold measurements"[tiab]) (3340)
- #13 "waist circumference"[tiab] or "hip circumference"[tiab] or "neck circumference"[tiab] (13,399)
- #12 "waist-to-hip ratio"[tiab] or "waist-to-hip ratios"[tiab] or "waist-hip ratio"[tiab] or "waist-hip ratios"[tiab] (6338)
- #11 "waist-to-height ratio"[tiab] or "waist-to-height ratios"[tiab] or "waist-height ratio"[tiab] or "waist-height ratios"[tiab] (587)

- #10 "bioelectric impedance"[tiab] or "bioelectrical impedance"[tiab] or "electric impedance"[tiab] or "electrical impedance"[tiab] or "bioelectric resistance"[tiab] or "bioelectrical resistance"[tiab] or "electric resistance"[tiab] or "electrical resistance"[tiab] or bia[tiab] (10,533)
- #9 ("near infrared interactance"[tiab] or NIR[tiab]) (6556)
- #8 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7) (579,710)
- #7 adiposity[tiab] or adipose[tiab] or "body composition"[tiab] or "body fat"[tiab] or "body weight"[tiab] or fatness[tiab] (214,862)
- #6 (((("Adiposity"[Mesh]) OR "Adipose Tissue"[Mesh]) OR "Body Composition"[Mesh]) OR "Body Weight"[Mesh]) (384,283)
- #5 "weight gain"[tiab] or "weight loss"[tiab] (85,952)
- #4 overweight[tiab] or "over weight*"[tiab] (33,914)
- #3 obes*[tiab] (159,094)
- #2 (("Overweight"[Mesh]) OR "Weight Gain"[Mesh]) OR "Weight Loss"[Mesh] (159,224)
- #1 "Obesity"[Mesh] (126,355)

EMBASE (OvidSP)

1974–2013, week 24. Searched 17 June 2013. Retrieved 2287 records.

1. exp obesity/ (263,295)
2. weight gain/ (58,597)
3. weight reduction/ (85,394)
4. obes\$.ti,ab. (214,390)
5. (overweight or over weight).ti,ab. (46,472)
6. (weight gain or weight loss).ti,ab. (112,861)
7. or/1-6 (442,794)
8. exp body composition/ (58,550)
9. body weight/ (180,005)
10. (adiposity or adipose).ti,ab. (73,719)
11. (body adj2 (composition or fat or weight)).ti,ab. (214,677)
12. fatness.ti,ab. (3315)
13. or/7-12 (717,815)
14. body mass/ (160,301)
15. skinfold thickness/ (7828)
16. waist circumference/ (18,940)
17. waist hip ratio/ (5962)
18. waist to height ratio/ (171)
19. weight height ratio/ (10)
20. neck circumference/ (152)
21. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$.ti,ab. (176,160)
22. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (1125)
23. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (494)
24. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (60)
25. (body fat adj2 percentage\$.ti,ab. (4433)
26. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (5749)

27. ((waist or hip or neck) adj3 circumference\$.ti,ab. (20,813)
28. ((waist-to-hip or waist-hip) adj3 ratio\$.ti,ab. (8313)
29. ((waist-to-height or waist-height) adj3 ratio\$.ti,ab. (783)
30. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (13,714)
31. (near infrared interactance or NIR).ti,ab. (6331)
32. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (1205)
33. (sagittal abdominal diameter\$ or supine abdominal diameter\$.ti,ab. (138)
34. or/14-33 (259,277)
35. track\$.ti,ab. (87,589)
36. traject\$.ti,ab. (32,963)
37. (persistence or persistent\$.ti,ab. (256,530)
38. (observ\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (97,714)
39. (monitor\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (48,403)
40. (surveil\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (8671)
41. (measure\$ adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (79,155)
42. ((annual\$ or regular\$ or recurr\$) adj3 (interview\$ or questionnaire\$)).ti,ab. (1580)
43. (lifespan or life span or lifecourse or life course).ti,ab. (38,855)
44. or/35-43 (630,994)
45. *cohort analysis/ (4457)
46. *longitudinal study/ (2201)
47. *follow up/ (12,602)
48. ((cohort or panel) adj1 (study or studies or analy\$)).ti,ab. (109,818)
49. (longitudinal adj1 (study or studies or survey or surveys or analy\$ or pattern\$ or data)).ti,ab. (62,065)
50. (follow up adj1 (study or studies or survey or surveys or analy\$ or data)).ti,ab. (66,939)
51. or/44-50 (852,107)
52. child/ (1,267,520)
53. preschool child/ (500,626)
54. infant/ (522,480)
55. adolescent/ (1,241,285)
56. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$.ti,ab. (1,546,923)
57. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$.ti,ab. (305,377)
58. (girl or girls or boy or boys or kid or kids).ti,ab. (207,250)
59. (young people or young person or young persons or young adult\$.ti,ab. (86,569)
60. or/52-58 (2,954,917)
61. adult/ or middle aged/ (4,773,254)
62. (adult\$ or midadult\$ or middle age\$ or later life).ti,ab. (962,049)
63. 61 or 62 (5,296,190)
64. 13 and 34 and 51 and 60 and 63 (2511)
65. (relation\$ or association\$ or predict\$ or risk or risks or mortality).ti,ab. (4,479,904)
66. (obes\$ or overweight or weight status or BMI or body mass index).ti,ab. (336,578)
67. (adult\$ or middle-age\$ or men or women or later life).ti,ab. (1,840,835)
68. ((relation\$ or association\$ or predict\$ or risk or risks or mortality) adj4 (obes\$ or overweight or weight status or BMI or body mass index) adj5 (adult\$ or middle-age\$ or men or women or later life)) [65 adj4 66 adj5 67].ti,ab. (4263)
69. 60 and 68 (1181)
70. 64 or 69 (3419)
71. (2007\$ or 2008\$ or 2009\$ or 2010\$ or 2011\$ or 2012\$ or 2013\$.em. (7,043,444)
72. 70 and 71 (2287)

PsycINFO (OvidSP)

1806–2013, June week 2. Searched 17 June 2013. Retrieved 806 records.

1. obesity/ (13,943)
2. overweight/ (2266)
3. weight gain/ or weight loss/ (3366)
4. obes\$.ti,ab. (20,620)
5. (overweight or over weight).ti,ab. (7922)
6. (weight gain or weight loss).ti,ab. (12,721)
7. or/1-6 (32,261)
8. body weight/ (9833)
9. (adiposity or adipose).ti,ab. (1914)
10. (body adj2 (composition or fat or weight)).ti,ab. (13,243)
11. fatness.ti,ab. (462)
12. or/7-11 (43,208)
13. body mass index/ (2147)
14. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$.ti,ab. (13,066)
15. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (87)
16. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (23)
17. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (0)
18. (body fat adj2 percentage\$.ti,ab. (315)
19. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (256)
20. ((waist or hip or neck) adj3 circumference\$.ti,ab. (1288)
21. ((waist-to-hip or waist-hip) adj3 ratio\$.ti,ab. (508)
22. ((waist-to-height or waist-height) adj3 ratio\$.ti,ab. (44)
23. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (456)
24. (near infrared interactance or NIR).ti,ab. (38)
25. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (79)
26. (sagittal abdominal diameter\$ or supine abdominal diameter\$.ti,ab. (7)
27. or/13-26 (14,533)
28. (track\$ or trajet\$ or persistence or persistent\$.ti,ab. (69,027)
29. ((observ\$ or monitor\$ or surveil\$ or measure\$) adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (26,566)
30. ((annual\$ or regular\$ or recurr\$) adj3 (interview\$ or questionnaire\$)).ti,ab. (603)
31. (lifespan or life span or lifecourse or life course).ti,ab. (15,357)
32. or/28-31 (109,073)
33. cohort analysis/ (971)
34. exp *longitudinal studies/ (2561)
35. *followup studies/ (1496)
36. ((cohort or panel) adj1 (study or studies or analy\$)).ti,ab. (11,031)
37. (longitudinal adj1 (study or studies or survey or surveys or analy\$ or pattern\$ or data)).ti,ab. (36,916)
38. (follow up adj1 (study or studies or survey or surveys or analy\$ or data)).ti,ab. (13,649)
39. or/32-38 (164,950)
40. (adolescence 13 17 yrs or childhood birth 12 yrs or preschool age 2 5 yrs or school age 6 12 yrs).ag. (567,131)
41. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$.ti,ab. (537,261)
42. (adolescenc\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$.ti,ab. (207,480)
43. (girl or girls or boy or boys or kid or kids).ti,ab. (77,464)
44. (young people or young person or young persons or young adult\$.ti,ab. (41,916)
45. or/40-44 (853,904)

46. (adulthood 18 yrs older or middle age 40 64 yrs or thirties 30 39 yrs or young adulthood 18 29 yrs).ag. (1,223,100)
47. (adult\$ or midadult\$ or middle age\$ or later life).ti,ab. (285,272)
48. 46 or 47 (1,336,121)
49. 12 and 27 and 39 and 45 and 48 (360)
50. (relation\$ or association\$ or predict\$ or risk or risks or mortality).ti,ab. (1,068,050)
51. (obes\$ or overweight or weight status or BMI or body mass index).ti,ab. (30,601)
52. (adult\$ or middle-age\$ or men or women or later life).ti,ab. (482,086)
53. ((relation\$ or association\$ or predict\$ or risk or risks or mortality) adj5 (obes\$ or overweight or weight status or BMI or body mass index) adj6 (adult\$ or middle-age\$ or men or women or later life)).ti,ab. [50 adj5 51 adj6 52] (798)
54. 49 or 53 (1106)
55. (2007\$ or 2008\$ or 2009\$ or 2010\$ or 2011\$ or 2012\$ or 2013\$).dp. (1,005,336)
56. 54 and 55 (806)

Cumulative Index to Nursing and Allied Health Literature (EBSCOhost)

1981–7 June 2013. Searched 17 June 2013. Retrieved 1156 records.

Search term	Number retrieved
S59 S57 AND S58	1156
S58 EM 2007 OR EM 2008 OR EM 2009 OR EM 2010 OR EM 2011 OR EM 2012 OR EM 2013	1,536,421
S57 S52 OR S56	1791
S56 S53 N5 S54 N6 S55	1342
S55 TI (adult* or middle-age* or men or women or "later life") or AB (adult* or middle-age* or men or women or "later life")	239,088
S54 TI (obes* or overweight or "weight status" or BMI or "body mass index") or AB (obes* or overweight or "weight status" or BMI or "body mass index")	40,211
S53 TI (relation* or association* or predict* or risk or risks or mortality) or AB (relation* or association* or predict* or risk or risks or mortality)	449,134
S52 S10 AND S29 AND S42 AND S48 AND S51	555
S51 S49 OR S50	583,307
S50 TI (adult* or midadult* or "middle age*" or "later life") or AB (adult* or midadult* or "middle age*" or "later life")	108,318
S49 (ZG "adult: 19-44 years") or (ZG "middle aged: 45-64 years")	533,351
S48 S43 OR S44 OR S45 OR S46 OR S47	413,550
S47 TI ("young people" or "young person" or "young persons" or "young adult*") or AB ("young people" or "young person" or "young persons" or "young adult*")	14,989
S46 TI (girl or girls or boy or boys or kid or kids) or AB (girl or girls or boy or boys or kid or kids)	20,952
S45 TI (adolescen* or juvenile* or youth* or teenage* or youngster*) or AB (adolescen* or juvenile* or youth* or teenage* or youngster*)	56,605
S44 TI (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*) or AB (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*)	213,504
S43 (ZG "adolescent: 13-18 years") or (ZG "child, preschool: 2-5 years") or (ZG "child: 6-12 years")	320,940
S42 S37 OR S38 OR S39 OR S40 OR S41	94,591
S41 TI ("follow up" N2 stud* or "follow up" N2 survey* or "follow up" N2 analy* or "follow up" data) or AB ("follow up" N2 stud* or "follow up" N2 survey* or "follow up" N2 analy* or "follow up" data)	10,078

	Search term	Number retrieved
S40	TI (longitudinal N2 stud* or longitudinal N2 survey* or longitudinal N2 analy* or longitudinal N2 pattern* or longitudinal N2 data) or AB (longitudinal N2 stud* or longitudinal N2 survey* or longitudinal N2 analy* or longitudinal N2 pattern* or longitudinal N2 data)	14,785
S39	TI (cohort N2 stud* or cohort N2 analy* or panel N2 stud* or panel N2 analy*) or AB (cohort N2 stud* or cohort N2 analy* or panel N2 stud* or panel N2 analy*)	22,482
S38	(MM "Prospective Studies+")	433
S37	S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36	54,403
S36	TI (lifespan or "life span" or lifecourse or "life course") or AB (lifespan or "life span" or lifecourse or "life course")	3428
S35	TI (annual* N3 interview* or annual* N3 questionnaire* or regular* N3 interview* or regular* N3 questionnaire* or recurr* N3 interview* or recurr* N3 questionnaire*) or AB (annual* N3 interview* or annual* N3 questionnaire* or regular* N3 interview* or regular* N3 questionnaire* or recurr* N3 interview* or recurr* N3 questionnaire*)	393
S34	TI (measure* N3 repeat* or measure* N3 regular* or measure* N3 continu* or measure* N3 frequent* or measure* N3 period* or measure* N3 recurr* or measure* N3 perenn* or measure* N3 prolong* or measure* N3 perpetu* or measure* N3 "long term") or AB (measure* N3 repeat* or measure* N3 regular* or measure* N3 continu* or measure* N3 frequent* or measure* N3 period* or measure* N3 recurr* or measure* N3 perenn* or measure* N3 prolong* or measure* N3 perpetu* or measure* N3 "long term")	12,762
S33	TI (surveil* N3 repeat* or surveil* N3 regular* or surveil* N3 continu* or surveil* N3 frequent* or surveil* N3 period* or surveil* N3 recurr* or surveil* N3 perenn* or surveil* N3 prolong* or surveil* N3 perpetu* or surveil* N3 "long term") or AB (surveil* N3 repeat* or surveil* N3 regular* or surveil* N3 continu* or surveil* N3 frequent* or surveil* N3 period* or surveil* N3 recurr* or surveil* N3 perenn* or surveil* N3 prolong* or surveil* N3 perpetu* or surveil* N3 "long term")	805
S32	TI (monitor* N3 repeat* or monitor* N3 regular* or monitor* N3 continu* or monitor* N3 frequent* or monitor* N3 period* or monitor* N3 recurr* or monitor* N3 perenn* or monitor* N3 prolong* or monitor* N3 perpetu* or monitor* N3 "long term") or AB (monitor* N3 repeat* or monitor* N3 regular* or monitor* N3 continu* or monitor* N3 frequent* or monitor* N3 period* or monitor* N3 recurr* or monitor* N3 perenn* or monitor* N3 prolong* or monitor* N3 perpetu* or monitor* N3 "long term")	4382
S31	TI (observ* N3 repeat* or observ* N3 regular* or observ* N3 continu* or observ* N3 frequent* or observ* N3 period* or observ* N3 recurr* or observ* N3 perenn* or observ* N3 prolong* or observ* N3 perpetu* or observ* N3 "long term") or AB (observ* N3 repeat* or observ* N3 regular* or observ* N3 continu* or observ* N3 frequent* or observ* N3 period* or observ* N3 recurr* or observ* N3 perenn* or observ* N3 prolong* or observ* N3 perpetu* or observ* N3 "long term")	4657
S30	TI (track* or trajet* or persistence or persistent*) or AB (track* or trajet* or persistence or persistent*)	29,753
S29	S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28	40,956
S28	TI ("sagittal abdominal diameter*" or "supine abdominal diameter*") or AB ("sagittal abdominal diameter*" or "supine abdominal diameter*")	21
S27	TI (benn* N3 index* or benn* N3 indices or rohrer* N3 index* or rohrer* N3 indices* or ponderal N3 index* or ponderal N3 indices or corpulence N3 index* or corpulence N3 indices) or AB (benn* N3 index* or benn* N3 indices or rohrer* N3 index* or rohrer* N3 indices* or ponderal N3 index* or ponderal N3 indices or corpulence N3 index* or corpulence N3 indices)	79
S26	TI ("near infrared interactance" or NIR) or AB ("near infrared interactance" or NIR)	57
S25	TI (bioelectric* N3 impedance or electric* N3 impedance or bioelectric* N3 resistance or electric* N3 resistance or bia) or AB (bioelectric* N3 impedance or electric* N3 impedance or bioelectric* N3 resistance or electric* N3 resistance or bia)	883

	Search term	Number retrieved
S24	TI (waist-to-height N3 ratio* or waist-height N3 ratio*) or AB (waist-to-height N3 ratio* or waist-height N3 ratio*)	98
S23	TI (waist-to-hip N3 ratio* or waist-hip N3 ratio*) or AB (waist-to-hip N3 ratio* or waist-hip N3 ratio*)	855
S22	TI (waist N3 circumference* or hip N3 circumference* or neck N3 circumference*) or AB (waist N3 circumference* or hip N3 circumference* or neck N3 circumference*)	2383
S21	TI ("skin fold" N3 thickness* or skinfold N3 thickness* or "skin fold" N3 test* or skinfold N3 test* or "skin fold" N3 measure* or skinfold N3 measure*) or AB ("skin fold" N3 thickness* or skinfold N3 thickness* or "skin fold" N3 test* or skinfold N3 test* or "skin fold" N3 measure* or skinfold N3 measure*)	712
S20	TI ("body fat" N3 percentage*) or AB ("body fat" N3 percentage*)	783
S19	TI ("body adipos*" N3 index* or "body adipos*" N3 indices) or AB ("body adipos*" N3 index* or "body adipos*" N3 indices)	9
S18	TI ("fat free mass" N3 index* or "fat free mass" N3 indices or ffm) or AB ("fat free mass" N3 index* or "fat free mass" N3 indices or ffm)	78
S17	TI ("fat mass" N3 index* or "fat mass" N3 indices or fmi) or AB ("fat mass" N3 index* or "fat mass" N3 indices or fmi)	144
S16	TI ("body mass" N3 index* or "body mass" N3 indices or bmi or quetelet*) or AB ("body mass" N3 index* or "body mass" N3 indices or bmi or quetelet*)	19,190
S15	(MH "Electric Impedance")	1562
S14	(MH "Waist-Hip Ratio")	1252
S13	(MH "Waist Circumference")	275
S12	(MH "Skinfold Thickness")	2268
S11	(MH "Body Mass Index")	28,392
S10	S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9	71,298
S9	TI (body N2 composition or body N2 fat or body N2 weight) or AB (body N2 composition or body N2 fat or body N2 weight)	13,891
S8	TI (adiposity or adipose or fatness) or AB (adiposity or adipose or fatness)	3867
S7	(MH "Body Weight")	8959
S6	(MH "Body Composition")	7940
S5	(MH "Adipose Tissue")	4511
S4	TI ("weight gain" or "weight loss") or AB ("weight gain" or "weight loss")	11,296
S3	TI (obes* or overweight or "over weight") or AB (obes* or overweight or "over weight")	27,898
S2	(MH "Weight Gain") OR (MH "Weight Loss")	12,531
S1	(MH "Obesity+")	32,334

The Cochrane Library: Cochrane Database of Systematic Reviews and Cochrane Central Register of Controlled Trials (Wiley Online Library)

2013: CDSR Issue 6/12, CENTRAL Issue 5/12. Searched 17 June 2013. Retrieved 4 records in CDSR and 281 records in CENTRAL.

- #1 MeSH descriptor: [Obesity] explode all trees (6452)
- #2 MeSH descriptor: [Overweight] this term only (1072)
- #3 MeSH descriptor: [Weight Gain] this term only (1416)
- #4 MeSH descriptor: [Weight Loss] this term only (2918)
- #5 (obes* or overweight or (over next weight)):ti,ab,kw (10,756)
- #6 ((weight next gain) or (weight next loss)):ti,ab,kw (9014)
- #7 MeSH descriptor: [Adiposity] this term only (203)
- #8 MeSH descriptor: [Body Composition] explode all trees (2773)
- #9 MeSH descriptor: [Body Weight] this term only (5538)
- #10 (adiposity or adipose or fatness):ti,ab,kw (2168)
- #11 (body near/2 (composition or fat or weight)):ti,ab,kw (18,126)
- #12 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 (29,278)
- #13 MeSH descriptor: [Body Mass Index] this term only (5044)
- #14 MeSH descriptor: [Skinfold Thickness] this term only (269)
- #15 MeSH descriptor: [Waist Circumference] this term only (261)
- #16 MeSH descriptor: [Waist-Hip Ratio] this term only (158)
- #17 MeSH descriptor: [Electric Impedance] this term only (313)
- #18 (("body mass" near/3 (index* or indices)) or bmi or quetelet*):ti,ab,kw (11,870)
- #19 (("fat mass" near/3 (index* or indices)) or fmi):ti,ab,kw (49)
- #20 (("fat free mass" near/3 (index* or indices)) or ffm):ti,ab,kw (28)
- #21 ("body adipos*" near/3 (index* or indices)):ti,ab,kw (1)
- #22 ("body fat" near/2 percentage*):ti,ab,kw (328)
- #23 (("skin fold" or skinfold) near/3 (thickness* or test* or measure*)):ti,ab,kw (590)
- #24 ((waist or hip or neck) near/3 circumference*):ti,ab,kw (1244)

- #25 ((waist-to-hip or waist-hip) near/3 ratio*):ti,ab,kw (542)
- #26 ((waist-to-height or waist-height) near/3 ratio*):ti,ab,kw (16)
- #27 (((bioelectric* or electric*) near/3 (impedance or resistance)) or bia):ti,ab,kw (598)
- #28 ("near infrared interactance" or NIR):ti,ab,kw (49)
- #29 ((benn* or rohrer* or ponderal or corpulence) near/3 (index* or indices)):ti,ab,kw (32)
- #30 ("sagittal abdominal diameter*" or "supine abdominal diameter*"):ti,ab,kw (8)
- #31 #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 (13,412)
- #32 track* or trajet* or persistence or persistent*:ti,ab,kw (11,683)
- #33 (observ* or monitor* or surveil* or measure*) near/3 (repeat* or regular* or continu* or frequent* or period* or recurr* or perenn* or prolong* or perpetu* or "long term"):ti,ab,kw (17,771)
- #34 (annual* or regular* or recurr*) near/3 (interview* or questionnaire*):ti,ab,kw (348)
- #35 lifespan or "life span" or lifecourse or "life course":ti,ab,kw (286)
- #36 MeSH descriptor: [Cohort Studies] this term only (5618)
- #37 MeSH descriptor: [Longitudinal Studies] this term only (3807)
- #38 MeSH descriptor: [Follow-Up Studies] this term only (38,849)
- #39 (cohort or panel) near/1 (study or studies or analy*):ti,ab,kw (7541)
- #40 longitudinal near/1 (study or studies or survey or surveys or analy* or pattern* or data):ti,ab,kw (5152)
- #41 (followup or follow-up or "follow up") near/1 (study or studies or survey or surveys or analy* or pattern* or data):ti,ab,kw (42,804)
- #42 #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 (78,737)
- #43 MeSH descriptor: [Child] explode all trees (64)
- #44 MeSH descriptor: [Infant] explode all trees (12,099)
- #45 MeSH descriptor: [Adolescent] explode all trees (69,924)
- #46 MeSH descriptor: [Young Adult] this term only (112)
- #47 child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*:ti,ab,kw (83,100)
- #48 adolescen* or juvenile* or youth* or teenage* or youngster*:ti,ab,kw (83,300)
- #49 girl or girls or boy or boys or kid or kids:ti,ab,kw (3932)

- #50 "young people" or "young person" or "young persons" or "young adult*":ti,ab,kw (21,570)
- #51 #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 (149,377)
- #52 MeSH descriptor: [Adult] explode all trees (863)
- #53 adult* or midadult* or (middle next age*) or "later life":ti,ab,kw (356,717)
- #54 #52 or #53 (357,080)
- #55 #12 and #31 and #42 and #51 and #54 (235)
- #56 ((relation* or association* or predict* or risk or risks or mortality) near/5 (obes* or overweight or weight status or BMI or body mass index) near/6 (adult* or middle-age* or men or women or later life)):ti,ab,kw (264)
- #57 #55 or #56 **from 2007** (292)

Centre for Reviews and Dissemination databases: Database of Abstracts of Reviews of Effects, Health Technology Assessment and NHS Economic Evaluation Database (Centre for Reviews and Dissemination interface)

17 June 2013. Searched 17 June 2013. Retrieved 26 records in DARE, 2 records in HTA and 9 records in NHS EED.

1. MeSH DESCRIPTOR Obesity EXPLODE ALL TREES (685)
2. MeSH DESCRIPTOR Overweight EXPLODE ALL TREES (698)
3. MeSH DESCRIPTOR Weight Gain EXPLODE ALL TREES (108)
4. MeSH DESCRIPTOR Weight Loss EXPLODE ALL TREES (309)
5. (obes* or overweight or "over weight" or "weight gain" or "weight loss") (1773)
6. MeSH DESCRIPTOR Adiposity EXPLODE ALL TREES (11)
7. MeSH DESCRIPTOR Body Composition EXPLODE ALL TREES (72)
8. MeSH DESCRIPTOR Body Weight EXPLODE ALL TREES (1005)
9. (adiposity or adipose or fatness) (70)
10. ((body NEAR2 (composition or fat or weight))) (723)
11. (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10) (2223)
12. MeSH DESCRIPTOR Body Mass Index EXPLODE ALL TREES (221)
13. MeSH DESCRIPTOR Skinfold Thickness EXPLODE ALL TREES (4)
14. MeSH DESCRIPTOR Waist Circumference EXPLODE ALL TREES (14)
15. MeSH DESCRIPTOR Waist-Hip Ratio EXPLODE ALL TREES (0)
16. MeSH DESCRIPTOR Electric Impedance EXPLODE ALL TREES (14)
17. (((("body mass" NEAR3 (index* or indices)) or bmi or quetelet*)) (930)
18. (((("fat mass" NEAR3 (index* or indices)) or fmi)) (5)
19. (((("fat free mass" NEAR3 (index* or indices)) or ffm)) (0)
20. (((("body adipos*" NEAR3 (index* or indices)) (1)
21. (((("body fat" NEAR2 percentage*)) (9)
22. (((("skin fold" or skinfold) NEAR3 (thickness* or test* or measure*)) (48)
23. (((waist or hip or neck) NEAR3 circumference*)) (66)
24. (((waist-to-hip or waist-hip) NEAR3 ratio*)) (22)
25. (((waist-to-height or waist-height) NEAR3 ratio*)) (2)
26. (((bioelectric* or electric*) NEAR3 (impedance or resistance)) or bia)) (28)
27. (((benn* or rohrer* or ponderal or corpulence) NEAR3 (index* or indices))) (6)
28. (((infrared interactance" or NIR)) (7)
29. (((sagittal abdominal diameter*" or "supine abdominal diameter*")) (0)

30. (#12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29) (986)
31. (track* or traject* or persistence or persistent*) (17,333)
32. ((observ* or monitor* or surveil* or measure*) near3 (repeat* or regular* or continu* or frequent* or period* or recurr* or perenn* or prolong* or perpetu* or "long term")) (602)
33. ((annual* or regular* or recurr*) near3 (interview* or questionnaire*)) (6)
34. (lifespan or "life span" or lifecourse or "life course") (108)
35. MeSH DESCRIPTOR Cohort Studies (1111)
36. MeSH DESCRIPTOR Longitudinal Studies (129)
37. MeSH DESCRIPTOR Follow-Up Studies EXPLODE ALL TREES (0)
38. ((cohort or panel) near2 (study or studies or analy*)) (3956)
39. (longitudinal near2 (study or studies or survey or surveys or analy* or pattern* or data)) (421)
40. (("follow up" or followup) near2 (study or studies or survey or surveys or analy* or pattern* or data)) (3166)
41. #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 (23,434)
42. MeSH DESCRIPTOR Child EXPLODE ALL TREES (3678)
43. MeSH DESCRIPTOR Infant EXPLODE ALL TREES (2265)
44. (MeSH DESCRIPTOR Adolescent EXPLODE ALL TREES) (3457)
45. (MeSH DESCRIPTOR Young Adult EXPLODE ALL TREES) (1125)
46. (((child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*)) (9055)
47. (((adolescen* or juvenile* or youth* or teenage* or youngster*)) (4302)
48. (((girl or girls or boy or boys or kid or kids))) (278)
49. ((("young people" or "young person" or "young persons" or "young adult*")) (1494)
50. #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 (11,257)
51. MeSH DESCRIPTOR Adult EXPLODE ALL TREES (13,312)
52. (adult* or midadult* or "middle age*" or "later life") (16,889)
53. #51 OR #52 (18,319)
54. #11 AND #30 AND #41 AND #50 AND #53 (40)
55. (((relation* or association* or predict* or risk or risks or mortality) near5 (obes* or overweight or weight status or BMI or body mass index) near6 (adult* or middle-age* or men or women or later life))) (15)
56. #54 OR #55 (52)
57. (* FROM 2007 TO 2013) (34,534)
58. #56 AND #57 (37)

Science Citation Index (Web of Science)

1900–14 June 2013. Searched 17 June 2013. Retrieved 1829 records.

Search term	Number retrieved
# 19 #17 not #18 Databases=SCI-EXPANDED	1829
# 18 TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or pig or pigs or cats or bovine or cow or sheep or ovine or porcine or monkey) Databases=SCI-EXPANDED	3,803,559
# 17 #15 AND #16 Databases=SCI-EXPANDED	1894
# 16 PY=(2007-2013) Databases=SCI-EXPANDED	10,274,844

	Search term	Number retrieved
# 15	#13 OR #14 <i>Databases=SCI-EXPANDED</i>	2927
# 14	TS=((relation* or association* or predict* or risk or risks or mortality) NEAR/3 (obes* or overweight or "weight status" or BMI or "body mass index") NEAR/4 (adult* or middle-age* or men or women or "later life")) AND TS=(child* or infant* or pediat* or paediat* or schoolchild* or "school age" or "school aged" or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boy or boys or kid or kids or "young people" or "young person" or "young persons" or "young adult" or "young adults") <i>Databases=SCI-EXPANDED</i>	1383
# 13	#1 AND #6 AND #10 AND #11 AND #12 <i>Databases=SCI-EXPANDED</i>	1873
# 12	TS=(adult* or midadult* or "middle age*" or "later life") <i>Databases=SCI-EXPANDED</i>	803,294
# 11	TS=(child* or infant* or pediat* or paediat* or schoolchild* or "school age" or "school aged" or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boy or boys or kid or kids or "young people" or "young person" or "young persons" or "young adult" or "young adults") <i>Databases=SCI-EXPANDED</i>	1,339,321
# 10	#7 OR #8 OR #9 <i>Databases=SCI-EXPANDED</i>	913,241
# 9	TS=((cohort or panel) NEAR/1 (study or studies or analy*)) or TS=((longitudinal or "follow up" or followup) NEAR/1 (study or studies or survey or surveys or analy* or pattern* or data)) <i>Databases=SCI-EXPANDED</i>	188,765
# 8	TS=((annual* or regular* or recur*) NEAR/3 (interview* or questionnaire*)) or TS=(lifespan or "life span" or lifecourse or "life course") <i>Databases=SCI-EXPANDED</i>	41,054
# 7	TS=(track* or trajet* or persistence or persistent*) or TS=((observ* or monitor* or surveil* or measure*) NEAR/3 (repeat* or regular* or continu* or frequent* or period* or recur* or perenn* or prolong* or perpetu* or "long term")) <i>Databases=SCI-EXPANDED</i>	703,711
# 6	#2 OR #3 OR #4 OR #5 <i>Databases=SCI-EXPANDED</i>	169,737
# 5	TS=((bioelectric* or electric*) NEAR/3 (impedance or resistance)) or bia) or TS=("near infrared interactance" or NIR) or TS=((benn* or rohrer* or ponderal or corpulence) NEAR/3 (index* or indices)) or TS=(sagittal abdominal diameter* or supine abdominal diameter*) <i>Databases=SCI-EXPANDED</i>	48,466
# 4	TS=((waist or hip or neck) NEAR/3 circumference*) or TS=((waist-to-hip or waist-hip) NEAR/3 ratio*) or TS=((waist-to-height or waist-height) NEAR/3 ratio*) <i>Databases=SCI-EXPANDED</i>	17,338
# 3	TS=("body adiposity" NEAR/3 (index* or indices)) or TS=("body fat" NEAR/2 percentage*) or TS(("skin fold" or skinfold) NEAR/3 (thickness* or test* or measure*)) <i>Databases=SCI-EXPANDED</i>	6792

	Search term	Number retrieved
# 2	TS=((“body mass” NEAR/3 (index* or indices)) or bmi or quetelet*) or TS=((“fat mass” NEAR/3 (index* or indices)) or fmi) or TS=((“fat free mass” NEAR/3 (index* or indices)) or ffm) <i>Databases=SCI-EXPANDED</i>	115,482
# 1	TS=(obes* or overweight or “over weight” or “weight gain” or “weight loss” or adiposity or adipose or fatness) or TS=(body NEAR/2 (composition or fat or weight)) <i>Databases=SCI-EXPANDED</i>	453,027

Conference Proceedings Citation Index – Science (Web of Science)

1990–14 June 2013. Searched 17 June 2013. Retrieved 152 records.

	Search term	Number retrieved
# 15	#13 OR #14 <i>Databases=CPCI-S</i>	152
# 14	TS=((relation* or association* or predict* or risk or risks or mortality) NEAR/3 (obes* or overweight or “weight status” or BMI or “body mass index”) NEAR/4 (adult* or middle-age* or men or women or “later life”)) AND TS=(child* or infant* or pediat* or paediat* or schoolchild* or “school age” or “school aged” or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boy or boys or kid or kids or “young people” or “young person” or “young persons” or “young adult” or “young adults”) <i>Databases=CPCI-S</i>	91
# 13	#1 AND #6 AND #10 AND #11 AND #12 <i>Databases=CPCI-S</i>	69
# 12	TS=(adult* or midadult* or “middle age*” or “later life”) <i>Databases=CPCI-S</i>	66,704
# 11	TS=(child* or infant* or pediat* or paediat* or schoolchild* or “school age” or “school aged” or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boys or kid or kids or “young people” or “young person” or “young persons” or “young adult” or “young adults”) <i>Databases=CPCI-S</i>	134,639
# 10	#7 OR #8 OR #9 <i>Databases=CPCI-S</i>	220,083
# 9	TS=((cohort or panel) NEAR/1 (study or studies or analy*)) or TS=((longitudinal or “follow up” or followup) NEAR/1 (study or studies or survey or surveys or analy* or pattern* or data)) <i>Databases=CPCI-S</i>	19,090
# 8	TS=((annual* or regular* or recur*) NEAR/3 (interview* or questionnaire*)) or TS=(lifespan or “life span” or lifecourse or “life course”) <i>Databases=CPCI-S</i>	4413
# 7	TS=(track* or traject* or persistence or persistent*) or TS=((observ* or monitor* or surveil* or measure*) NEAR/3 (repeat* or regular* or continu* or frequent* or period* or recur* or perenn* or prolong* or perpetu* or “long term”)) <i>Databases=CPCI-S</i>	198,195

	Search term	Number retrieved
# 6	#2 OR #3 OR #4 OR #5 Databases=CPCI-S	23,836
# 5	TS=((bioelectric* or electric*) NEAR/3 (impedance or resistance)) or bia) or TS=(“near infrared interactance” or NIR) or TS=((benn* or rohrer* or ponderal or corpulence) NEAR/3 (index* or indices)) or TS=(sagittal abdominal diameter* or supine abdominal diameter*) Databases=CPCI-S	14,260
# 4	TS=((waist or hip or neck) NEAR/3 circumference*) or TS=((waist-to-hip or waist-hip) NEAR/3 ratio*) or TS=((waist-to-height or waist-height) NEAR/3 ratio*) Databases=CPCI-S	886
# 3	TS=(“body adiposity” NEAR/3 (index* or indices)) or TS=(“body fat” NEAR/2 percentage*) or TS=(“skin fold” or skinfold) NEAR/3 (thickness* or test* or measure*)) Databases=CPCI-S	351
# 2	TS=(“body mass” NEAR/3 (index* or indices)) or bmi or quetelet*) or TS=(“fat mass” NEAR/3 (index* or indices)) or fmi) or TS=(“fat free mass” NEAR/3 (index* or indices)) or ffmf) Databases=CPCI-S	9083
# 1	TS=(obes* or overweight or “over weight” or “weight gain” or “weight loss” or adiposity or adipose or fatness) or TS=(body NEAR/2 (composition or fat or weight)) Databases=CPCI-S	48,448

Health Management Information Consortium (OvidSP)

1979–March 2013. Searched 17 June 2013. Retrieved 52 records.

1. exp Obesity/ (2727)
2. (obes\$ or overweight or over weight or weight gain or weight loss).ti,ab. (3514)
3. exp Body weight/ (842)
4. (adiposity or adipose or (body adj2 (composition or fat or weight)) or fatness).ti,ab. (621)
5. or/1-4 (4574)
6. exp body mass index/ (496)
7. weight size ratios/ (72)
8. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$.ti,ab. (1674)
9. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (10)
10. ((fat free mass adj3 (index\$ or indices)) or ffmf).ti,ab. (4)
11. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (0)
12. (body fat adj2 percentage\$.ti,ab. (31)
13. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (32)
14. ((waist or hip or neck) adj3 circumference\$.ti,ab. (222)
15. ((waist-to-hip or waist-hip) adj3 ratio\$.ti,ab. (72)
16. ((waist-to-height or waist-height) adj3 ratio\$.ti,ab. (10)
17. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (15)
18. (near infrared interactance or NIR).ti,ab. (1)
19. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (5)
20. (sagittal abdominal diameter\$ or supine abdominal diameter\$.ti,ab. (2)
21. or/6-20 (1881)
22. (track\$ or trajet\$ or persistence or persistent\$.ti,ab. (2602)

23. ((observ\$ or monitor\$ or surveil\$ or measure\$) adj3 (repeat\$ or regular\$ or continu\$ or frequent\$ or period\$ or recurr\$ or perenn\$ or prolong\$ or perpetu\$ or long term)).ti,ab. (1287)
24. ((annual\$ or regular\$ or recurr\$) adj3 (interview\$ or questionnaire\$)).ti,ab. (56)
25. (lifespan or life span or lifecourse or life course).ti,ab. (456)
26. cohort studies/ (757)
27. longitudinal studies/ (457)
28. ((cohort or panel) adj1 (study or studies or analy\$)).ti,ab. (2763)
29. (longitudinal adj1 (study or studies or survey or surveys or analy\$ or pattern\$ or data)).ti,ab. (1552)
30. (follow up adj1 (study or studies or survey or surveys or analy\$ or data)).ti,ab. (835)
31. or/22-30 (9166)
32. exp Children/ or exp Older children/ or exp Pre school children/ (17,728)
33. exp Infants/ (1520)
34. exp Young people/ (9377)
35. exp Young adults/ (281)
36. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (29,945)
37. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (6446)
38. (girl or girls or boy or boys or kid or kids).ti,ab. (1508)
39. (young people or young person or young persons or young adult\$).ti,ab. (5502)
40. or/32-39 (40,506)
41. adults/ or middle aged people/ (2555)
42. (adult\$ or midadult\$ or middle age\$ or later life).ti,ab. (12,127)
43. 41 or 42 (12,746)
44. 5 and 21 and 31 and 40 and 43 (67)
45. (2007\$ or 2008\$ or 2009\$ or 2010\$ or 2011\$ or 2012\$ or 2013\$).dp,yr. (68,585)
46. 44 and 45 (52)

Trials Register of Promoting Health Interventions (Evidence for Policy and Practice Information and Co-ordinating Centre)

18 June 2013. Searched 18 June 2013. Retrieved 14 records (post-2007).

1. Freetext: "obes*" OR overweight OR "over weight" OR "weight gain" OR "weight loss" (862)
2. Freetext: adiposity OR adipose OR fatness OR "body composition" or "body fat" or "body weight" (280)
3. 1 OR 2 (918)
4. Freetext: "track*" OR "traject*" OR persistence OR "persistent*" (101)
5. Freetext: "cohort study" OR "cohort studies" OR "longitudinal study" OR "longitudinal studies" OR "follow up study" OR "follow up studies" (129)
6. 4 OR 5 (223)
7. 3 AND 6 (27)

Obesity and Sedentary Behaviour Database (Evidence for Policy and Practice Information and Co-ordinating Centre)

18 June 2013. Searched 18 June 2013. Retrieved 13 records (post-2007).

1. Freetext: "track*" OR "traject*" OR persistence OR "persistent*" (9)
2. Freetext: "cohort study" OR "cohort studies" OR "longitudinal study" OR "longitudinal studies" OR "follow up study" OR "follow up studies" (27)
3. 1 OR 2 (32)

OAister (<http://oaister.worldcat.org/>)

Searched 18 June 2013. Retrieved 79 records.

kw:(obes* OR overweight OR "weight gain" OR adiposity) kw:("body mass index*" OR bmi OR quetelet* OR "fat mass index*" OR "fat free mass index*" OR "body adiposity index*" OR "body fat percentage" OR "skin fold" OR skinfold OR "waist circumference*" OR "hip circumference*" OR "neck circumference*" OR "waist-to-hip" OR "waist-hip" OR "waist-to-height" OR "waist-height" OR "bioelectric* impedance" OR "electric* impedance" OR "benn* index*" OR "rohrer* index*" OR "ponderal index*" OR "corpulence index*" OR "sagittal abdominal diameter*" OR "supine abdominal diameter*") AND (track* OR trajet* OR persistence OR persistent* OR "cohort study" OR "cohort studies" OR "longitudinal study" OR "longitudinal studies" OR "follow up study" OR "follow up studies") kw:(child* OR infant* OR pediat* OR paediat* OR schoolchild* OR "school age*" OR schoolage* OR adolescen* OR juvenile* OR youth* OR teenage* OR youngster* OR "young people" OR "young person" OR "young persons" OR "young adult*") AND (adult* OR "middle age*") > '2007..2013' limited to Libraries Worldwide

OpenGrey (www.opengrey.eu/)

Searched 18 June 2013. Retrieved 0 records.

(obes* OR overweight OR "weight gain" OR adiposity) AND (track* OR trajet* OR persistence OR persistent* OR "cohort study" OR "cohort studies" OR "longitudinal study" OR "longitudinal studies" OR "follow up study" OR "follow up studies")

Review of the diagnostic accuracy of childhood measures of obesity**MEDLINE and MEDLINE In-Process & Other Non-Indexed Citations (OvidSP)**

1946–2013, May week 5. Searched 10 June 2013. Retrieved 2412 records in MEDLINE and 50 records in MEDLINE In-Process & Other Non-Indexed Citations.

1. exp Obesity/ (133,014)
2. Overweight/ (10,556)
3. Weight Gain/ (21,776)
4. Weight Loss/ (22,903)
5. obes\$.ti,ab. (152,384)
6. (overweight or over weight).ti,ab. (32,167)
7. (weight gain or weight loss).ti,ab. (82,180)
8. or/1-7 (267,262)
9. Adiposity/ or Adipose Tissue/ (63,489)
10. exp Body Composition/ (35,563)
11. Body Weight/ (159,038)
12. (adiposity or adipose).ti,ab. (56,647)
13. (body adj2 (composition or fat or weight)).ti,ab. (168,451)
14. fatness.ti,ab. (2834)
15. or/8-14 (541,557)
16. Body Mass Index/ (75,019)
17. Skinfold Thickness/ (5476)
18. Waist Circumference/ (3842)
19. Waist-Hip Ratio/ (2713)
20. Electric Impedance/ (11,165)
21. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$.ti,ab. (113,321)

22. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (823)
23. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (343)
24. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (35)
25. (body fat adj2 percentage\$).ti,ab. (3469)
26. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (4708)
27. ((waist or hip or neck) adj3 circumference\$).ti,ab. (13,184)
28. ((waist-to-hip or waist-hip) adj3 ratio\$).ti,ab. (6212)
29. ((waist-to-height or waist-height) adj3 ratio\$).ti,ab. (514)
30. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (10,288)
31. (near infrared interactance or NIR).ti,ab. (4634)
32. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (999)
33. (sagittal abdominal diameter\$ or supine abdominal diameter\$).ti,ab. (108)
34. or/16-33 (168,960)
35. exp Densitometry/ (28,031)
36. exp Plethysmography/ (18,381)
37. Neutron Activation Analysis/ (1682)
38. (body volume adj3 (index\$ or indices)).ti,ab. (1)
39. (densitometr\$ or hydrodensitometr\$).ti,ab. (13,282)
40. ((hydrostatic or underwater or water) adj3 (weighing or analys\$ or measure\$)).ti,ab. (12,322)
41. (absorptiometry or DXA or DEXA).ti,ab. (18,761)
42. ((water or air) adj3 displacement).ti,ab. (999)
43. (air displacement plethysmograph\$ or pea pod or peapod or infant body composition system\$ or bodpod or bod pod).ti,ab. (319)
44. (neutron\$ adj3 activat\$).ti,ab. (2611)
45. ((multicomponent\$ or multi component\$ or multimodal\$ or multi modal\$ or composit\$) adj3 model\$).ti,ab. (2039)
46. (deuterium adj3 dilut\$).ti,ab. (452)
47. or/35-46 (80,449)
48. exp child/ (1,510,589)
49. exp Infant/ (916,662)
50. Adolescent/ (1,568,189)
51. Young Adult/ (310,115)
52. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,205,015)
53. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (236,539)
54. (girl or girls or boy or boys or kid or kids).ti,ab. (155,309)
55. (young people or young person or young persons or young adult\$).ti,ab. (67,202)
56. or/48-55 (3,198,543)
57. 15 and 34 and 47 and 56 (2417)
58. exp Animals/ not Humans/ (3,903,550)
59. 57 not 58 (2412)

PubMed (National Library of Medicine)

1946–10 June 2013. Searched 10 June 2013. Retrieved 2116 records.

- #45 (#43 NOT #44) (2116)
- #44 (animals [mh] NOT humans [mh]) (3,786,976)
- #43 (#9 AND #25 AND #36 AND #42) (2120)
- #42 ((#37 OR #38 OR #39 OR #40 OR #41)) (3,204,504)

- #41 "young people"[tiab] or "young person"[tiab] or "young persons"[tiab] or young adult*[tiab] (68,815)
- #40 girl[tiab] or girls[tiab] or boy[tiab] or boys[tiab] or kid[tiab] or kids[tiab] (162,265)
- #39 adolescen*[tiab] or juvenile*[tiab] or youth*[tiab] or teenage*[tiab] or youngster*[tiab] (246,765)
- #38 child*[tiab] or infant*[tiab] or pediat*[tiab] or paediat*[tiab] or schoolchild*[tiab] or school age*[tiab] or schoolage*[tiab] (1,247,217)
- #37 (((("Child"[Mesh]) OR "Infant"[Mesh]) OR "Adolescent"[Mesh]) OR "Young Adult"[Mesh]) (2,835,930)
- #36 ((#26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35)) (70,730)
- #35 Search deuterium dilut*[tiab] (255)
- #34 ("multicomponent model"[tiab] or "multicomponent models"[tiab] or "multi component model"[tiab] or "multi component models"[tiab] or "multimodal model"[tiab] or "multimodal models"[tiab] or "multi modal model"[tiab] or "multi modal models"[tiab] or "composite model"[tiab] or "composite models"[tiab]) (422)
- #33 neutron* activat*[tiab] (3609)
- #32 air displacement plethysmograph*[tiab] or "pea pod"[tiab] or peapod[tiab] or infant body composition system*[tiab] or bodpod[tiab] or "bod pod"[tiab] (385)
- #31 water displacement[tiab] or air displacement[tiab] (815)
- #30 absorptiometry[tiab] or DXA[tiab] or DEXA[tiab] (19,261)
- #29 (hydrostatic weighing[tiab] or hydrostatic analys*[tiab] or hydrostatic measure*[tiab] or underwater weighing[tiab] or underwater analys*[tiab] or underwater measure*[tiab] or water weighing[tiab] or water analys*[tiab] or water measure*[tiab]) (3067)
- #28 densitometr*[tiab] or hydrodensitometr*[tiab] (13,428)
- #27 "body volume index"[TIAB] or "body volume indices"[tiab] (0)
- #26 ((("Densitometry"[Mesh]) OR "Plethysmography"[Mesh]) OR "Neutron Activation Analysis"[Mesh]) (46,668)
- #25 ((#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24)) (173,811)
- #24 (sagittal abdominal diameter*[tiab] or supine abdominal diameter*[tiab]) (114)
- #23 benn* index[tiab] or benn* indices[tiab] or rohrer* index[tiab] or rohrer* indices[tiab] or "ponderal index"[tiab] or "ponderal indices"[tiab] or "corpulence index"[tiab] or "corpulence indices"[tiab] (972)
- #22 ("near infrared interactance"[tiab] or NIR[tiab]) (6538)

- #21 "bioelectric impedance"[tiab] or "bioelectrical impedance"[tiab] or "electric impedance"[tiab] or "electrical impedance"[tiab] or "bioelectric resistance"[tiab] or "bioelectrical resistance"[tiab] or "electric resistance"[tiab] or "electrical resistance"[tiab] or bia[tiab] (10,514)
- #20 "waist-to-height ratio"[tiab] or "waist-to-height ratios"[tiab] or "waist-height ratio"[tiab] or "waist-height ratios"[tiab] (584)
- #19 "waist-to-hip ratio"[tiab] or "waist-to-hip ratios"[tiab] or "waist-hip ratio"[tiab] or "waist-hip ratios"[tiab] (6331)
- #18 "waist circumference"[tiab] or "hip circumference"[tiab] or "neck circumference"[tiab] (13,353)
- #17 ("skinfold thickness"[tiab] or "skinfold test"[tiab] or "skinfold tests"[tiab] or "skinfold measure"[tiab] or "skinfold measurement"[tiab] or "skinfold measures"[tiab] or "skinfold measurements"[tiab]) (3335)
- #16 ("skin fold thickness"[tiab] or "skin fold test"[tiab] or "skin fold tests"[tiab] or "skin fold measure"[tiab] or "skin fold measurement"[tiab] or "skin fold measures"[tiab] or "skin fold measurements"[tiab]) (658)
- #15 ("body fat percentage"[tiab] or "body fat percentages"[tiab]) (1198)
- #14 "body adiposity index"[tiab] or "body adiposity indices"[tiab] or "body adiposie index"[tiab] or "body adipose indices"[tiab] (43)
- #13 ("fat free mass index"[tiab] or "fat free mass indices"[tiab] or ffm[tiab]) (244)
- #12 "fat mass index"[tiab] or "fat mass indices"[tiab] or fmi[tiab] (430)
- #11 ("body mass index"[tiab] or "body mass indices"[tiab] or bmi[tiab] or quetelet*[tiab]) (118,076)
- #10 (((("Body Mass Index"[Mesh]) OR "Skinfold Thickness"[Mesh]) OR "Waist Circumference"[Mesh]) OR "Waist-Hip Ratio"[Mesh]) OR "Electric Impedance"[Mesh] (85,640)
- #9 (#6 OR #7 OR #8) (578,940)
- #8 adiposity[tiab] or adipose[tiab] or "body composition"[tiab] or "body fat"[tiab] or "body weight"[tiab] or fatness[tiab] (214,556)
- #7 (((("Adiposity"[Mesh]) OR "Adipose Tissue"[Mesh]) OR "Body Composition"[Mesh]) OR "Body Weight"[Mesh] (383,871)
- #6 ((#1 OR #2 OR #3 OR #4 OR #5)) (278,389)
- #5 "weight gain"[tiab] or "weight loss"[tiab] (85,808)
- #4 overweight[tiab] or "over weight*"[tiab] (33,801)
- #3 obes*[tiab] (158,729)
- #2 ((("Overweight"[Mesh]) OR "Weight Gain"[Mesh]) OR "Weight Loss"[Mesh] (158,971)
- #1 "Obesity"[Mesh] (126,162)

EMBASE (OvidSP)

1974–2013, week 23. Searched 10 June 2013. Retrieved 2274 records.

1. exp obesity/ (262,617)
2. weight gain/ (58,401)
3. weight reduction/ (85,101)
4. obes\$.ti,ab. (213,837)
5. (overweight or over weight).ti,ab. (46,324)
6. (weight gain or weight loss).ti,ab. (112,520)
7. or/1-6 (441,658)
8. exp body composition/ (58,421)
9. body weight/ (179,655)
10. (adiposity or adipose).ti,ab. (73,593)
11. (body adj2 (composition or fat or weight)).ti,ab. (214,271)
12. fatness.ti,ab. (3314)
13. or/7-12 (716,288)
14. body mass/ (159,745)
15. skinfold thickness/ (7810)
16. waist circumference/ (18,862)
17. waist hip ratio/ (5940)
18. waist to height ratio/ (166)
19. weight height ratio/ (10)
20. neck circumference/ (143)
21. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$.ti,ab. (175,493)
22. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (1119)
23. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (491)
24. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (60)
25. (body fat adj2 percentage\$.ti,ab. (4420)
26. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (5741)
27. ((waist or hip or neck) adj3 circumference\$.ti,ab. (20,733)
28. ((waist-to-hip or waist-hip) adj3 ratio\$.ti,ab. (8299)
29. ((waist-to-height or waist-height) adj3 ratio\$.ti,ab. (778)
30. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (13,679)
31. (near infrared interactance or NIR).ti,ab. (6312)
32. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (1205)
33. (sagittal abdominal diameter\$ or supine abdominal diameter\$.ti,ab. (136)
34. or/14-33 (258,369)
35. densitometry/ (16,109)
36. exp plethysmograph/ (451)
37. neutron activation analysis/ (5326)
38. (body volume adj3 (index\$ or indices)).ti,ab. (6)
39. (densitometr\$ or hydrodensitometr\$.ti,ab. (17,847)
40. ((hydrostatic or underwater or water) adj3 (weighing or analys\$ or measure\$)).ti,ab. (17,975)
41. (absorptiometry or DXA or DEXA).ti,ab. (25,906)
42. ((water or air) adj3 displacement).ti,ab. (1325)
43. (air displacement plethysmograph\$ or pea pod or peapod or infant body composition system\$ or bodpod or bod pod).ti,ab. (511)
44. (neutron\$ adj3 activat\$.ti,ab. (5851)
45. ((multicomponent\$ or multi component\$ or multimodal\$ or multi modal\$ or composit\$) adj3 model\$.ti,ab. (2750)
46. (deuterium adj3 dilut\$.ti,ab. (529)
47. or/35-46 (78,881)
48. child/ (1,266,225)

49. preschool child/ (500,023)
50. infant/ (522,108)
51. adolescent/ (1,240,231)
52. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,545,191)
53. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (304,919)
54. (girl or girls or boy or boys or kid or kids).ti,ab. (206,972)
55. (young people or young person or young persons or young adult\$).ti,ab. (86,424)
56. or/48-55 (2,993,496)
57. 13 and 34 and 47 and 56 (2274)

PsycINFO (OvidSP)

1806–2013, June week 1. Searched 11 June 2013. Retrieved 133 records.

1. obesity/ (13,925)
2. overweight/ (2263)
3. weight gain/ or weight loss/ (3364)
4. obes\$.ti,ab. (20,582)
5. (overweight or over weight).ti,ab. (7911)
6. (weight gain or weight loss).ti,ab. (12,709)
7. or/1-6 (32,209)
8. body weight/ (9825)
9. (adiposity or adipose).ti,ab. (1912)
10. (body adj2 (composition or fat or weight)).ti,ab. (13,234)
11. fatness.ti,ab. (462)
12. or/7-11 (43,149)
13. body mass index/ (2140)
14. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (13,043)
15. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (87)
16. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (23)
17. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (0)
18. (body fat adj2 percentage\$).ti,ab. (315)
19. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (256)
20. ((waist or hip or neck) adj3 circumference\$).ti,ab. (1284)
21. ((waist-to-hip or waist-hip) adj3 ratio\$).ti,ab. (507)
22. ((waist-to-height or waist-height) adj3 ratio\$).ti,ab. (43)
23. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (455)
24. (near infrared interactance or NIR).ti,ab. (37)
25. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (79)
26. (sagittal abdominal diameter\$ or supine abdominal diameter\$).ti,ab. (7)
27. or/13-26 (14,507)
28. plethysmography/ (133)
29. (body volume adj3 (index\$ or indices)).ti,ab. (0)
30. (densitometr\$ or hydrodensitometr\$).ti,ab. (210)
31. ((hydrostatic or underwater or water) adj3 (weighing or analys\$ or measure\$)).ti,ab. (516)
32. (absorptiometry or DXA or DEXA).ti,ab. (513)
33. ((water or air) adj3 displacement).ti,ab. (34)
34. (air displacement plethysmograph\$ or pea pod or peapod or infant body composition system\$ or bodpod or bod pod).ti,ab. (18)
35. (neutron\$ adj3 activat\$).ti,ab. (13)
36. ((multicomponent\$ or multi component\$ or multimodal\$ or multi modal\$ or composit\$) adj3 model\$).ti,ab. (678)
37. (deuterium adj3 dilut\$).ti,ab. (14)

38. or/28-37 (2084)
39. (adolescence 13 17 yrs or childhood birth 12 yrs or preschool age 2 5 yrs or school age 6 12 yrs or young adulthood 18 29 yrs).ag. (778,079)
40. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti, ab. (536,641)
41. (adolescenc\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (207,223)
42. (girl or girls or boy or boys or kid or kids).ti,ab. (77,393)
43. (young people or young person or young persons or young adult\$).ti,ab. (41,848)
44. or/39-43 (1,040,736)
45. 12 and 27 and 38 and 44 (133)

Cumulative Index to Nursing and Allied Health Literature (EBSCOhost)

1981–7 June 2013. Searched 11 June 2013. Retrieved 551 records.

	Search term	Number retrieved
S49	S10 AND S29 AND S42 AND S48	551
S48	S43 OR S44 OR S45 OR S46 OR S47	412,874
S47	TI ("young people" or "young person" or "young persons" or "young adult*") or AB ("young people" or "young person" or "young persons" or "young adult*")	14,961
S46	TI (girl or girls or boy or boys or kid or kids) or AB (girl or girls or boy or boys or kid or kids)	20,926
S45	TI (adolescen* or juvenile* or youth* or teenage* or youngster*) or AB (adolescen* or juvenile* or youth* or teenage* or youngster*)	56,494
S44	TI (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*) or AB (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*)	213,146
S43	(ZG "adolescent: 13-18 years") or (ZG "child, preschool: 2-5 years") or (ZG "child: 6-12 years")	320,453
S42	S30 OR S31 OR S32 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41	6568
S41	TI (deuterium N3 dilut*) or AB (deuterium N3 dilut*)	72
S40	TI (multicomponent* N3 model* or "multi component*" N3 model* or multimodal* N3 model* or "multi modal* N3 model or composit* N3 model*") or AB (multicomponent* N3 model* or "multi component*" N3 model* or multimodal* N3 model* or "multi modal* N3 model or composit* N3 model*")	24
S39	TI (neutron* N3 activat*) or AB (neutron* N3 activat*)	32
S38	TI ("air displacement plethysmograph*" or "pea pod" or peapod or "infant body composition system*" or bodpod or "bod pod") or AB ("air displacement plethysmograph*" or "pea pod" or peapod or "infant body composition system*" or bodpod or "bod pod")	93
S37	TI (water N3 displacement or air N3 displacement) or AB (water N3 displacement or air N3 displacement)	147
S36	TI (absorptiometry or DXA or DEXA) or AB (absorptiometry or DXA or DEXA)	2237
S35	TI (hydrostatic N3 weighing or hydrostatic N3 analys* or hydrostatic N3 measure* or underwater N3 weighing or underwater N3 analys* or underwater N3 measure* or water N3 weighing or water N3 analys* or water N3 measure*) or AB (hydrostatic N3 weighing or hydrostatic N3 analys* or hydrostatic N3 measure* or underwater N3 weighing or underwater N3 analys* or underwater N3 measure* or water N3 weighing or water N3 analys* or water N3 measure*)	732
S34	TI (densitometr* or hydrodensitometr*) or AB (densitometr* or hydrodensitometr*)	520
S33	TI ("body volume" N3 index* or "body volume" N3 indices) or AB ("body volume" N3 index* or "body volume" N3 indices)	178
S32	TI ("body volume" N3 index* or "body volume" N3 indices) or AB ("body volume" N3 index* or "body volume" N3 indices) [CINAHL SmartText Searching – ignored]	0
S31	(MH "Plethysmography+")	1090
S30	(MH "Densitometry+")	3881

	Search term	Number retrieved
S29	S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28	40,846
S28	TI ("sagittal abdominal diameter*" or "supine abdominal diameter*") or AB ("sagittal abdominal diameter*" or "supine abdominal diameter*")	21
S27	TI (benn* N3 index* or benn* N3 indices or rohrer* N3 index* or rohrer* N3 indices* or ponderal N3 index* or ponderal N3 indices or corpulence N3 index* or corpulence N3 indices) or AB (benn* N3 index* or benn* N3 indices or rohrer* N3 index* or rohrer* N3 indices* or ponderal N3 index* or ponderal N3 indices or corpulence N3 index* or corpulence N3 indices)	79
S26	TI ("near infrared interactance" or NIR) or AB ("near infrared interactance" or NIR)	57
S25	TI (bioelectric* N3 impedance or electric* N3 impedance or bioelectric* N3 resistance or electric* N3 resistance or bia) or AB (bioelectric* N3 impedance or electric* N3 impedance or bioelectric* N3 resistance or electric* N3 resistance or bia)	882
S24	TI (waist-to-height N3 ratio* or waist-height N3 ratio*) or AB (waist-to-height N3 ratio* or waist-height N3 ratio*)	97
S23	TI (waist-to-hip N3 ratio* or waist-hip N3 ratio*) or AB (waist-to-hip N3 ratio* or waist-hip N3 ratio*)	853
S22	TI (waist N3 circumference* or hip N3 circumference* or neck N3 circumference*) or AB (waist N3 circumference* or hip N3 circumference* or neck N3 circumference*)	2378
S21	TI ("skin fold" N3 thickness* or skinfold N3 thickness* or "skin fold" N3 test* or skinfold N3 test* or "skin fold" N3 measure* or skinfold N3 measure*) or AB ("skin fold" N3 thickness* or skinfold N3 thickness* or "skin fold" N3 test* or skinfold N3 test* or "skin fold" N3 measure* or skinfold N3 measure*)	712
S20	TI ("body fat" N3 percentage*) or AB ("body fat" N3 percentage*)	783
S19	TI ("body adipos*" N3 index* or "body adipos*" N3 indices) or AB ("body adipos*" N3 index* or "body adipos*" N3 indices)	9
S18	TI ("fat free mass" N3 index* or "fat free mass" N3 indices or ffm) or AB ("fat free mass" N3 index* or "fat free mass" N3 indices or ffm)	78
S17	TI ("fat mass" N3 index* or "fat mass" N3 indices or fmi) or AB ("fat mass" N3 index* or "fat mass" N3 indices or fmi)	144
S16	TI ("body mass" N3 index* or "body mass" N3 indices or bmi or quetelet*) or AB ("body mass" N3 index* or "body mass" N3 indices or bmi or quetelet*)	19,132
S15	(MH "Electric Impedance")	1560
S14	(MH "Waist-Hip Ratio")	1251
S13	(MH "Waist Circumference")	271
S12	(MH "Skinfold Thickness")	2268
S11	(MH "Body Mass Index")	28,324
S10	S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9	71,129
S9	TI (body N2 composition or body N2 fat or body N2 weight) or AB (body N2 composition or body N2 fat or body N2 weight)	13,869
S8	TI (adiposity or adipose or fatness) or AB (adiposity or adipose or fatness)	3860
S7	(MH "Body Weight")	8937
S6	(MH "Body Composition")	7934
S5	(MH "Adipose Tissue")	4507
S4	TI ("weight gain" or "weight loss") or AB ("weight gain" or "weight loss")	11,268
S3	TI (obes* or overweight or "over weight") or AB (obes* or overweight or "over weight")	27,804
S2	(MH "Weight Gain") OR (MH "Weight Loss")	12,508
S1	(MH "Obesity+")	32,251

***The Cochrane Library: Cochrane Database of Systematic Reviews and
Cochrane Central Register of Controlled Trials (Wiley Online Library)***

2013: CDSR Issue 5/12, CENTRAL Issue 5/12. Searched 11 June 2013. Retrieved 0 records in CDSR and 169 records in CENTRAL.

- #1 MeSH descriptor: [Obesity] explode all trees (6452)
- #2 MeSH descriptor: [Overweight] this term only (1072)
- #3 MeSH descriptor: [Weight Gain] this term only (1416)
- #4 MeSH descriptor: [Weight Loss] this term only (2918)
- #5 (obes* or overweight or (over next weight)):ti,ab,kw (10,756)
- #6 ((weight next gain) or (weight next loss)):ti,ab,kw (9014)
- #7 MeSH descriptor: [Adiposity] this term only (203)
- #8 MeSH descriptor: [Body Composition] explode all trees (2773)
- #9 MeSH descriptor: [Body Weight] this term only (5538)
- #10 (adiposity or adipose or fatness):ti,ab,kw (2168)
- #11 (body near/2 (composition or fat or weight)):ti,ab,kw (18,126)
- #12 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 (29,278)
- #13 MeSH descriptor: [Body Mass Index] this term only (5044)
- #14 MeSH descriptor: [Skinfold Thickness] this term only (269)
- #15 MeSH descriptor: [Waist Circumference] this term only (261)
- #16 MeSH descriptor: [Waist-Hip Ratio] this term only (158)
- #17 MeSH descriptor: [Electric Impedance] this term only (313)
- #18 (("body mass" near/3 (index* or indices)) or bmi or quetelet*):ti,ab,kw (11,870)
- #19 (("fat mass" near/3 (index* or indices)) or fmi):ti,ab,kw (49)
- #20 (("fat free mass" near/3 (index* or indices)) or ffm):ti,ab,kw (28)
- #21 ("body adipos*" near/3 (index* or indices)):ti,ab,kw (1)
- #22 ("body fat" near/2 percentage*):ti,ab,kw (328)

- #23 (“skin fold” or skinfold) near/3 (thickness* or test* or measure*):ti,ab,kw (590)
- #24 ((waist or hip or neck) near/3 circumference*):ti,ab,kw (1244)
- #25 ((waist-to-hip or waist-hip) near/3 ratio*):ti,ab,kw (542)
- #26 ((waist-to-height or waist-height) near/3 ratio*):ti,ab,kw (16)
- #27 (((bioelectric* or electric*) near/3 (impedance or resistance)) or bia):ti,ab,kw (598)
- #28 (“near infrared interactance” or NIR):ti,ab,kw (49)
- #29 ((benn* or rohrer* or ponderal or corpulence) near/3 (index* or indices)):ti,ab,kw (32)
- #30 (“sagittal abdominal diameter*” or “supine abdominal diameter*“):ti,ab,kw (8)
- #31 #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 (13,412)
- #32 MeSH descriptor: [Densitometry] explode all trees (1365)
- #33 MeSH descriptor: [Plethysmography] explode all trees (948)
- #34 MeSH descriptor: [Neutron Activation Analysis] this term only (15)
- #35 (“body volume” near/3 (index* or indices)):ti,ab,kw (0)
- #36 (densitometr* or hydrodensitometr*):ti,ab,kw (610)
- #37 ((hydrostatic or underwater or water) near/3 (weighing or analys* or measure*)):ti,ab,kw (517)
- #38 absorptiometry or DXA or DEXA:ti,ab,kw (2626)
- #39 ((water or air) near/3 displacement):ti,ab,kw (62)
- #40 (“air displacement plethysmograph*” or “pea pod” or peapod or “infant body composition system*” or bodpod or “bod pod“):ti,ab,kw (18)
- #41 (neutron* near/3 activat*):ti,ab,kw (58)
- #42 ((multicomponent* or “multi component*” or multimodal* or “multi modal*” or composit*) near/3 model*):ti,ab,kw (44)
- #43 (deuterium near/3 dilut*):ti,ab,kw (31)
- #44 #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 (4645)
- #45 MeSH descriptor: [Child] explode all trees (64)

- #46 MeSH descriptor: [Infant] explode all trees (12,099)
- #47 MeSH descriptor: [Adolescent] this term only (69,925)
- #48 MeSH descriptor: [Young Adult] this term only (112)
- #49 (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*):ti,ab,kw (83,100)
- #50 (adolescen* or juvenile* or youth* or teenage* or youngster*):ti,ab,kw (83,300)
- #51 (girl or girls or boy or boys or kid or kids):ti,ab,kw (3932)
- #52 ("young people" or "young person" or "young persons" or "young adult*"):ti,ab,kw (21,570)
- #53 #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 (149,377)
- #54 #12 and #31 and #44 and #53 (170)

Centre for Reviews and Dissemination databases: Database of Abstracts of Reviews of Effects, Health Technology Assessment and NHS Economic Evaluation Database (Centre for Reviews and Dissemination interface)

10 June 2013. Searched 11 June 2013. Retrieved 8 records in DARE, 1 record in HTA and 0 records in NHS EED.

1. MeSH DESCRIPTOR Obesity EXPLODE ALL TREES (685)
2. MeSH DESCRIPTOR Overweight EXPLODE ALL TREES (698)
3. MeSH DESCRIPTOR Weight Gain EXPLODE ALL TREES (108)
4. MeSH DESCRIPTOR Weight Loss EXPLODE ALL TREES (310)
5. (obes* or overweight or "over weight" or "weight gain" or "weight loss") (1772)
6. MeSH DESCRIPTOR Adiposity EXPLODE ALL TREES (11)
7. MeSH DESCRIPTOR Body Composition EXPLODE ALL TREES (72)
8. MeSH DESCRIPTOR Body Weight EXPLODE ALL TREES (1005)
9. (adiposity or adipose or fatness) (70)
10. ((body NEAR2 (composition or fat or weight))) (723)
11. (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10) (2222)
12. MeSH DESCRIPTOR Body Mass Index EXPLODE ALL TREES (220)
13. MeSH DESCRIPTOR Skinfold Thickness EXPLODE ALL TREES (4)
14. MeSH DESCRIPTOR Waist Circumference EXPLODE ALL TREES (14)
15. MeSH DESCRIPTOR Waist-Hip Ratio EXPLODE ALL TREES (0)
16. MeSH DESCRIPTOR Electric Impedance EXPLODE ALL TREES (14)
17. (((("body mass" NEAR3 (index* or indices)) or bmi or quetelet*)) (927)
18. (((("fat mass" NEAR3 (index* or indices)) or fmi)) (5)
19. (((("fat free mass" NEAR3 (index* or indices)) or ffm)) (0)
20. (((("body adipos*" NEAR3 (index* or indices)) (1)
21. (((("body fat" NEAR2 percentage*)) (9)
22. (((("skin fold" or skinfold) NEAR3 (thickness* or test* or measure*)) (48)
23. (((waist or hip or neck) NEAR3 circumference*)) (66)

24. (((waist-to-hip or waist-hip) NEAR3 ratio*)) (22)
25. (((waist-to-height or waist-height) NEAR3 ratio*)) (2)
26. (((bioelectric* or electric*) NEAR3 (impedance or resistance)) or bia)) (28)
27. (((benn* or rohrer* or ponderal or corpulence) NEAR3 (index* or indices))) (6)
28. ((("infrared interactance" or NIR)) (7)
29. ((("sagittal abdominal diameter*" or "supine abdominal diameter*")) (0)
30. (#12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29) (983)
31. MeSH DESCRIPTOR Densitometry EXPLODE ALL TREES (81)
32. MeSH DESCRIPTOR Plethysmography EXPLODE ALL TREES (21)
33. MeSH DESCRIPTOR Neutron Activation Analysis EXPLODE ALL TREES (0)
34. ((("body volume" NEAR3 (index* or indices))) (0)
35. ((densitometr* or hydrodensitometr*)) (61)
36. (((hydrostatic or underwater or water) NEAR3 (weighing or analys* or measure*))) (16)
37. (absorptiometry or DXA or DEXA) (137)
38. (((water or air) NEAR3 displacement)) (7)
39. ((("air displacement plethysmograph*" or "pea pod" or peapod or "infant body composition system*" or bodpod or "bod pod")) (4)
40. ((neutron* NEAR3 activat*)) (0)
41. (((multicomponent* or "multi component*" or multimodal* or "multi modal*" or composit*) NEAR3 model*)) (1)
42. ((deuterium NEAR3 dilut*)) (1)
43. (#31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42) (196)
44. MeSH DESCRIPTOR Child EXPLODE ALL TREES (3665)
45. MeSH DESCRIPTOR Infant EXPLODE ALL TREES (2258)
46. MeSH DESCRIPTOR Adolescent EXPLODE ALL TREES (3456)
47. MeSH DESCRIPTOR Young Adult EXPLODE ALL TREES (1124)
48. ((child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*)) (9033)
49. ((adolescen* or juvenile* or youth* or teenage* or youngster*)) (4300)
50. ((girl or girls or boy or boys or kid or kids)) (278)
51. ((("young people" or "young person" or "young persons" or "young adult*")) (1492)
52. (#44 or #45 or #46 or #47 or #48 or #49 or #50 or #51) (11,234)
53. #11 AND #30 AND #43 AND #52 (9)

Science Citation Index (Web of Science)

1900–7 June 2013. Searched 11 June 2013. Retrieved 1666 records.

	Search term	Number retrieved
# 13	#11 NOT #12 <i>Databases=SCI-EXPANDED Timespan=All years</i>	1666
# 12	TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or pig or pigs or cats or bovine or cow or sheep or ovine or porcine or monkey) <i>Databases=SCI-EXPANDED Timespan=All years</i>	3,774,018
# 11	#1 AND #6 AND #9 AND #10 <i>Databases=SCI-EXPANDED Timespan=All years</i>	1721
# 10	TS=(child* or infant* or pediat* or paediat* or schoolchild* or "school age" or "school aged" or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boy or boys or kid or kids or "young people" or "young person" or "young persons" or "young adult" or "young adults") <i>Databases=SCI-EXPANDED Timespan=All years</i>	1,337,616
# 9	#7 OR #8 <i>Databases=SCI-EXPANDED Timespan=All years</i>	134,636
# 8	TS=((water or air) NEAR/3 displacement) or TS=("air displacement plethysmography" or "pea pod" or peapod or "infant body composition system" or bodpod or "bod pod") or TS=(neutron* NEAR/3 activat*) or TS=((multicomponent* or "multi component" or multimodal* or "multi modal" or composi*) NEAR/3 model*) or TS=(deuterium NEAR/3 dilut*) <i>Databases=SCI-EXPANDED Timespan=All years</i>	40,070
# 7	TS=("body volume" NEAR/3 (index* or indices)) or TS=(densitometr* or hydrodensitometr*) or TS=((hydrostatic or underwater or water) NEAR/3 (weighing or analys* or measure*)) or TS=(absorptiometry or DXA or DEXA) <i>Databases=SCI-EXPANDED Timespan=All years</i>	95,866
# 6	#2 OR #3 OR #4 OR #5 <i>Databases=SCI-EXPANDED Timespan=All years</i>	169,334
# 5	TS=((bioelectric* or electric*) NEAR/3 (impedance or resistance)) or bia) or TS=("near infrared interactance" or NIR) or TS=((benn* or rohret* or ponderal or corpulence) NEAR/3 (index* or indices)) or TS=(sagittal abdominal diameter* or supine abdominal diameter*) <i>Databases=SCI-EXPANDED Timespan=All years</i>	48,378
# 4	TS=((waist or hip or neck) NEAR/3 circumference*) or TS=((waist-to-hip or waist-hip) NEAR/3 ratio*) or TS=((waist-to-height or waist-height) NEAR/3 ratio*) <i>Databases=SCI-EXPANDED Timespan=All years</i>	17,295
# 3	TS=("body adiposity" NEAR/3 (index* or indices)) or TS=("body fat" NEAR/2 percentage*) or TS(("skin fold" or skinfold) NEAR/3 (thickness* or test* or measure*)) <i>Databases=SCI-EXPANDED Timespan=All years</i>	6781
# 2	TS(("body mass" NEAR/3 (index* or indices)) or bmi or quetelet*) or TS(("fat mass" NEAR/3 (index* or indices)) or fmi) or TS(("fat free mass" NEAR/3 (index* or indices)) or ffmf) <i>Databases=SCI-EXPANDED Timespan=All years</i>	115,175
# 1	TS=(obes* or overweight or "over weight" or "weight gain" or "weight loss" or adiposity or adipose or fatness) or TS=(body NEAR/2 (composition or fat or weight)) <i>Databases=SCI-EXPANDED Timespan=All years</i>	452,263

Conference Proceedings Citation Index – Science (Web of Science)

1990–7 June 2013. Searched 11 June 2013. Retrieved 80 records.

	Search term	Number retrieved
# 11	#1 AND #6 AND #9 AND #10 <i>Databases=CPCI-S Timespan=All years</i>	80
# 10	TS=(child* or infant* or pediat* or paediat* or schoolchild* or "school age" or "school aged" or schoolage* or adolescen* or juvenile* or youth* or teenage* or youngster* or girl or girls or boy or boys or kid or kids or "young people" or "young person" or "young persons" or "young adult" or "young adults") <i>Databases=CPCI-S Timespan=All years</i>	134,449
# 9	#7 OR #8 <i>Databases=CPCI-S Timespan=All years</i>	26,397
# 8	TS=((water or air) NEAR/3 displacement) or TS=("air displacement plethysmography" or "pea pod" or peapod or "infant body composition system" or bodpod or "bod pod") or TS=(neutron* NEAR/3 activat*) or TS=((multicomponent* or "multi component" or multimodal* or "multi modal" or composit*) NEAR/3 model*) or TS=(deuterium NEAR/3 dilut*) <i>Databases=CPCI-S Timespan=All years</i>	10,641
# 7	TS=("body volume" NEAR/3 (index* or indices)) or TS=(densitometr* or hydrodensitometr*) or TS=((hydrostatic or underwater or water) NEAR/3 (weighing or analys* or measure*)) or TS=(absorptiometry or DXA or DEXA) <i>Databases=CPCI-S Timespan=All years</i>	15,925
# 6	#2 OR #3 OR #4 OR #5 <i>Databases=CPCI-S Timespan=All years</i>	23,800
# 5	TS(((bioelectric* or electric*) NEAR/3 (impedance or resistance)) or bia) or TS(("near infrared interactance" or NIR) or TS=((benn* or rohrer* or ponderal or corpulence) NEAR/3 (index* or indices)) or TS=(sagittal abdominal diameter* or supine abdominal diameter*)) <i>Databases=CPCI-S Timespan=All years</i>	14,242
# 4	TS=((waist or hip or neck) NEAR/3 circumference*) or TS=((waist-to-hip or waist-hip) NEAR/3 ratio*) or TS=((waist-to-height or waist-height) NEAR/3 ratio*) <i>Databases=CPCI-S Timespan=All years</i>	886
# 3	TS=("body adiposity" NEAR/3 (index* or indices)) or TS=("body fat" NEAR/2 percentage*) or TS(("skin fold" or skinfold) NEAR/3 (thickness* or test* or measure*)) <i>Databases=CPCI-S Timespan=All years</i>	351
# 2	TS(("body mass" NEAR/3 (index* or indices)) or bmi or quetelet*) or TS(("fat mass" NEAR/3 (index* or indices)) or fmi) or TS(("fat free mass" NEAR/3 (index* or indices)) or ffm)	9065
	<i>Databases=CPCI-S Timespan=All years</i>	
# 1	TS=(obes* or overweight or "over weight" or "weight gain" or "weight loss" or adiposity or adipose or fatness) or TS=(body NEAR/2 (composition or fat or weight)) <i>Databases=CPCI-S Timespan=All years</i>	48,407

Health Management Information Consortium (OvidSP)

1979–March 2013. Searched 11 June 2013. Retrieved 13 records.

1. exp Obesity/ (2727)
2. (obes\$ or overweight or over weight or weight gain or weight loss).ti,ab. (3514)
3. exp Body weight/ (842)
4. (adiposity or adipose or (body adj2 (composition or fat or weight)) or fatness).ti,ab. (621)
5. or/1-4 (4574)
6. exp body mass index/ (496)
7. weight size ratios/ (72)
8. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (1674)
9. ((fat mass adj3 (index\$ or indices)) or fmi).ti,ab. (10)
10. ((fat free mass adj3 (index\$ or indices)) or ffm).ti,ab. (4)
11. (body adipos\$ adj3 (index\$ or indices)).ti,ab. (0)
12. (body fat adj2 percentage\$).ti,ab. (31)
13. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (32)
14. ((waist or hip or neck) adj3 circumference\$).ti,ab. (222)
15. ((waist-to-hip or waist-hip) adj3 ratio\$).ti,ab. (72)
16. ((waist-to-height or waist-height) adj3 ratio\$).ti,ab. (10)
17. (((bioelectric\$ or electric\$) adj3 (impedance or resistance)) or bia).ti,ab. (15)
18. (near infrared interactance or NIR).ti,ab. (1)
19. ((benn\$ or rohrer\$ or ponderal or corpulence) adj3 (index\$ or indices)).ti,ab. (5)
20. (sagittal abdominal diameter\$ or supine abdominal diameter\$).ti,ab. (2)
21. or/6-20 (1881)
22. (body volume adj3 (index\$ or indices)).ti,ab. (0)
23. (densitometr\$ or hydrodensitometr\$).ti,ab. (19)
24. ((hydrostatic or underwater or water) adj3 (weighing or analys\$ or measure\$)).ti,ab. (22)
25. (absorptiometry or DXA or DEXA).ti,ab. (55)
26. ((water or air) adj3 displacement).ti,ab. (2)
27. (air displacement plethysmograph\$ or pea pod or peapod or infant body composition system\$ or bodpod or bod pod).ti,ab. (3)
28. (neutron\$ adj3 activat\$).ti,ab. (6)
29. ((multicomponent\$ or multi component\$ or multimodal\$ or multi modal\$ or composit\$) adj3 model\$).ti,ab. (9)
30. (deuterium adj3 dilut\$).ti,ab. (1)
31. or/22-30 (110)
32. exp Children/ or exp Older children/ or exp Pre school children/ (17,728)
33. exp Infants/ (1520)
34. exp Young people/ (9377)
35. exp Young adults/ (281)
36. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (29,945)
37. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (6446)
38. (girl or girls or boy or boys or kid or kids).ti,ab. (1508)
39. (young people or young person or young persons or young adult\$).ti,ab. (5502)
40. or/32-39 (40,506)
41. 5 and 21 and 31 and 40 (13)

Trials Register of Promoting Health Interventions (Evidence for Policy and Practice Information and Co-ordinating Centre)

12 June 2013. Searched 12 June 2013. Retrieved 22 records.

- 1 Freetext: "obes*" OR overweight OR "over weight" OR "weight gain" OR "weight loss" (862)
- 2 Freetext: adiposity OR adipose OR fatness OR "body composition" or "body fat" or "body weight" (280)
- 3 1 OR 2 (918)
- 4 Freetext: "body mass index*" OR "body mass indices" OR bmi OR quetelet* (459)
- 5 Freetext: "fat mass" NEAR "index*" OR "fat mass" NEAR "indices*" OR fmi (4)
- 6 Freetext: "fat free mass" NEAR "index*" OR "fat free mass" NEAR "indices*" OR ffmi (3)
- 7 Freetext: "fat free mass" NEAR "index*" OR "fat free mass" NEAR "indices*" OR ffmi (3)
- 8 Freetext: "body adipos*" NEAR "index*" OR "body adipos*" NEAR "indices*" (0)
- 9 Freetext: "body fat" NEAR "percentage*" (29)
- 10 Freetext: "skin fold" or skinfold (38)
- 11 Freetext: "waist" NEAR "circumference*" OR "hip" NEAR "circumference*" OR "neck" NEAR "circumference*" (119)
- 12 Freetext: "waist-to-hip" OR "waist-hip" OR "waist-to-height" OR "waist-height" (36)
- 13 Freetext: "bioelectric*" NEAR "impedance" OR "electric*" NEAR "impedance" OR "bioelectric*" NEAR "resistance" OR "electric*" NEAR "resistance" (7)
- 14 Freetext: "benn*" NEAR "index*" OR "rohrer*" NEAR "index*" OR "ponderal" NEAR "index*" OR "corpulence" NEAR "index*" OR "benn*" NEAR "indices*" OR "rohrer*" NEAR "indices*" OR "ponderal" NEAR "indices*" OR "corpulence" NEAR "indices*" (0)
- 15 Freetext: "infrared interactance" OR NIR OR "sagittal abdominal diameter*" OR "supine abdominal diameter*" (2)
- 16 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 (520)
- 17 Freetext: "body volume" NEAR "index*" OR "body volume" NEAR "indices" (0)
- 18 Freetext: "densitometr*" OR "hydrodensitometr*" (2)
- 19 Freetext: "hydrostatic" NEAR "weighing" OR "underwater" NEAR "weighing" OR "water" NEAR "weighing" OR "hydrostatic" NEAR "analys*" OR "underwater" NEAR "analys*" OR "water" NEAR "analys*" OR "hydrostatic" NEAR "measure*" OR "underwater" NEAR "measure*" OR "water" NEAR "measure*" (42)
- 20 Freetext: absorptiometry OR "DXA" OR "DEXA" (22)
- 21 Freetext: "water" NEAR "displacement" OR "air" NEAR "displacement" (0)

22. Freetext: "plethysmograph*" OR "pea pod" OR "peapod" OR "infant body composition system*" OR bodpod OR "bod pod" (0)
23. Freetext: "multicomponent*" NEAR "model*" OR "multi component*" NEAR "model*" OR "multimodal*" NEAR "model*" OR "multi modal*" NEAR "model*" OR "composit*" NEAR "model*" (46)
24. Freetext: "deuterium" NEAR "dilut*" (0)
25. 17 OR 18 OR 19 OR 23 OR 24 OR 25 OR 26 OR 27 (108)
26. Freetext: "child*" OR "infant*" OR "pediat*" OR "paediat*" OR "schoolchild*" OR "school age*" OR "schoolage*" OR "adolescen*" OR "juvenile*" OR "youth*" OR "teenage*" OR "youngster*" OR girl OR girls OR boy OR boys OR kid OR kids OR "young people" OR "young person" OR "young persons" OR "young adult*" (2789)
27. 3 AND 16 AND 28 AND 29 (22)

Obesity and Sedentary Behaviour Database (Evidence for Policy and Practice Information and Co-ordinating Centre)

12 June 2013. Searched 12 June 2013. Retrieved 5 records.

1. Freetext: "body mass index*" OR "body mass indices" OR bmi OR quetelet* (226)
2. Freetext: "fat mass" NEAR "index*" OR "fat mass" NEAR "indices*" OR fmi (6)
3. Freetext: "fat free mass" NEAR "index*" OR "fat free mass" NEAR "indices*" OR ffmi (3)
4. Freetext: "body adipos*" NEAR "index*" OR "body adipos*" NEAR "indices*" (0)
5. Freetext: "body fat" NEAR "percentage*" (20)
6. Freetext: "skin fold" or skinfold (17)
7. Freetext: "waist" NEAR "circumference*" OR "hip" NEAR "circumference*" OR "neck" NEAR "circumference*" (22)
8. Freetext: "waist-to-hip" OR "waist-hip" OR "waist-to-height" OR "waist-height" (3)
9. Freetext: "bioelectric*" NEAR "impedance" OR "electric*" NEAR "impedance" OR "bioelectric*" NEAR "resistance" OR "electric*" NEAR "resistance" (9)
10. Freetext: "benn*" NEAR "index*" OR "rohrer*" NEAR "index*" OR "ponderal" NEAR "index*" OR "corpulence" NEAR "index*" OR "benn*" NEAR "indices*" OR "rohrer*" NEAR "indices*" OR "ponderal" NEAR "indices*" OR "corpulence" NEAR "indices*" (0)
11. Freetext: "infrared interactance" OR NIR OR "sagittal abdominal diameter*" OR "supine abdominal diameter*" (0)
12. 1 OR 2 OR 3 OR 4 OR 5 OR 7 OR 8 OR 9 OR 10 OR 11 (236)
13. Freetext: "body volume" NEAR "index*" OR "body volume" NEAR "indices" (0)
14. Freetext: "densitometr*" OR "hydrodensitometr*" (0)
15. Freetext: "hydrostatic" NEAR "weighing" OR "underwater" NEAR "weighing" OR "water" NEAR "weighing" OR "hydrostatic" NEAR "analys*" OR "underwater" NEAR "analys*" OR "water" NEAR "analys*" OR "hydrostatic" NEAR "measure*" OR "underwater" NEAR "measure*" OR "water" NEAR "measure*" (3)
16. Freetext: absorptiometry OR "DXA" OR "DEXA" (10)
17. Freetext: "water" NEAR "displacement" OR "air" NEAR "displacement" (1)
18. Freetext: "plethysmograph*" OR "pea pod" OR "peapod" OR "infant body composition system*" OR bodpod (0)
19. Freetext: "multicomponent*" NEAR "model*" OR "multi component*" NEAR "model*" OR "multimodal*" NEAR "model*" OR "multi modal*" NEAR "model*" OR "composit*" NEAR "model*" (3)
20. Freetext: "deuterium" NEAR "dilut*" (0)
21. 13 OR 14 OR 15 OR 17 OR 18 OR 19 OR 20 (6)
22. 12 AND 21 (5)

OAIster (<http://oaister.worldcat.org/>)

Searched 12 June 2013. Retrieved 92 records.

Search results for 'kw:(obes* OR overweight OR "weight gain" OR adiposity) kw:(("body mass index*" OR bmi OR quetelet* OR "fat mass index*" OR "fat free mass index*" OR "body adiposity index*" OR "body fat percentage" OR "skin fold" OR skinfold OR "waist circumference*" OR "hip circumference*" OR "neck circumference*" OR "waist-to-hip" OR "waist-hip" OR "waist-to-height" OR "waist-height" OR "bioelectric* impedance" OR "electric* impedance" OR "benn* index*" OR "rohrer* index*" OR "ponderal index*" OR "corpulence index*" OR "sagittal abdominal diameter*" OR "supine abdominal diameter*") AND ("body volume index*" OR densitometr* OR hydrodensitometr* OR hydrostatic OR "water weighing" OR "water analys*" OR "water measure*" OR absorptiometry OR DXA OR DEXA OR "water displacement" OR "air displacement" OR plethysmograph* OR "pea pod" OR peapod OR bodpod OR "neutron* activat*" OR "multicomponent* model*" OR "multimodal* model*" OR "deuterium dilute*") kw:(child* OR infant* OR pediat* OR paediat* OR schoolchild* OR "school age*" OR schoolage* OR adolescen* OR juvenile* OR youth* OR teenage* OR youngster* OR "young people" OR "young person" OR "young persons" OR "young adult*"))' limited to Libraries Worldwide.

OpenGrey (www.opengrey.eu/)

Searched 12 June 2013. Retrieved 0 records.

(obes* OR overweight OR "weight gain" OR adiposity) AND ("body volume index*" OR densitometr* OR hydrodensitometr* OR hydrostatic OR "water weighing" OR "water analys*" OR "water measure*" OR absorptiometry OR DXA OR DEXA OR "water displacement" OR "air displacement" OR plethysmograph* OR "pea pod" OR peapod OR bodpod OR "neutron* activat*" OR "multicomponent* model*" OR "multimodal* model*" OR "deuterium dilute*").

Review of the acceptability and ease of use of childhood measures of obesity**MEDLINE and MEDLINE In-Process & Other Non-Indexed Citations (OvidSP)**

1946–2013, November week 3. Searched 29 November 2013. Retrieved 1786 records in MEDLINE and 160 records in MEDLINE In-Process & Other Non-Indexed Citations.

1. exp *Obesity/ (100,481)
2. *Overweight/ (7451)
3. *Adiposity/ (2859)
4. obes\$.ti,ab. (165,769)
5. (overweight or over weight).ti,ab. (35,631)
6. adiposity.ti,ab. (13,580)
7. or/1-6 (197,718)
8. exp child/ or exp Infant/ or Adolescent/ (2,890,432)
9. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,257,816)
10. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (251,350)
11. (girl or girls or boy or boys or kid or kids).ti,ab. (161,848)
12. or/8-11 (3,161,861)
13. *body mass index/ (12,360)
14. ((body mass adj3 (index\$ or indices) or bmi or quetelet\$).ti,ab. (124,654)
15. *Skinfold Thickness/ (869)
16. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$ or ratio\$)).ti,ab. (5012)
17. *Waist-Hip Ratio/ (559)
18. ((waist-to-hip or waist-hip) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (6800)

19. ((waist-to-height or waist-height) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (612)
20. or/13-19 (130,736)
21. exp *qualitative research/ (1460)
22. exp *Interviews as Topic/ (4502)
23. exp *questionnaires/ (31,966)
24. qualitative.ti. (19,194)
25. (qualitative adj2 (research or design or analy\$ or study or studies)).ab. (31,413)
26. ((semi structured or semistructured or "in depth" or indepth or "face to face" or structured) adj3 (interview\$ or questionnaire\$)).ti,ab. (57,395)
27. focus group\$.ti,ab. (20,402)
28. (survey or surveys).ti,ab. (350,023)
29. or/21-28 (469,146)
30. 7 and 12 and 20 and 29 (2990)
31. limit 30 to yr="2008 -Current" (1786)

EMBASE (OvidSP)

1974–2013, week 47. Searched 29 November 2013. Retrieved 1817 records.

1. exp *obesity/ (155,014)
2. obes\$.ti,ab. (230,793)
3. (overweight or over weight).ti,ab. (50,932)
4. adiposity.ti,ab. (17,286)
5. or/1-4 (284,389)
6. child/ or preschool child/ or infant/ or adolescent/ (2,393,076)
7. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (1,609,328)
8. (adolescen\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (321,701)
9. (girl or girls or boy or boys or kid or kids).ti,ab. (216,205)
10. or/6-9 (3,060,352)
11. *body mass/ (13,857)
12. *skinfold thickness/ (878)
13. *waist hip ratio/ (435)
14. *waist to height ratio/ (73)
15. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (192,624)
16. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$ or ratio\$)).ti,ab. (6078)
17. ((waist-to-hip or waist-hip) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (9123)
18. ((waist-to-height or waist-height) adj3 (ratio\$ or test\$ or measure\$)).ti,ab. (943)
19. or/11-18 (200,267)
20. *qualitative research/ (1999)
21. exp *interview/ (4976)
22. exp *questionnaire/ (21,687)
23. qualitative.ti. (23,346)
24. (qualitative adj2 (research or design or analy\$ or study or studies)).ab. (39,253)
25. ((semi structured or semistructured or "in depth" or indepth or "face to face" or structured) adj3 (interview\$ or questionnaire\$)).ti,ab. (73,258)
26. focus group\$.ti,ab. (24,951)
27. (survey or surveys).ti,ab. (439,960)
28. or/20-27 (577,107)
29. 5 and 10 and 19 and 28 (3065)
30. limit 29 to yr="2008 -Current" (1981)
31. limit 30 to human (1817)

PsycINFO (OvidSP)

1806–2013, November week 4. Searched 29 November 2013. Retrieved 407 records.

1. obesity/ (14,582)
2. overweight/ (2395)
3. obes\$.ti,ab. (21,761)
4. (overweight or over weight).ti,ab. (8389)
5. (adiposity or adipose).ti,ab. (2017)
6. or/1-5 (26,356)
7. (adolescence 13 17 yrs or childhood birth 12 yrs or preschool age 2 5 yrs or school age 6 12 yrs).ag. (580,191)
8. (child\$ or infant\$ or pediat\$ or paediat\$ or schoolchild\$ or school age\$ or schoolage\$).ti,ab. (548,894)
9. (adolescenc\$ or juvenile\$ or youth\$ or teenage\$ or youngster\$).ti,ab. (213,993)
10. (girl or girls or boy or boys or kid or kids).ti,ab. (79,108)
11. or/7-10 (857,627)
12. body mass index/ (2341)
13. ((body mass adj3 (index\$ or indices)) or bmi or quetelet\$).ti,ab. (13,959)
14. ((skin fold or skinfold) adj3 (thickness\$ or test\$ or measure\$)).ti,ab. (266)
15. ((waist-to-hip or waist-hip) adj3 ratio\$).ti,ab. (536)
16. ((waist-to-height or waist-height) adj3 ratio\$).ti,ab. (49)
17. or/12-16 (14,433)
18. qualitative research/ (3954)
19. surveys/ (5716)
20. Interviews/ (6289)
21. questionnaires/ (13,293)
22. qualitative.ti. (12,856)
23. (qualitative adj2 (research or design or analy\$ or study or studies)).ab. (39,640)
24. ((semi structured or semistructured or "in depth" or indepth or "face to face" or structured) adj3 (interview\$ or questionnaire\$)).ti,ab. (54,779)
25. focus group\$.ti,ab. (18,305)
26. (survey or surveys).ti,ab. (167,456)
27. or/18-26 (277,935)
28. 6 and 11 and 17 and 27 (580)
29. limit 28 to (human and yr="2008 -Current") (407)

Cumulative Index to Nursing and Allied Health Literature (EBSCOhost)

1981–25 November 2013. Searched 29 November 2013. Retrieved 1087 records.

	Search term	Number retrieved
S32	S30 AND S31	1087
S31	EM 2008 OR EM 2009 OR EM 2010 OR EM 2011 OR EM 2012 OR EM 2013	2,101,609
S30	S4 AND S9 AND S17 AND S29	1436
S29	S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28	237,317
S28	T1 (survey or surveys) or AB (survey or surveys)	101,965
S27	T1 ("focus group*") or AB ("focus group*")	13,696
S26	T1 ("semi structured" N3 questionnaire* or semistructured N3 questionnaire* or "in depth" N3 questionnaire* or indepth N3 questionnaire* or "face to face" N3 questionnaire* or structured N3 questionnaire*) or AB ("semi structured" N3 questionnaire* or semistructured N3 questionnaire* or "in depth" N3 questionnaire* or indepth N3 questionnaire* or "face to face" N3 questionnaire* or structured N3 questionnaire*)	4055

	Search term	Number retrieved
S25	TI ("semi structured" N3 interview* or semistructured N3 interview* or "in depth" N3 interview* or indepth N3 interview* or "face to face" N3 interview* or structured N3 interview*) or AB ("semi structured" N3 interview* or semistructured N3 interview* or "in depth" N3 interview* or indepth N3 interview* or "face to face" N3 interview* or structured N3 interview*)	26,782
S24	AB (qualitative N2 research or qualitative N2 design or qualitative N2 analy* or qualitative N2 study or qualitative N2 studies)	25,762
S23	TI (qualitative)	11,199
S22	(MH "Surveys")	80,428
S21	(MH "Focus Groups")	23,633
S20	(MH "Structured Questionnaires")	3621
S19	(MH "Structured Interview")	7582
S18	(MH "Qualitative Studies")	54,848
S17	S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16	55,290
S16	TI (waist-to-height N3 ratio* or waist-height N3 ratio*) or AB (waist-to-height N3 ratio* or waist-height N3 ratio*)	152
S15	TI (waist-to-hip N3 ratio* or waist-hip N3 ratio*) or AB (waist-to-hip N3 ratio* or waist-hip N3 ratio*)	1080
S14	TI ("skin fold" N3 thickness* or skinfold N3 thickness* or "skin fold" N3 test* or skinfold N3 test* or "skin fold" N3 measure* or skinfold N3 measure*) or AB ("skin fold" N3 thickness* or skinfold N3 thickness* or "skin fold" N3 test* or skinfold N3 test* or "skin fold" N3 measure* or skinfold N3 measure*)	831
S13	TI ("body mass" N3 index* or "body mass" N3 indices or bmi or quetelet*) or AB ("body mass" N3 index* or "body mass" N3 indices or bmi or quetelet*)	25,156
S12	(MH "Waist-Hip Ratio")	1862
S11	(MH "Skinfold Thickness")	2693
S10	(MH "Body Mass Index")	41,875
S9	S5 OR S6 OR S7 OR S8	583,162
S8	TI (girl or girls or boy or boys or kid or kids) or AB (girl or girls or boy or boys or kid or kids)	27,490
S7	TI (adolescen* or juvenile* or youth* or teenage* or youngster*) or AB (adolescen* or juvenile* or youth* or teenage* or youngster*)	78,940
S6	TI (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*) or AB (child* or infant* or pediat* or paediat* or schoolchild* or "school age*" or schoolage*)	288,578
S5	(ZG "adolescent: 13-18 years") or (ZG "child, preschool: 2-5 years") or (ZG "child: 6-12 years")	464,855
S4	S1 or S2 or S3	60,863
S3	TI (adiposity) or AB (adiposity)	2421
S2	TI (obes* or overweight or "over weight") or AB (obes* or overweight or "over weight")	40,025
S1	(MH "Obesity")	47,606

Appendix 2 Protocol changes

Review of adult morbidities

Minimum study size of 1000.

Review of tracking of obesity into adulthood

Need for test accuracy data:

- reference standard in adulthood
- measures of effect.

Originally modelling and the tracking of obesity, regardless of measurement, increases data and reduces uncertainty in model. As no model studies report RR OR of obesity in adulthood, or use same simple measure as in childhood, do not give accuracy data – no evidence for accuracy in adulthood. Therefore these studies have been identified for future modelling but have not informed the review of predictive accuracy. Need reference standard and data from which accuracy estimates can be derived.

Review of the diagnostic accuracy of obesity measures in childhood

No protocol changes.

Review of the acceptability and ease of use of childhood measures of obesity

No protocol changes.

Appendix 3 Data extraction tables

Review of adult morbidities

TABLE 49 Prediction of adult morbidity review: childhood weight category assessment measure

Study	Childhood measurement	Reference data
Ahlgren (2004) ¹⁴⁰	BMI	Internally derived BMI at 14 years divided into median of each quintile
Baker (2007) ¹⁴²	BMI	Internally derived age- and sex-specific z-scores based on health examinations performed between 1955 and 1960
Baker (2007) ¹⁴¹	BMI	Internally derived age- and sex-specific z-scores based on health examinations performed between 1955 and 1960
Barker (2002) ¹⁴³	BMI	Internally derived age- and sex-specific z-scores based on piecewise linear function, backtransformed into corresponding BMI values
Barker (2005) ¹⁴⁴	BMI	Internally derived age- and sex-specific z-scores backtransformed into corresponding BMI values
Berentzen (2013) ¹⁴⁵	BMI	Internally derived
Bjorge (2004) ¹⁴⁶	BMI	External ^a
Bjorge (2008) ¹⁴⁷	BMI	External ^a
Cheng (2011) ¹¹⁷	BMI, WC	External CDC 2000 ²¹⁹ (age 6 years) and Chinese government standard
Cheung (2004) ¹¹⁸	BMI	<ul style="list-style-type: none"> • External^b • Internally derived 95th centile at age 11 years
De Stavola (2004) ¹⁴⁸	BMI	Internally derived age- and sex-specific z-scores
Engeland (2003) ¹⁴⁹	BMI	External ^a
Eriksson (2001) ¹⁵⁰	BMI	Internally derived age- and sex-specific z-scores based on piecewise linear function. z-scores were backtransformed into corresponding BMI values
Forsen (2000) ¹⁵¹	BMI	Internally derived age- and sex-specific z-scores based on piecewise linear function. z-scores were backtransformed into corresponding BMI values
Forsen (2004) ¹⁵²	BMI	Internally derived age- and sex-specific z-scores based on piecewise linear function. z-scores were backtransformed into corresponding BMI values
Goldhaber-Fiebert (2013) ¹²³	BMI	External ^a
Gunnell (1998) ¹⁵³	BMI	<ul style="list-style-type: none"> • External^c (main analysis) • Internally derived (secondary analysis)
Hilakivi-Clarke (2001) ¹⁵⁴	BMI	Internally derived age- and sex-specific z-scores based on piecewise linear function. z-scores were backtransformed into corresponding BMI values
Hypponen (2003) ¹⁵⁵	BMI	Internally derived age- and sex-specific z-score
Israeli (2007) ¹⁵⁶	BMI	Internal, using adult WHO cut-off points (O: ≥ 30 kg/m ² ; OW: 25.0–29.9 kg/m ²)
Janssen (2005) ¹⁵⁷	BMI	External ^{a,b}
Jeffreys (2004) ¹⁵⁸	BMI	Internally derived sex-specific z-scores (adjusted for sex in analyses)
Lawlor (2005) ¹⁵⁹	BMI	<ul style="list-style-type: none"> • Internally derived (main analysis) age- and sex-specific z-scores • External^b (secondary analysis)
Lawlor (2006) ¹⁶⁰	BMI	Internally derived sex- and age-specific z-scores
Leiba (2012) ¹⁶¹	BMI	External ^a

continued

TABLE 49 Prediction of adult morbidity review: childhood weight category assessment measure (*continued*)

Study	Childhood measurement	Reference data
Leiba (2013) ¹⁶²	BMI	Internally derived BMI quintiles and 2.5 BMI unit increments
Levi (2011) ¹⁶³	BMI	Internally derived (main and secondary analyses) using 85th centile cut-off point and by BMI quintiles
Levi (2012) ¹⁶⁴	BMI	Internally derived (main and secondary analyses) using 85th centile cut-off point and by BMI quintiles
Li (2007) ¹⁶⁵	BMI	External ^b
Mattsson (2008) ¹⁶⁷	BMI	Internally derived age- and sex-specific 80th centile (approximately 17 kg/m ² in children, 21.5 kg/m ² in adolescents)
Magnussen (2010) ¹⁶⁶	BMI	External ^b
Merten (2010) ¹²⁹	BMI	External ^a
Morrison (2010) ¹⁶⁸	BMI, WC ^d	Internally derived using 95th centile cut-off point (for both BMI and WC)
Osmond (2007) ¹⁶⁹	BMI	Internally derived age-specific z-scores (adjusted for sex in analyses)
Sachdev (2009) ¹⁷⁰	BMI	<ul style="list-style-type: none"> ● External^a (main analysis) ● Internally derived age-specific z-scores (adjusted for sex in analyses) (secondary analysis)
Schmidt (2011) ¹⁷¹	BMI, WC, WHR, sum of SFT ^e	Internally derived quartiles for BMI, WC, SFT (equation NR)
Tirosh (2011) ¹⁷²	BMI	<ul style="list-style-type: none"> ● Internally derived deciles at 17 years ● External^a

NR, not reported; O, obese; OW, overweight.

a CDC 2000.²¹⁹

b Cole 2000.²²⁰

c Cole 1990.²²¹

d WC site not reported.

e WC naval, sum SFT (triceps, biceps, scapula, suprailium).

TABLE 50 Population characteristics of morbidity studies

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow-up (years)	Male (%)	Ethnicity (%)	SES (%)	Weight distribution (%)
Ahlgren (2004) ¹⁴⁰	Copenhagen	161,063	117,415	7–14	NR	0	NR	NR	NR
Baker (2007) ¹⁴²	Copenhagen	276,835	NR	7–13	NR	51	NR	NR	NR
Baker (2007) ¹⁴¹	Copenhagen	276,835	NR	7–13	≥25	51	NR	NR	NR
Barker (2002) ¹⁴³	Helsinki 1934	10,519	8760	1–12	27–63	53	NR	NR	NR
Barker (2005) ¹⁴⁴	Helsinki 1934	10,519	8760	0–11	27–64	53	NR	NR	NR
Berentzen (2013) ¹⁴⁵	Copenhagen	372,636	285,884	7–13	31–80	51	NR	NR	NR
Bjorge (2004) ¹⁴⁶	Norway	227,224	227,221	14–19	47–52	51	NR	NR	OW: ^a 6
Bjorge (2008) ¹⁴⁷	Norway	227,000	226,682	14–19	Mean 52	51	NR	NR	OW: ^a 6
Cheng (2011) ¹¹⁷	BCAMSS	2189	1184	6–16	Mean 16 (SD 1.8)	54	Asian (Chinese) 100	Urban 'more affluent': 80	O: ^a 1 OW: ^b 15.3 O: ^b 40.8
Cheung (2004) ¹¹⁸	NCDS	17,000	12,327	7, 11, 16	42	52	NR	NR	OW: ^c 10.4 (7 years) to 11.4 (16 years)
De Stavola (2004) ¹⁴⁸	MRC NSHD	2547	2187	2–15	47–53	0	NR	NR	O: ^c 2.2 (7 years) to 1.4 (16 years)

continued

TABLE 50 Population characteristics of morbidity studies (continued)

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow-up (years)	Male (%)	Ethnicity (%)	SES (%)	Weight distribution (%)
Engeland (2003) ¹⁴⁹	Norway	NR	111,883	14–19	Mean 41	0	NR	NR	Low (<25th centile): 16 Medium (25th–74th centile): 65 High (75th–84th centile): 11 Very high (≥85th centile): ^a 8
Eriksson (2001) ¹⁵⁰	Helsinki 1934	5502	3544	0–12	27–63	100	NR	NR	NR
Forsen (2004) ¹⁵²	Helsinki 1934	5486	3003	0–11	27–64	0	NR	Low: 68 Medium: 21	NR
Forsen (2000) ¹⁵¹	Helsinki 1924	NR	7086	6–16	31–73	51	NR	High: 11 Low: 88	NR
Goldhaber-Fiebert (2013) ¹²³	NLSY79/PSID/ NHANES	NR	2780	2–15	38–49	51	NR	High: 4 NR: 8	OW: ^a 9–10 for 5-year-olds; 14–15 for 15-year-olds
Gunnell (1998) ¹⁵³	Boyd Orr	NR	2399	2–14	Up to 73	49	NR	NR	NR
Hilakivi-Clarke (2001) ¹⁵⁴	Helsinki 1924	NR	3447	7 and 15	Minimum 38 (76% > 50 years)	0	NR	NR	O: ^a 12–13 for 5-year-olds; 11–17 for 15-year-olds
Hypponen (2003) ¹⁵⁵	British birth cohort	16,751	10,683	7, 11, 16	41	NR	NR	NR	NR

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow-up (years)	Male (%)	Ethnicity (%)	SES (%)	Weight distribution (%)
Israeli (2007) ¹⁵⁶	Israel SPEC	18,513	NR	16–19	26–45	100	NR; nearly all Caucasian	NR	OW: ^d 7.4 O: ^d 1.1
Janssen (2005) ¹⁵⁷	Bogalusa	3865	1709	4–15	19–38	44	White: 66 Black: 34	NR	HW: ^a 83.7 OW: ^a 9.9 O: ^a 6.4 OW or O: ^a 16.3
Jeffreys (2004) ¹⁵⁸	Boyd Orr	2997	2347	2–14	Up to 66	49	NR	Low: 67	NR
Lawlor (2005) ¹⁵⁹	Aberdeen	12,150	11,106	Mean 4.9	48–54	NR	NR	NR	OW: ^c 18 O: ^c 3
Lawlor (2006) ¹⁶⁰	Aberdeen	12,150	5793	Mean 4.9	46–50	NR	NR	NR	OW: ^c 18 O: ^c 3
Leiba (2012) ¹⁶¹	Israeli army	NR	1,110,835	16–19	Mean 35	100	Origin: Europe 41.5; Asia 26.7; Africa 26.3; Israel 5.2	Low: 27 Medium: 51.3 High: 21.7	OW or O: ^a 12.1
Leiba (2013) ¹⁶²	Israeli army	NR	1,110,835	16–19	Mean 44	100	Origin: Europe 41.5; Asia 26.7; Africa 26.3; Israel 5.2	Low: 27 Medium: 51.3 High: 21.7	OW or O: ^a 12.1

continued

TABLE 50 Population characteristics of morbidity studies (continued)

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow-up (years)	Male (%)	Ethnicity (%)	SES (%)	Weight distribution (%)
Levi (2011) ¹⁶³	Israeli army	NR	1,109,864	16–19	19–57	100	Origin: Europe 41.5; Asia 26.7; Africa 26.3; Israel 5.2	NR	OW or O: ^a 12.5
Levi (2012) ¹⁶⁴	Israeli army	NR	720,927	16–19	29–56	100	Origin: Europe 41.5; Asia 26.7; Africa 26.3; Israel 5.2	Low: 28.6 Medium: 48.9 High: 21.6	O or OW: ^a 10
Li (2007) ¹⁶⁵	British birth cohort 1958	13,294	9285	7–16	45	52	NR	NR	OW: ^a 8 O: ^a 2
Mattsson (2008) ¹⁶⁷	Young Finns	4320	2195	3–18	24–39	46	Caucasian 100	Low: 3.4–13.1 Medium 73.7–86.6 High: 9–17.2	OW or O: ^a 10 NR
Magnussen (2010) ¹⁶⁶	Young Finns/ Bogalusa	20,745	10,439	12–19	19–26	51.1	White: 55 Asian: 6 Black: 22 Hispanic: 16 Native American: ≈1	NR	NR
Merten (2010) ¹²⁹	NLSAH	1889 (PFS 822; NGHS 1067)	Up to 1058 (NGHS)	PFS: mean 12.4 NGHS: NR	PFS: 32–44 NGHS: 19	PFS: 47 NGHS: 0	White: 72 Black: 28	NR	NR

Study	Cohort	Number at baseline	Number at follow-up	Childhood age (years)	Adult age at final follow-up (years)	Male (%)	Ethnicity (%)	SES (%)	Weight distribution (%)
Morrison (2010) ¹⁶⁸	NGHS/PFS	NR	12,439	0–11	NR	52	NR	NR	NR
Osmond (2007) ¹⁶⁹	Helsinki 1934	8181	1492	2–14	26–33	58	NR (presumably Asian)	NR	NR
Sachdev (2009) ¹⁷⁰	Delhi	8498	2188	7–15	26–36	50	NR	NR	NR
Schmidt (2011) ¹⁷¹	ASHFS	NR	37,674	Mean 17.1	Mean 34	100	NR	NR	NR; range from 15 to 36 kg/m ²
Tirosh (2011) ¹⁷²	Israel – SPEC	161,063	117,415	Median 7.2 to 14.5	NR	0	NR	NR	NR

ASHFS, Australian Schools Health Fitness Survey; BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; HW, healthy weight; MRC NSHD, Medical Research Council National Survey of Health and Development; NGHS, National Growth and Health study; NR, not reported; O, obese; OW, overweight; PFS, Princeton follow-up study; SPEC, Staff Periodic Examination Center.

a CDC 2000.²¹⁹

b Chinese Government standard.

c Cole 2000.²²⁰

d WHO cut-off points (O: ≥ 30 kg/m², OW: 25.0–29.9 kg/m²).

e Cole 1990.²²¹

Review of tracking of obesity into adulthood

TABLE 51 Study characteristics of tracking studies

Study	Country in which study conducted	Study/cohort name	Study dates		Study design	Setting for anthropometric measure in childhood
			Start	Finish		
Cheng (2011) ¹¹⁷	China	BCAMSS	2004	2010	Longitudinal	School
Cheung (2004) ¹¹⁸	UK	NCDS (1958 British birth cohort)	1958	2000	Longitudinal	Community
Engeland (2004) ¹¹⁹	Norway	None	1963	1999	Longitudinal	Community
Freedman (2001) ¹²⁰	USA/Canada	Bogalusa	1973	1996	Longitudinal	School children
Freedman (2005) ¹²²	USA/Canada	Bogalusa	1973	1994	Longitudinal	School children
Freedman (2005) ¹²¹	USA/Canada	Bogalusa	1973	1996	Longitudinal	School children
Gordon-Larsen (2004) ¹²⁴	USA/Canada	NLSAH	1996	2002	Longitudinal	School
Goldhaber-Fiebert (2013) ¹²³	USA/Canada	NHANES/NLSY79	1970	2008	Longitudinal	Community
Juhola (2011) ¹²⁵	Finland	Cardiovascular Risk in Young Finns	1980	2007	Longitudinal	NR
Juonala (2006) ¹²⁶	Finland	Cardiovascular Risk in Young Finns	1980	2001	Longitudinal	NR
Liddle (2012) ¹²⁷	Australia/New Zealand	MUSP	1986	NR (follow-up for 18 years)	Longitudinal	NR
Mamun (2005) ¹²⁸	Australia/New Zealand	MUSP	1986–90	2000–4	Longitudinal	NR
Merten (2010) ¹²⁹	USA/Canada	NLSAH	1995	2001	Longitudinal	School
Nakanio (2010) ¹³¹	Japan	Tokushima Prefecture	2001	2008	Longitudinal	School
Nakano (2010) ¹³⁰	Japan	Tokushima Prefecture	2001	2007	Longitudinal	School
Patton (2011) ¹³²	Australia/New Zealand	None	1992	2003	Longitudinal	School
Power (1997) ¹³³	UK	NCDS (1958 British birth cohort)	1958	1991	Longitudinal	Community
Reilly (2011) ¹³⁴	UK	ALSPAC	1998/1999	2003/2004	Longitudinal	Research clinic

Study	Country in which study conducted	Study/cohort name	Study dates		Study design	Setting for anthropometric measure in childhood
			Start	Finish		
Starc (2011) ¹³⁵	Slovenia	1988–90 Slovenian cohort	1997	2008	Longitudinal	School
Stovitz (2010) ¹³⁶	USA/Canada	CATCH	1991	2001	Longitudinal	School
Thompson (2007) ¹³⁷	USA/Canada	NGHS/PFS	1986	1997	Longitudinal	School
Venn (2007) ¹³⁸	Australia/New Zealand	ASHFS	1985	2005	Longitudinal	School
Wang (2008) ¹³⁹	USA/Canada	NLSY79	1981	2002	Longitudinal	Self-reported; data collected by interview/survey

ALSPAC, Avon Longitudinal Study of Parents and Children; ASHFS, Australian Schools Health Fitness Survey; BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; CATCH, Child and Adolescent Trial for Cardiovascular Health; NGHS, National Growth and Health study; NR, not reported; PFS, Princeton follow-up study.

TABLE 52 Childhood measures of tracking studies

Study	Childhood measure	Reference data/standardisation
Cheng (2011) ¹¹⁷	BMI	CDC 2000 ²¹⁹ > 85th centile (OW)/> 95th centile (O)
	WC	'Chinese reference population'
Cheung (2004) ¹¹⁸	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O), ROC derived
Engeland (2004) ¹¹⁹	BMI (kg/m ²)	CDC 2000 ²¹⁹ > 85th centile (OW)/> 95th centile (O) (≥ 85th centile very high weight)
Freedman (2001) ¹²⁰	BMI (kg/m ²)	The authors used cut-off points < 50th, 50th–74th, 75th–84th, 85th–94th and ≥ 95th centiles. The cut-off point of ≥ 95th centile was defined as OW in the paper, but extracted as O for the review
Freedman (2005) ¹²²	BMI (kg/m ²)	Children: BMI ≥ 95th centile OW
Freedman (2005) ¹²¹	BMI (kg/m ²)	> 85th–94th centile at risk of OW, > 95th centile OW
Goldhaber-Fiebert (2013) ¹²³	BMI (kg/m ²)	CDC 2000 ²¹⁹ > 85th centile (OW)/> 95th centile (O)
Gordon-Larsen (2004) ¹²⁴	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Juhola (2011) ¹²⁵	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Juonala (2006) ¹²⁶	BMI (kg/m ²)	BMI 80th–90th centile (OW)/90th centile (O)
Liddle (2012) ¹²⁷	BMI	IOTF/Cole: > 17.42 kg/m ² OW/O for boys and > 17.15 kg/m ² OW/O for girls
	SFT	One site measured; measurements were converted to a z-score internally adjusted for age and sex. Cut-off points generated proportions of OW/O similar to Cole 2000 BMI subgroups
Mamun (2005) ¹²⁸	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Merten (2010) ¹²⁹	BMI (kg/m ²)	CDC 2000 ²¹⁹ > 95th centile O
Nakano (2010) ¹³⁰	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Nakano (2010) ¹³¹	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Patton (2011) ¹³²	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Power (1997) ¹³³	BMI (kg/m ²)	UK90 > 91st centile (OW)/≥ 98th centile (O); 95th centile used also
Reilly (2011) ¹³⁴	BMI (kg/m ²)	UK90 > 85th centile (OW)/> 95th centile (O)
Starc (2011) ¹³⁵	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Stovitz (2010) ¹³⁶	BMI (kg/m ²)	CDC 2000 reference growth charts BMI > 85th centile (OW)/> 95th centile (O)
Thompson (2007) ¹³⁷	BMI (kg/m ²)	CDC 2000 ²¹⁹ > 85th centile (OW)/> 95th centile (O). The authors used CDC 95th centile to define OW, but it was extracted as O in this review
Venn 2007 ¹³⁸	BMI (kg/m ²)	IOTF/Cole/WHO BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Wang (2008) ¹³⁹	BMI (kg/m ²)	CDC 2000 revised growth chart > 85th centile (OW)/> 95th centile (O)

O, obese; OW, overweight.

TABLE 53 Adult^a measures of tracking studies

Study	Reference data/standardisation
Cheng (2011) ¹¹⁷	CDC 2000 ²¹⁹ > 85th centile (OW)/> 95th centile (O)
Cheung (2004) ¹¹⁸	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O); cut-off points derived from ROC curves
Engeland (2004) ¹¹⁹	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O); the authors used additional intermediate cut-off points
Freedman (2001) ¹²⁰	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Freedman (2005) ¹²²	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Freedman (2005) ¹²¹	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Goldhaber-Fiebert (2013) ¹²³	CDC 2000 ²¹⁹ > 85th centile (OW)/> 95th centile (O)
Gordon-Larsen (2004) ¹²⁴	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Juhola (2011) ¹²⁵	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Juonala (2006) ¹²⁶	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Liddle (2012) ¹²⁷	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Mamun (2005) ¹²⁸	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Merten (2010) ¹²⁹	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Nakano (2010) ¹³⁰	IOTF (Cole 2000220) children cut-off points
Nakano (2010) ¹³¹	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Patton (2011) ¹³²	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Power (1997) ¹³³	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Reilly (2011) ¹³⁴	> 85th centile (OW)/> 95th centile (O)
Starc (2011) ¹³⁵	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Stovitz (2010) ¹³⁶	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Thompson (2007) ¹³⁷	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Venn (2007) ¹³⁸	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)
Wang (2008) ¹³⁹	IOTF/Cole/WHO adult BMI 25 kg/m ² (OW)/30 kg/m ² (O)

O, obese; OW, overweight.

a Adult refers to the second measure, and thus can include adolescence, i.e. in those studies that tracked weight status from childhood to adolescence.

TABLE 54 Population characteristics of tracking studies

Study	Total <i>n</i> at baseline	Total <i>n</i> at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Male (%)	Ethnicity (%)	Weight distribution (%)	SES (%)
Cheng (2011) ¹¹⁷	2 189	1 184	6–16	Mean 16 (SD 1.8)	54	Asian (Chinese)	OW: 15.3 O: 40.8	Urban 'more affluent'
Cheung (2004) ¹¹⁸	17 000	12,327; analysis on randomly selected 50% sample	7, 11, 16	33 for tracking, 42 for morbidities	52 (at 7 years)	NR	OW: 10.4 (7 years) to 11.4 (16 years) (whole cohort at baseline) O: 2.2 (7 years) to 1.4 (16 years) (whole cohort at baseline)	NR
Engeland (2004) ¹¹⁹	227,003	128,121	Mean 17 (range 14–19)	Range 24–54	NR	NR	OW: 4.9 for boys and 7.3 for girls (OW ≥ 85th centile)	NR
Freedman (2001) ¹²⁰	9597	2617	Mean 10 (SD 3), range 2–17	Mean 27 (SD 5), range 18–37	43	Black: 32	O: 7	NR
Freedman (2005) ¹²²	11,411	2610	Mean 10.0 (SD 3), range 2–17	Mean 27.5 (range 18–37)	42.7	Black: 32	OW: 7 for boys and 6 for girls	NR
Freedman (2005) ¹²¹	7923	2392	Mean 9.7 (range 5–14)	Range 18–37	44.9	Black: 36	OW: ≈ 7	NR
Goldhaber-Fiebert (2013) ¹²³	NR	4884 (tracking), 2780 (morbidities)	2–15	18 years (for tracking), 38–49 (for morbidities)	51	NR	OW: 9–10 for 5-year-olds, 14–15 for 15-year-olds O: 12–13 for 5-year-olds, 11–17 for 15-year-olds	NR

Study	Total <i>n</i> at baseline	Total <i>n</i> at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Male (%)	Ethnicity (%)	Weight distribution (%)	SES (%)
Gordon-Larsen (2004) ¹²⁴	14,438	9795 (including total population at 13–15 years, 16–17 years and 18–20 years)	Mean 16.0 (95% CI 15.8 to 16.2), range 13–20	Mean 21.4 (range 19–26)	49	White: 55.9 Asian: 7.5 Black: 20.5 Hispanic: 16.2 (all of whole cohort)	O: 10.9 (95% CI 9.8 to 12.1)	NR
Juhola (2011) ¹²⁵	3596	2204	Range 3–18	30–45	45.1	NR	NR	NR
Juonala (2006) ¹²⁶	3596	2260	Range 3–18	24–39	NR	NR	HW/lean: 51 (BMI < 50th centile) OW: 10.5 (BMI 80th–90th centile) O: 8.6 (BMI > 90th centile)	NR
Liddle (2012) ¹²⁷	3960	1755	5	Mean 20.5 (range 18.2–23.1)	50	98% European descent	NR	NR
Marmun (2005) ¹²⁸	NR	2794	5	14	NR	NR	OW: 17 (OW or O)	NR

continued

TABLE 54 Population characteristics of tracking studies (continued)

Study	Total <i>n</i> at baseline	Total <i>n</i> at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Male (%)	Ethnicity (%)	Weight distribution (%)	SES (%)
Merten (2010) ¹²⁹	20,745	10,439	Mean 15 (range 12–19)	22	51.1	White: 55 Asian: 6 Black: 22 Hispanic: 16 Native American: ≈ 1	NR	NR
Nakano (2010) ¹³⁰	22,827	16,245	8	14	51.9	NR	OW: 18.28 for boys and 17.09 for girls	NR
Nakano (2010) ¹³¹	7506	5024	7	14	51.8	NR	O: 5.94 for boys and 4.13 for girls	NR
Patton (2011) ¹³²	1943	1520	Mean age 14.9 and 15.5 for two entry points at 1992 and 1993	24	46	NR	NR	NR
Power (1997) ¹³³	17,733	11,407	7–16	33	51.7	NR	NR	NR
		(<i>n</i> = 13,296 at first assessment at age 7 years)						Parental education: one-third had incomplete schooling; one-third completed schooling; half had university degree

Study	Total <i>n</i> at baseline	Total <i>n</i> at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Male (%)	Ethnicity (%)	Weight distribution (%)	SES (%)
Reilly (2011) ¹³⁴	7759	5175	7	13	49.4	NR	HW: 83.6 OW: 8.1 for male and 9.6 for female O: 8.2 for male and 6.8 for female	By maternal educational attainment: no qualification, 10.4 for males and 10.9 for females; degree qualification, 17.4 for males and 18.4 for females
Starc (2011) ¹³⁵	21,777	4833	7.7 (SD 0.3)	18	48.2	NR	HW: males 81.1, females 82.5 OW: males 13.2, females 13.1 O: males 5.7, females 4.4	NR
Stovitz (2010) ¹³⁶	5106	2802	8.7 (SD 0.45)	18.3 (SD 0.5)	48.8	White: 74 Black: 12 Hispanic: 10 Other: 4	HW: 74.6 OW: 14.9 OW or O: 25.4 O: 10.5	NR
Thompson (2007) ¹³⁷	1963	1669 (at age 16 years)	10–16	21–23	0	White: 49 Black: 51	OW: at baseline, 7.4–8.7 for Caucasian; 17.4–18.2 for AA (the authors used CDC 95th centile to define OW, but it was extracted as O in the review)	NR

continued

TABLE 54 Population characteristics of tracking studies (continued)

Study	Total <i>n</i> at baseline	Total <i>n</i> at final follow-up	Childhood age (years)	Adult (final follow-up) age (years)	Male (%) (of adults)	Ethnicity (%)	Weight distribution (%)	SES (%)
Venn (2007) ¹³⁸	8498	4571	7–15	24–34	48 (of adults)	NR	OW: boys 8.3, girls 9.7 O: boys 1.5, girls 1.4	NR
Wang (2008) ¹³⁹	2513	1309	16–17	37–38	52	White: 52 Black: 28 Hispanic: 20	OW: 89 OW: 8 O: 3	NR The authors reported that 47% of the study sample had educational attainment of college or above

AA, African American; HW, healthy weight; NR, not reported; O, obese; OW, overweight.

TABLE 55 2 x 2 data

Author	Population	Obesity measure	Childhood				Adult				Numbers			
			Age at measure (years)		Definition/cut-off point		Age at measure (years)		Definition/cut-off point		Bad to bad	Bad to good	Good to bad	Bad to bad
			Good	Bad	Good	Bad	Good	Bad						
Nakano ¹³¹	Boys and girls	BMI	7	≤ 85th centile	> 85th centile	14	≤ 85th centile	> 85th centile	458	363	356	3847		
Nakano ¹³¹	Boys	BMI	7	≤ 85th centile	> 85th centile	14	≤ 85th centile	> 85th centile	259	188	192	1962		
Nakano ¹³¹	Girls	BMI	7	≤ 85th centile	> 85th centile	14	≤ 85th centile	> 85th centile	199	175	164	1885		
Gordon-Larsen ¹²⁴	Boys and girls	BMI	13–15	≤ 95th centile	> 95th centile	19–26	< 30 kg/m ²	≥ 30 kg/m ²	289	62	364	2537		
Gordon-Larsen ¹²⁴	Boys and girls	BMI	16–17	≤ 95th centile	> 95th centile	19–26	< 30 kg/m ²	≥ 30 kg/m ²	395	71	592	3142		
Gordon-Larsen ¹²⁴	Boys and girls	BMI	13–15	≤ 85th centile	> 85th centile	19–26	< 30 kg/m ²	≥ 30 kg/m ²	322	91	315	2521		
Gordon-Larsen ¹²⁴	Boys and girls	BMI	16–17	≤ 85th centile	> 85th centile	19–26	< 30 kg/m ²	≥ 30 kg/m ²	412	84	533	3176		
Stovitz ¹³⁶	Boys and girls	BMI	8.7 (SD 0.45)	≤ 85th centile	> 85th centile	Mean 18.3 (SD 0.5)	≤ 85th centile	> 85th centile	566	146	431	1659		
Thompson ¹³⁷	Girls	BMI	10	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	187	84	218	1474		
Thompson ¹³⁷	Girls	BMI	11	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	195	88	193	1381		
Thompson ¹³⁷	Girls	BMI	12	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	211	102	172	1389		
Thompson ¹³⁷	Girls	BMI	13	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	209	80	164	1354		
Thompson ¹³⁷	Girls	BMI	14	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	196	75	145	1241		
Thompson ¹³⁷	Girls	BMI	15	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	202	63	131	1221		
Thompson ¹³⁷	Girls	BMI	16	≤ 95th centile	> 95th centile	21–23	< 30 kg/m ²	≥ 30 kg/m ²	202	57	124	1286		
Mamun ¹²⁸	Boys and girls	BMI	5	≤ 85th centile	> 85th centile	14	≤ 85th centile	> 85th centile	296	173	405	1920		
Nakano ¹³⁰	Boys	BMI	8	≤ 85th centile	> 85th centile	14	≤ 85th centile	> 85th centile	336	209	155	2282		
Nakano ¹³⁰	Girls	BMI	8	≤ 85th centile	> 85th centile	14	≤ 85th centile	> 85th centile	232	232	170	2081		
Nakano ¹³⁰	Boys	BMI	8	≤ 95th centile	> 95th centile	14	≤ 95th centile	> 95th centile	63	114	45	2760		
Nakano ¹³⁰	Girls	BMI	8	≤ 95th centile	> 95th centile	14	≤ 95th centile	> 95th centile	35	77	25	2578		
Merten ¹²⁹	Boys and girls	BMI	12–19	≤ 95th centile	> 95th centile	19–26	≤ 95th centile	> 95th centile	1081	294	1579	7485		

TABLE 56 3 × 3 data

Author	Population	Obesity measure	Childhood			Adulthood	
			Age at measure (years)	Definition/cut-off point			Age at measure (years)
				HW	OW	O	
Freedman ¹²⁰	Boys and girls	BMI	2–17	≤ 84th centile	85th–94th centile	≥ 95th centile	18–37
Liddle ¹²⁷	Boys and girls	BMI	5	≤ 84th centile	85th–94th centile	≥ 95th centile	18.2–23.1
Liddle ¹²⁷	Boys and girls	Triceps SFT	5	NR	NR	NR	18.2–23.1
Reilly ¹³⁴	Boys and girls	BMI	7	≤ 84th centile	85th–94th centile	≥ 95th centile	13
Reilly ¹³⁴	Boys	BMI	7	≤ 84th centile	85th–94th centile	≥ 95th centile	13
Reilly ¹³⁴	Girls	BMI	7	≤ 84th centile	85th–94th centile	≥ 95th centile	13
Freedman ¹²¹	Boys and girls	BMI	5–14	≤ 84th centile	85th–94th centile	≥ 95th centile	18–37
Freedman ¹²¹	Boys/blacks	BMI	5–14	≤ 84th centile	85th–94th centile	≥ 95th centile	18–37
Freedman ¹²¹	Boys/whites	BMI	5–14	≤ 84th centile	85th–94th centile	≥ 95th centile	18–37
Freedman ¹²¹	Girls/blacks	BMI	5–14	≤ 84th centile	85th–94th centile	≥ 95th centile	18–37
Freedman ¹²¹	Girls/whites	BMI	5–14	≤ 84th centile	85th–94th centile	≥ 95th centile	18–37
Starc ¹³⁵	Boys	BMI	7	≤ 84th centile	85th–94th centile	≥ 95th centile	18
Starc ¹³⁵	Boys	BMI	11	≤ 84th centile	85th–94th centile	≥ 95th centile	18
Starc ¹³⁵	Girls	BMI	7	≤ 84th centile	85th–94th centile	≥ 95th centile	18
Starc ¹³⁵	Girls	BMI	11	≤ 84th centile	85th–94th centile	≥ 95th centile	18
Venn ¹³⁸	Boys and girls	BMI	7–15	≤ 84th centile	85th–94th centile	≥ 95th centile	24–34
Venn ¹³⁸	Boys	BMI	7–15	≤ 84th centile	85th–94th centile	≥ 95th centile	24–34
Venn ¹³⁸	Girls	BMI	7–15	≤ 84th centile	85th–94th centile	≥ 95th centile	24–34
Cheng ¹¹⁷	Boys and girls	BMI	6–16	NR	NR	NR	12–22

HW, healthy weight; NR, not reported; O, obese; OW, overweight.

Definition/cut-off point			Numbers								
HW	OW	O	O to O	O to OW	O to HW	OW to O	OW to OW	OW to HW	HW to O	HW to OW	HW to HW
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	144	30	12	129	84	40	308	555	1315
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	18	15	11	67	85	78	122	273	1086
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	10	16	22	54	70	114	143	287	1039
≤ 84th centile	85th–94th centile	≥ 95th centile	281	68	41	152	167	140	206	446	3674
≤ 84th centile	85th–94th centile	≥ 95th centile	158	34	19	78	62	68	103	222	1816
≤ 84th centile	85th–94th centile	≥ 95th centile	123	34	22	74	105	72	103	224	1858
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	128	29	16	112	81	32	279	505	1210
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	23	2	3	9	10	5	42	73	216
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	39	10	6	33	30	7	70	196	300
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	32	4	2	35	14	6	72	111	201
< 25 kg/m ²	25–29 kg/m ²	30 kg/m ²	34	13	5	35	27	14	94	126	493
NR	NR	30 kg/m ²	24	70	27	20	128	131	15	281	1416
NR	NR	30 kg/m ²	23	50	14	23	181	154	3	196	1272
NR	NR	30 kg/m ²	17	45	38	13	88	195	6	118	1747
NR	NR	30 kg/m ²	16	24	9	13	118	196	2	83	1601
≤ 84th centile	85th–94th centile	≥ 95th centile	37	19	9	174	152	88	354	1194	2544
≤ 84th centile	85th–94th centile	≥ 95th centile	15	15	3	77	78	29	196	797	998
≤ 84th centile	85th–94th centile	≥ 95th centile	22	4	6	97	74	59	158	397	1546
NR	NR	NR	309	136	38	33	85	63	10	57	452

TABLE 57 2 x 3 data

Author	Childhood			Adulthood			Numbers								
	Population	Obesity measure	Age at measure (years)	Definition/cut-off point (centile)		Age at measure (years)	Definition/cut-off (kg/m ²)		Bad to O	Bad to OW	Good to O	Good to OW	Good to HW	Good to HW	
				Good	Bad		HW	OW							
Power ¹³³	Boys	BMI	7	≤95th	>95th	33	<25	25–29	30	81	87	43	396	1759	2039
Power ¹³³	Boys	BMI	11	≤95th	>95th	33	<25	25–29	30	91	83	34	365	1673	1999
Power ¹³³	Boys	BMI	16	≤95th	>95th	33	<25	25–29	30	98	64	12	303	1510	1871
Power ¹³³	Girls	BMI	7	≤95th	>95th	33	<25	25–29	30	98	59	66	446	1042	2776
Power ¹³³	Girls	BMI	11	≤95th	>95th	33	<25	25–29	30	107	71	40	408	998	2763
Power ¹³³	Girls	BMI	16	≤95th	>95th	33	<25	25–29	30	104	62	20	354	929	2492
England ¹¹⁹	Boys	BMI	14–19	≤85th	>85th	24–54	<25	25–29	30	1500	1316	190	3833	26,265	28,418
England ¹¹⁹	Girls	BMI	14–19	≤85th	>85th	24–54	<25	25–29	30	1830	1867	1185	3438	14,784	43,495

HW, healthy weight; O, obese; OW, overweight.

TABLE 58 3 x 2 data

Author	Population	Childhood			Adulthood			Numbers						
		Obesity measure	Definition/cut-off point (centile)		Age at measure (years)	Definition/cut-off point		O to bad	O to good	OW to bad	OW to good	HW to bad	HW to good	
			HW	OW		O	Good (kg/m ²)							Bad (kg/m ²)
Freedman ¹²²	Boys	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	NR	NR	13	1	23	114
Freedman ¹²²	Boys	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	25	7	15	18	37	316
Freedman ¹²²	Boys	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	39	12	34	31	59	461
Freedman ¹²²	Boys	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	52	7	45	49	76	492
Freedman ¹²²	Boys	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	31	5	30	21	62	290
Freedman ¹²²	Girls	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	11	4	11	10	41	157
Freedman ¹²²	Girls	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	45	9	34	23	87	449
Freedman ¹²²	Girls	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	56	16	63	39	107	626
Freedman ¹²²	Girls	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	53	11	70	45	96	658
Freedman ¹²²	Girls	BMI	<85th	85th–95th	>95th	Mean 27.5 (range 18–37)	<30	>30	28	4	41	18	77	428
Wang ¹³⁹	Boys and girls	BMI	<85th	85th–95th	>95th	37–38	<30	>30	39	6	69	32	237	926
Wang ¹³⁹	Boys	BMI	<85th	85th–95th	>95th	37–38	<30	>30	24	5	33	20	123	479
Wang ¹³⁹	Girls	BMI	<85th	85th–95th	>95th	37–38	<30	>30	15	1	36	12	114	447

continued

TABLE 58 3 x 2 data (continued)

Author	Population	Obesity measure	Childhood			Adulthood			Numbers						
			Age at measure (years)	Definition/cut-off point (centile)		Age at measure (years)	Definition/cut-off point		O to bad	O to good	OW to bad	OW to good	HW to bad	HW to good	
				HW	OW		O	Good (kg/m ²)							Bad (kg/m ²)
Patton ¹³²	Boys and girls	BMI	14.9–17.4	<85th	85th–95th	>95th	24	<25	>25	89	10	228	159	163	871
Patton ¹³²	Boys	BMI	14.9–17.4	<85th	85th–95th	>95th	24	<25	>25	34	2	130	52	105	373
Patton ¹³²	Girls	BMI	14.9–17.4	<85th	85th–95th	>95th	24	<25	>25	55	8	98	107	58	498
Patton ¹³²	Boys and girls	BMI	14.9–17.4	<85th	85th–95th	>95th	24	<25	>25	48	51	38	349	12	1022
Patton ¹³²	Boys	BMI	14.9–17.4	<85th	85th–95th	>95th	24	<25	>25	18	18	20	162	5	473
Patton ¹³²	Girls	BMI	14.9–17.4	<85th	85th–95th	>95th	24	<25	>25						
Juonala ¹²⁶	Boys and girls	BMI	3–9	<85th	85th–95th	>95th	24–39	<30	>30	34	65	23	89	50	820
Juonala ¹²⁶	Boys and girls	BMI	12–18	<85th	85th–95th	>95th	24–39	<30	>30	61	34	34	91	78	881
Juonala ¹²⁶	Boys and girls	BMI	3–18	<85th	85th–95th	>95th	24–39	<30	>30	95	99	57	180	128	1701

HW, healthy weight; NR, not reported; O, obese; OW, overweight.

TABLE 59 Calculated sensitivity, specificity and PPV: childhood obesity to adult obesity

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity		Specificity		PPV			
				Estimate	95% CI (lower limit)	Estimate	95% CI (lower limit)	Estimate	95% CI (lower limit)	Estimate	95% CI (upper limit)
Gordon-Larsen (2004) ¹²⁴	Both	13–15	19–26	44.3	6.2	82.4	91.7	82.3	42.4	100	100
Gordon-Larsen (2004) ¹²⁴	Both	16–17	19–26	40	9.4	70.6	92.7	84.8	52.2	100	100
Thompson (2007) ¹³⁷	Girls	10	21–23	46.2	0	94.8	83.4	69	13.9	100	100
Thompson (2007) ¹³⁷	Girls	11	21–23	50.3	0.5	100	81.9	68.9	15	100	100
Thompson (2007) ¹³⁷	Girls	12	21–23	55.1	5.3	100	80.4	67.4	15.5	100	100
Thompson (2007) ¹³⁷	Girls	13	21–23	56	5.6	100	82.5	72.3	20.7	100	100
Thompson (2007) ¹³⁷	Girls	14	21–23	57.5	5	100	81.8	72.3	19	100	100
Thompson (2007) ¹³⁷	Girls	15	21–23	60.7	8.2	100	83.3	76.2	24.9	100	100
Thompson (2007) ¹³⁷	Girls	16	21–23	62	9.3	100	85.1	78	27.5	100	100
Nakano (2010) ¹³⁰	Boys	8	14	58.3	0	100	88.8	35.6	0	100	100
Nakano (2010) ¹³⁰	Girls	8	14	58.3	0	100	90.7	31.3	0	100	100
Liddle (2012) ¹²⁷	Both	5	18–23	8.7	0	47.1	91.9	40.9	0	100	100
Reilly (2011) ¹³⁴	Both	7	13	44	5.5	82.5	93.1	72.1	27.6	100	100
Reilly (2011) ¹³⁴	Boys	7	13	46.6	0	99.7	91.2	74.9	16.4	100	100
Reilly (2011) ¹³⁴	Girls	7	13	41	0	96.7	91.4	68.7	0.8	100	100
Starc (2011) ¹³⁵	Boys	7	18	40.7	0	100	86.1	19.8	0	90.8	100
Starc (2011) ¹³⁵	Boys	11	18	46.9	0	100	88.4	26.4	0	100	100
Starc (2011) ¹³⁵	Girls	7	18	47.2	0	100	88.5	17	0	90.6	100
Starc (2011) ¹³⁵	Girls	11	18	51.6	0	100	92.9	32.7	0	100	100
Venn (2007) ¹³⁸	Both	7–15	24–34	6.5	0	26.8	96.7	56.9	0	100	100
Venn (2007) ¹³⁸	Boys	7–15	24–34	5.2	0	30.8	94.9	45.5	0	100	100
Venn (2007) ¹³⁸	Girls	7–15	24–34	7.9	0	39.7	96.5	68.8	0	100	100
Cheng (2011) ¹¹⁷	Both	7–16	12–22	87.8	53.6	100	51.5	64	21.2	100	100

continued

TABLE 59 Calculated sensitivity, specificity and PPV: childhood obesity to adult obesity (continued)

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity		Specificity		PPV			
				Estimate	95% CI (lower limit)	Estimate	95% CI (upper limit)	Estimate	95% CI (lower limit)	Estimate	95% CI (upper limit)
Power (1997) ¹³³	Boys	7	33	17	0	50.7	96.7	38.4	0	100	100
Power (1997) ¹³³	Boys	11	33	20	0	56.7	96.9	43.8	0	100	100
Power (1997) ¹³³	Boys	16	33	24.4	0	66.4	97.8	56.3	0	100	100
Power (1997) ¹³³	Girls	7	33	18	0	50.3	96.8	43.9	0	100	100
Power (1997) ¹³³	Girls	11	33	20.8	0	55.9	97.1	49.1	0	100	100
Power (1997) ¹³³	Girls	16	33	22.7	0	61.1	97.7	55.9	0	100	100
Freedman (2005) ¹²¹	Boys	6-8	27	32.5	0	100	97.9	78.1	0	100	100
Freedman (2005) ¹²¹	Boys	9-11	27	29.5	0	100	97.6	76.5	0	100	100
Freedman (2005) ¹²¹	Boys	12-14	27	30.1	0	98.5	98.7	88.1	5.5	100	100
Freedman (2005) ¹²¹	Boys	15-17	27	25.2	0	100	98.4	86.1	0	100	100
Freedman (2005) ¹²¹	Girls	2-5	27	17.5	0	100	97.7	73.3	0	100	100
Freedman (2005) ¹²¹	Girls	6-8	27	27.1	0	94.7	98.1	83.3	0	100	100
Freedman (2005) ¹²¹	Girls	9-11	27	24.8	0	81.1	97.7	77.8	0	100	100
Freedman (2005) ¹²¹	Girls	12-14	27	24.2	0	80.9	98.5	82.8	0	100	100
Freedman (2005) ¹²¹	Girls	15-17	27	19.2	0	83.1	99.1	87.5	0	100	100
Wang (2008) ¹³⁹	Both	16-17	27	11.3	0	44.7	99.4	86.7	0	100	100
Wang (2008) ¹³⁹	Boys	16-17	37-38	13.3	0	62.9	99	82.8	0	100	100
Wang (2008) ¹³⁹	Girls	16-17	37-38	9.1	0	53	99.8	93.8	0	100	100
Juonala (2006) ¹²⁶	Both	3-9	24-39	31.8	0	100	93.3	34.3	0	100	100
Juonala (2006) ¹²⁶	Both	12-18	24-39	35.3	0	100	96.6	64.2	0	100	100
Juonala (2006) ¹²⁶	Both	3-18	24-39	33.9	0	89.3	95	49	0	100	100

TABLE 60 Calculated sensitivity, specificity and PPV: childhood obesity to adult overweight

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity		Specificity		PPV			
				Estimate	95% CI (lower limit)	Estimate	95% CI (lower limit)	Estimate	95% CI (lower limit)	Estimate	95% CI (upper limit)
Liddle (2012) ¹²⁷	Both	5	18–23	5.7	0	24.6	0	75	0	100	100
Reilly (2011) ¹³⁴	Both	7	13	26.4	2.6	50.2	0	89.5	59.1	100	100
Reilly (2011) ¹³⁴	Boys	7	13	29.2	0	64	0	91	52.4	100	100
Reilly (2011) ¹³⁴	Girls	7	13	23.7	0	56.1	0	87.7	39.6	100	100
Freedman (2005) ¹²²	Both	5–14	18–37	13.8	0	33.9	0	90.8	47.7	100	100
Starc (2011) ¹³⁵	Boys	7	18	17.5	0	49.6	0	77.7	3.5	100	100
Starc (2011) ¹³⁵	Boys	11	18	15.3	0	47.6	0	83.9	6.7	100	100
Starc (2011) ¹³⁵	Girls	7	18	21.6	0	69.2	0	62	0	100	100
Starc (2011) ¹³⁵	Girls	11	18	15.6	0	60	0	81.6	0	100	100
Venn (2007) ¹³⁸	Both	7–15	24–34	2.9	0	10.4	0	86.2	2.4	100	100
Venn (2007) ¹³⁸	Boys	7–15	24–34	2.5	0	11.4	0	90.9	0	100	100
Venn (2007) ¹³⁸	Girls	7–15	24–34	3.5	0	16.6	0	81.3	0	100	100
Cheng (2011) ¹¹⁷	Both	7–16	12–22	70.6	35	100	0	92.1	68	100	100
Power (1997) ¹³³	Boys	7	33	7.2	0	17.7	0	79.6	25.2	100	100
Power (1997) ¹³³	Boys	11	33	7.9	0	19.1	0	83.7	33.5	100	100
Power (1997) ¹³³	Boys	16	33	8.2	0	20.3	0	93.1	55.4	100	100
Power (1997) ¹³³	Girls	7	33	9.5	0	23.7	0	70.4	10.5	100	100
Power (1997) ¹³³	Girls	11	33	11.2	0	26.7	0	81.7	30.4	100	100
Power (1997) ¹³³	Girls	16	33	11.5	0	27.9	0	89.2	44.6	100	100
Patton (2011) ¹³²	Both	15–17	24	18.5	0	53.2	0	89.9	30.5	100	100
Patton (2011) ¹³²	Boys	15–17	24	12.6	0	52.3	0	94.4	19.3	100	100
Patton (2011) ¹³²	Girls	15–17	24	26.1	0	85.4	0	87.3	5.1	100	100
Patton (2011) ¹³²	Both	15–17	24	49	0	100	0	48.5	0	100	100
Patton (2011) ¹³²	Boys	15–17	24	41.9	0	100	0	50	0	100	100

TABLE 61 Calculated sensitivity, specificity and PPV: childhood overweight to adult obesity

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity			Specificity			PPV		
				Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)
Gordon-Larsen (2004) ¹²⁴	Both	13–15	19–26	50.5	11.7	89.3	96.5	89.5	100	78	38	100
Gordon-Larsen (2004) ¹²⁴	Both	16–17	19–26	43.6	12	75.2	97.4	91.9	100	83.1	50.1	100
Liddle (2012) ¹²⁷	Both	5	18–23	41.1	0	100	87.8	71.5	100	31	0	85.8
Reilly (2011) ¹³⁴	Both	7	13	67.8	31.6	100	90.8	82.4	99.2	51	17.4	84.6
Reilly (2011) ¹³⁴	Boys	7	13	69.6	20.6	100	91.8	80.4	100	56.3	8.8	100
Reilly (2011) ¹³⁴	Girls	7	13	65.7	12	100	89.9	77.6	100	45.8	0	92.9
Starc (2011) ¹³⁵	Boys	7	18	74.6	0	100	82.7	66.3	99.1	11	0	41.7
Starc (2011) ¹³⁵	Boys	11	18	93.9	26.9	100	78.6	60	97.2	10.3	0	38.5
Starc (2011) ¹³⁵	Girls	7	18	83.3	0	100	83.6	68.2	99	7.6	0	33.7
Starc (2011) ¹³⁵	Girls	11	18	93.5	6.7	100	82.9	66.5	99.3	7.7	0	34.6
Venn (2007) ¹³⁸	Both	7–15	24–34	37.3	0	77.2	93.3	85.6	100	44.1	0	88.6
Venn (2007) ¹³⁸	Boys	7–15	24–34	31.9	0	85.7	93.5	82.5	100	42.4	0	100
Venn (2007) ¹³⁸	Girls	7–15	24–34	43	0	100	93.1	82.2	100	45.4	0	100
Cheng (2011) ¹¹⁷	Both	7–16	12–22	97.2	80	100	61.3	28.2	94.4	51.5	13.5	89.5
Engeland (2004) ¹¹⁹	Boys	14–19	24–54	28.1	16	40.2	97.3	96	98.6	49.9	32	67.8
Engeland (2004) ¹¹⁹	Girls	14–19	24–54	34.7	21.8	47.6	95	93.3	96.7	37.5	23.9	51.1
Freedman (2005) ¹²¹	Boys	2–5	27	36.1	0	100	99.1	81.8	100	92.9	0	100
Freedman (2005) ¹²¹	Boys	6–8	27	51.9	0	100	92.7	65.1	100	61.5	0	100
Freedman (2005) ¹²¹	Boys	9–11	27	55.3	0	100	91.5	67.2	100	62.9	0	100
Freedman (2005) ¹²¹	Boys	12–14	27	56.1	0	100	89.8	64.5	100	63.4	0	100

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity			Specificity			PPV		
				Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)
Freedman (2005) ¹²¹	Boys	15–17	27	49.6	0	100	91.8	61.5	100	70.1	0	100
Freedman (2005) ¹²¹	Girls	2–5	27	34.9	0	100	91.8	50.7	100	61.1	0	100
Freedman (2005) ¹²¹	Girls	6–8	27	47.6	0	100	93.3	71	100	71.2	0	100
Freedman (2005) ¹²¹	Girls	9–11	27	52.7	0	100	91.9	71.4	100	68.4	0	100
Freedman (2005) ¹²¹	Girls	12–14	27	56.2	0	100	92.2	72.5	100	68.7	0.8	100
Freedman (2005) ¹²¹	Girls	15–17	27	47.3	0	100	95.1	75.2	100	75.8	0	100
Wang (2008) ¹³⁹	Both	16–17	37–38	31.3	0	80.2	96.1	83.9	100	74	2.8	100
Wang (2008) ¹³⁹	Boys	16–17	37–38	31.7	0	99.7	95	76	100	69.5	0	100
Wang (2008) ¹³⁹	Girls	16–17	37–38	30.9	0	100	97.2	82.1	100	79.7	0	100
Juonala (2006) ¹²⁶	Both	3–9	24–39	53.3	0	100	84.2	61.3	100	27	0	86.9
Juonala (2006) ¹²⁶	Both	12–18	24–39	54.9	0	100	87.6	67.2	100	43.2	0	100
Juonala (2006) ¹²⁶	Both	12–18	24–39	54.3	0	100	85.9	70.6	100	35.3	0	80.4

TABLE 62 Calculated sensitivity, specificity and PPV: childhood overweight to adult overweight

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity			Specificity			PPV		
				Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)
Nakano (2010) ¹³¹	Both	7	14	56.3	22.2	90.4	91.4	82.9	99.9	55.8	21.8	89.8
Nakano (2010) ¹³¹	Boys	7	14	57.4	11.8	100	91.3	79.4	100	57.9	12.1	100
Nakano (2010) ¹³¹	Girls	7	14	54.8	3.6	100	91.5	79.5	100	53.2	2.6	100
Stovitz (2010) ¹³⁶	Both	9	18	56.8	26.1	87.5	91.9	79.3	100	79.5	49.8	100
Nakano (2010) ¹³⁰	Boys	8	14	68.4	27.3	100	91.6	80.7	100	61.7	20.9	100
Nakano (2010) ¹³⁰	Girls	8	14	57.7	9.4	100	90	77.8	100	50	4.5	95.5
Liddle (2012) ¹²⁷	Both	5	18–23	31.9	0	69.8	92.4	77.2	100	67.5	12	100
Reilly (2011) ¹³⁴	Both	7	13	50.6	23.6	77.6	95.3	88.6	100	78.7	51.2	100
Reilly (2011) ¹³⁴	Boys	7	13	50.5	12.3	88.7	95.4	86	100	79.2	40.3	100
Reilly (2011) ¹³⁴	Girls	7	13	50.7	12.6	88.8	95.2	85.7	100	78.1	39	100
Freedman (2005) ¹²²	Both	5–14	18–37	30.9	4	57.8	96.2	85.6	100	87.9	55.9	100
Starc (2011) ¹³⁵	Boys	7	18	45	3	87	90	75.2	100	60.5	12.6	100
Starc (2011) ¹³⁵	Boys	11	18	58.2	13.9	100	88.3	71.7	100	62.2	17.1	100
Starc (2011) ¹³⁵	Girls	7	18	56.8	0	100	88.2	74	100	41.2	0	89.7
Starc (2011) ¹³⁵	Girls	11	18	66.8	9.1	100	88.6	73.9	100	45.5	0	95.8
Venn (2007) ¹³⁸	Both	7–15	24–34	19.8	2	37.6	96.3	89.1	100	79.7	43.7	100
Venn (2007) ¹³⁸	Boys	7–15	24–34	15.7	0	36.5	96.9	86.3	100	85.3	38.2	100
Venn (2007) ¹³⁸	Girls	7–15	24–34	26.2	0	57.6	96	86.4	100	75.2	22.9	100

Author	Sex	Age in childhood (years)	Age in adulthood/ adolescence (years)	Sensitivity			Specificity			PPV		
				Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)	Estimate	95% CI (lower limit)	95% CI (upper limit)
Cheng (2011) ¹¹⁷	Both	7–16	12–22	89.4	65.4	100	81.7	49.5	100	84.8	57.5	100
Engeland (2004) ¹¹⁹	Boys	14–19	24–54	8.6	5.6	11.6	99.3	98.3	100	93.7	85	100
Engeland (2004) ¹¹⁹	Girls	14–19	24–54	16.9	11.9	21.9	97.3	95.8	98.8	75.7	63.7	87.7
Patton (2011) ¹³²	Both	15–17	24	66	23.6	100	83.8	61.4	100	65.2	22.9	100
Patton (2011) ¹³²	Boys	15–17	24	61	2.7	100	87.4	55.9	100	75.2	17.9	100
Patton (2011) ¹³²	Girls	15–17	24	72.5	12.3	100	81.2	50.3	100	57.1	0	100
Patton (2011) ¹³²	Both	15–17	24	87.8	23	100	71.9	48.5	95.3	17.7	0	51.6
Patton (2011) ¹³²	Boys	15–17	24	88.4	0	100	72.4	38.1	100	17.4	0	67.7

TABLE 63 Goldhaber-Fiebert et al. (2013)¹²³ extracted results

Population	Measure	Timing of first measure (age in years)	Cut-off point (centile)	Cut-off point (kg/m ²)	Children positive (%)	Total n	Sensitivity	95% CI (upper limit)	95% CI (lower limit)	Specificity	95% CI (upper limit)	95% CI (lower limit)
Boys	BMI	2	> 85th	≥ 30	34	663	51	62	40	68	72	64
Boys	BMI	5	> 85th	≥ 30	21	838	48	57	40	83	86	81
Boys	BMI	10	> 85th	≥ 30	30	1105	88	93	80	77	79	74
Girls	BMI	2	> 85th	≥ 30	31	675	44	55	33	70	74	66
Girls	BMI	5	> 85th	≥ 30	23	766	52	62	41	81	83	77
Girls	BMI	10	> 85th	≥ 30	32	1128	84	89	76	75	78	73
Boys	BMI	2	> 95th	≥ 30	24	663	37	49	27	78	81	75
Boys	BMI	5	> 95th	≥ 30	12	838	33	42	26	92	94	90
Boys	BMI	10	> 95th	≥ 30	15	1105	64	72	55	90	92	88
Girls	BMI	2	> 95th	≥ 30	20	675	31	42	22	81	84	78
Girls	BMI	5	> 95th	≥ 30	13	766	38	48	28	90	92	87
Girls	BMI	10	> 95th	≥ 30	14	1128	57	65	48	92	93	90
Boys	BMI	2	> 85th	≥ 25	34	663	42	49	36	70	74	65
Boys	BMI	5	> 85th	≥ 25	21	838	34	39	29	85	88	82
Boys	BMI	10	> 85th	≥ 25	30	1105	64	68	58	86	88	83
Girls	BMI	2	> 85th	≥ 25	31	675	38	45	32	71	75	67
Girls	BMI	5	> 85th	≥ 25	23	766	40	46	34	85	87	81
Girls	BMI	10	> 85th	≥ 25	32	1128	64	69	59	83	85	80
Boys	BMI	2	> 95th	≥ 25	24	663	31	38	26	80	84	76
Boys	BMI	5	> 95th	≥ 25	12	838	21	26	17	93	95	90
Boys	BMI	10	> 95th	≥ 25	15	1105	37	42	32	95	96	93

Population	Measure	Timing of first measure (age in years)	Cut-off point (centile)	Cut-off point (kg/m ²)	Children positive (%)	Total n	Sensitivity	95% CI (upper limit)	95% CI (lower limit)	Specificity	95% CI (upper limit)	95% CI (lower limit)
Girls	BMI	2	> 95th	≥25	20	675	24	30	18	81	84	77
Girls	BMI	5	> 95th	≥25	13	766	25	31	20	92	94	89
Girls	BMI	10	> 95th	≥25	14	1128	36	41	31	96	97	94
White children	BMI	2	> 85th	≥30	29	659	31	45	20	72	75	68
White children	BMI	5	> 85th	≥30	20	750	49	59	39	83	86	80
White children	BMI	10	> 85th	≥30	26	1018	81	88	71	79	81	76
Black and Hispanic children	BMI	2	> 85th	≥30	37	679	54	63	45	66	70	62
Black and Hispanic children	BMI	5	> 85th	≥30	24	854	50	59	42	81	84	78
Black and Hispanic children	BMI	10	> 85th	≥30	35	1215	88	92	82	74	76	71
White children	BMI	2	> 95th	≥30	18	659	19	32	10	82	85	78
White children	BMI	5	> 95th	≥30	11	750	33	43	24	92	94	90
White children	BMI	10	> 95th	≥30	11	1018	55	66	44	93	95	91
Black and Hispanic children	BMI	2	> 95th	≥30	25	679	41	51	32	77	81	74
Black and Hispanic children	BMI	5	> 95th	≥30	14	854	37	46	29	90	92	87
Black and Hispanic children	BMI	10	> 95th	≥30	18	1215	62	69	55	89	91	87

continued

TABLE 63 Goldhaber-Fiebert et al. (2013)¹²³ extracted results (continued)

Population	Measure	Timing of first measure (age in years)	Cut-off point (centile)	Cut-off point (kg/m ²)	Children positive (%)	Total n	Sensitivity	95% CI (upper limit)	95% CI (lower limit)	Specificity	95% CI (upper limit)	95% CI (lower limit)
White children	BMI	2	> 85th	≥25	29	659	33	40	26	73	77	69
White children	BMI	5	> 85th	≥25	20	750	37	43	30	86	89	83
White children	BMI	10	> 85th	≥25	26	1018	59	65	53	85	88	83
Black and Hispanic children	BMI	2	> 85th	≥25	37	679	45	51	39	68	72	63
Black and Hispanic children	BMI	5	> 85th	≥25	24	854	36	42	31	84	87	80
Black and Hispanic children	BMI	10	> 85th	≥25	35	1215	67	71	62	83	86	80
White children	BMI	2	> 95th	≥25	18	659	20	27	14	82	85	78
White children	BMI	5	> 95th	≥25	11	750	22	28	17	93	95	91
White children	BMI	10	> 95th	≥25	11	1018	32	38	26	96	98	95
Black and Hispanic children	BMI	2	> 95th	≥25	25	679	33	39	27	79	83	75
Black and Hispanic children	BMI	5	> 95th	≥25	14	854	24	29	19	92	94	89
Black and Hispanic children	BMI	10	> 95th	≥25	18	1215	39	44	34	94	96	92

TABLE 64 Cheung et al. 2004:¹¹⁸ summary data not included in meta-analysis (1)

Population	First measure	Timing of first measure (age in years)	Cut-off point (kg/m ²)	Second measure	Timing of second measure (age in years)	Cut-off point (kg/m ²)	Comparison	Total n	Sensitivity	Specificity	PPV	NPV
Random 50% – male	BMI	11	International BMI = 25.6	BMI	33	30	O vs. OW/HW	2135	7.7	99.3	56.3	89.8
Random 50% – male	BMI	11	ROC curve BMI = 17.9	BMI	33	30	O vs. OW/HW	2135	71.7	72.4	24.1	95.4
Random 50% – male	BMI	11	95th centile BMI = 22.3	BMI	33	30	O vs. OW/HW	2135	21.9	97.2	49	91
Random 50% – female	BMI	11	International BMI = 26.1	BMI	33	30	O vs. OW/HW	2096	6.9	99.1	51.5	88.9
Random 50% – female	BMI	11	ROC curve BMI = 18.3	BMI	33	30	O vs. OW/HW	2096	75.7	69.7	25	95.6
Random 50% – female	BMI	11	95th centile BMI = 23.2	BMI	33	30	O vs. OW/HW	2096	20.2	96.3	42	90
Random 50% – male	BMI	11	International BMI = 20.9	BMI	33	25	O/OW vs. HW	2135	13.9	97.1	83.4	52.2
Random 50% – male	BMI	11	ROC curve BMI = 17.0	BMI	33	25	O/OW vs. HW	2135	65.6	68.6	68.4	65.8
Random 50% – male	BMI	11	85th centile BMI = 19.5	BMI	33	25	O/OW vs. HW	2135	23.3	94	80.1	54.2
Random 50% – female	BMI	11	International BMI = 21.2	BMI	33	25	O/OW vs. HW	2096	23	95	71.3	69.5
Random 50% – female	BMI	11	ROC curve BMI = 17.5	BMI	33	25	O/OW vs. HW	2096	69.8	63.6	50.9	79.6
Random 50% – female	BMI	11	85th centile BMI = 20.5	BMI	33	25	O/OW vs. HW	2096	28.8	92.7	68	70.6

HW, healthy weight; O, obese; OW, overweight.

TABLE 65 Cheung et al. 2004:¹⁸ summary data not included in meta-analysis (2)

Population	First measure	Timing of first measure (age in years)	Cut-off point (kg/m ²)	Second measure	Timing of second measure (age in years)	Cut-off point (kg/m ²)	Comparison	Total n	AUC	95% CI (upper limit)	95% CI (lower limit)
Random 50% – male	BMI	7	ROC curve BMI = 17.9	BMI	33	30	O vs. OW/HW	2174	0.72	0.68	0.76
Random 50% – male	BMI	11	ROC curve BMI = 17.9	BMI	33	30	O vs. OW/HW	2085	0.78	0.75	0.81
Random 50% – male	BMI	16	ROC curve BMI = 17.9	BMI	33	30	O vs. OW/HW	1903	0.82	0.78	0.85
Random 50% – female	BMI	7	ROC curve BMI = 18.3	BMI	33	30	O vs. OW/HW	2174	0.69	0.65	0.72
Random 50% – female	BMI	11	ROC curve BMI = 18.3	BMI	33	30	O vs. OW/HW	2085	0.8	0.77	0.83
Random 50% – female	BMI	16	ROC curve BMI = 18.3	BMI	33	30	O vs. OW/HW	1903	0.83	0.8	0.86
Random 50% – male	BMI	7	ROC curve BMI = 17.9	BMI	33	25	O/OW vs. HW	2174	0.66	0.64	0.68
Random 50% – male	BMI	11	ROC curve BMI = 17.9	BMI	33	25	O/OW vs. HW	2085	0.73	0.71	0.75
Random 50% – male	BMI	16	ROC curve BMI = 17.9	BMI	33	25	O/OW vs. HW	1903	0.75	0.73	0.77
Random 50% – female	BMI	7	ROC curve BMI = 18.3	BMI	33	25	O/OW vs. HW	2174	0.66	0.63	0.68
Random 50% – female	BMI	11	ROC curve BMI = 18.3	BMI	33	25	O/OW vs. HW	2085	0.75	0.72	0.77
Random 50% – female	BMI	16	ROC curve BMI = 18.3	BMI	33	25	O/OW vs. HW	1903	0.79	0.77	0.81

HW, healthy weight; O, obese; OW, overweight.

TABLE 66 Juhola *et al.* 2011:^{1,25} summary data not included in meta-analysis

Population	First measure	Timing of first measure (age in years)	Cut-off point (first measure)	Second measure	Timing of second measure (age in years)	Cut-off point (second measure)	Total n	Sensitivity	Specificity	PPV	NPV
Boys and girls	BMI	3	O: 95th centile	BMI	30–45	O: 30 kg/m ²	314	14.6	96.7	40	88.3
Boys and girls	BMI	6	O: 95th centile	BMI	30–45	O: 30 kg/m ²	342	11.1	96.6	33.3	87.8
Boys and girls	BMI	9	O: 95th centile	BMI	30–45	O: 30 kg/m ²	360	15.9	97.6	58.8	84.6
Boys and girls	BMI	12	O: 95th centile	BMI	30–45	O: 30 kg/m ²	399	16.3	97.8	66.7	81
Boys and girls	BMI	15	O: 95th centile	BMI	30–45	O: 30 kg/m ²	395	18	99.7	91.7	87
Boys and girls	BMI	18	O: 95th centile	BMI	30–45	O: 30 kg/m ²	344	16.9	98.9	81.3	80.5
Boys and girls	BMI	3–18	O: 95th centile	BMI	30–45	O: 30 kg/m ²	2154	15.8	97.9	61.5	84.7
Boys	BMI	3	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	153	18.2	99.2	80	87.8
Boys	BMI	6	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	142	25	94.3	25	88.5
Boys	BMI	9	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	172	30	92.3	45	86.2
Boys	BMI	12	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	171	38.2	97.1	76.5	86.4
Boys	BMI	15	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	182	31.4	98.6	84.6	85.8
Boys	BMI	18	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	155	35	95.7	73.7	80.9
Boys	BMI	3–18	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	975	30.9	96.2	65.1	85.9
Girls	BMI	3	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	161	5.3	96.5	16.7	88.4
Girls	BMI	6	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	200	36	91.1	37.5	90.9
Girls	BMI	9	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	188	30.3	93.6	50	86.3
Girls	BMI	12	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	228	19.2	94.3	50	79.8
Girls	BMI	15	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	213	23.1	99.5	85.7	90.3
Girls	BMI	18	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	189	21.6	98	72.7	90.3
Girls	BMI	3–18	IOTF cut-off points	BMI	30–45	O: 30 kg/m ²	1179	22.9	95.5	50	86.4

Review of the diagnostic accuracy of obesity measures in childhood

TABLE 67 Sensitivity and specificity: diagnosing obesity

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
BMI									
Bartok (2011) ¹⁷⁴	White girls	11	CDC	82nd centile	DEXA	95th centile	172	95 (NR)	83 (NR)
Bartok (2011) ¹⁷⁴	White girls	13	CDC	82nd centile	DEXA	95th centile	151	93 (NR)	88 (NR)
Bartok (2011) ¹⁷⁴	White girls	9	CDC	85th centile	DEXA	95th centile	173	90 (NR)	94 (NR)
Bartok (2011) ¹⁷⁴	White girls	15	CDC	85th centile	DEXA	95th centile	160	96 (NR)	95 (NR)
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	?	85th centile	Underwater (hydrostatic) weighting	90th centile	159	29 (11 to 51)	99 (96 to 100)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	?	85th centile	Underwater (hydrostatic) weighting	90th centile	157	23 (10 to 40)	100 (99 to 100)
Himes (1989) ¹⁸⁶	All children	8.4–18.99	?	85th centile	Underwater (hydrostatic) weighting	90th centile	316	25 (16 to 37)	100 (98 to 100) ^a
Sproule (2009) ¹⁸⁸	Spinal muscular atrophy	5–18	CDC	85th centile	DEXA	95th centile	25	80 (NR)	95 (NR)
Harrington (2013) ¹⁸⁵	White girls	5–18	Optimal	89th centile	DEXA	?	83	100 (NR)	90 (NR)
Harrington (2013) ¹⁸⁵	White boys	5–18	Optimal	94th centile	DEXA	?	94	100 (NR)	97 (NR)
Field (2003) ¹⁷⁸	Unselected	10 (SD 2.2)	?	95th centile	DEXA	90th centile	596	65 (NR)	99 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–18	CDC	95th centile	DEXA	95th centile	1196	92.5 (NR)	89.4 (NR)
Freedman (2013) ¹⁸⁰	Boys	8–19	CDC	95th centile	DEXA	?	4518	75 (72 to 78) ^b	95 (94 to 95) ^b
Freedman (2013) ¹⁸⁰	Girls	8–19	CDC	95th centile	DEXA	?	2847	76 (72 to 80) ^b	95 (94 to 96) ^b

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Freedman (2013) ¹⁸⁰	All children	8–19	CDC	95th centile	DEXA	?	7365	76 (73 to 78)	95 (94 to 95) ^a
Reilly (2010) ¹⁹⁵	Boys	9.9	UK90	95th centile	DEXA	90th centile	3809	96 (94 to 98) ^b	95 (94 to 95) ^b
Reilly (2010) ¹⁹⁵	Girls	9.9	UK90	95th centile	DEXA	90th centile	3913	94 (91 to 96) ^b	96 (96 to 97) ^b
Reilly (2010) ¹⁹⁵	All children	9.9	UK90	95th centile	DEXA	90th centile	7722	95 (94 to 97)	95 (95 to 96) ^a
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	95th centile	DEXA	95th centile	825	85 (65 to 96) ^b	97 (95 to 98) ^b
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	95th centile	DEXA	95th centile	815	54 (37 to 69) ^b	100 (99 to 100) ^b
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	95th centile	DEXA	95th centile	1640	66 (53 to 77)	98 (97 to 99) ^a
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	95th centile	DEXA	Prevalence matched to BMI	825	67 (52 to 80) ^b	98 (97 to 99) ^b
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	95th centile	DEXA	Prevalence matched to BMI	815	81 (61 to 93) ^b	99 (99 to 100) ^b
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	95th centile	DEXA	Prevalence matched to BMI	1640	72 (60 to 82)	99 (98 to 99) ^a
Freedman (2009) ¹⁷⁹	Boys	5–18	CDC	95th centile	DEXA	95th centile	626	75 (65 to 83) ^b	95 (93 to 97) ^b
Freedman (2009) ¹⁷⁹	Girls	5–18	CDC	95th centile	DEXA	95th centile	570	80 (70 to 88) ^b	97 (94 to 98) ^b
Freedman (2009) ¹⁷⁹	All children	5–18	CDC	95th centile	DEXA	95th centile	1196	77 (70 to 83)	96 (94 to 97) ^a
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	95th centile	DEXA (adjusted for sex and ethnicity)	95th centile	406	76 (53 to 92) ^b	91 (88 to 94) ^b
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	95th centile	DEXA (adjusted for sex and ethnicity)	95th centile	573	69 (49 to 85) ^b	91 (88 to 93) ^b
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	95th centile	DEXA (adjusted for sex and ethnicity)	95th centile	979	72 (58 to 84)	91 (89 to 93) ^a

continued

TABLE 67 Sensitivity and specificity: diagnosing obesity (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	95th centile	DEXA (adjusted for sex)	95th centile	406	71 (48 to 89) ^b	91 (88 to 94) ^b
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	95th centile	DEXA (adjusted for sex)	95th centile	573	90 (73 to 98) ^b	92 (90 to 94) ^b
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	95th centile	DEXA (adjusted for sex)	95th centile	979	82 (69 to 91)	92 (90 to 93) ^a
Wickramasinghe (2005) ^{2,04}	White boys	5–14.99	CDC	95th centile	D ₂ O	20% BF	44	3.5 (NR)	100 (NR)
Wickramasinghe (2005) ^{2,04}	White girls	5–14.99	CDC	95th centile	D ₂ O	30% BF	52	20 (NR)	100 (NR)
Wickramasinghe (2005) ^{2,04}	White children	5–14.99	CDC	95th centile	D ₂ O	Boys 20% BF; girls 30% BF	96	6 (1 to 17)	98 (89 to 100) ^a
Wickramasinghe (2005) ^{2,04}	Sri Lankan boys	5–14.99	CDC	95th centile	D ₂ O	20% BF	27	12.5 (NR)	100 (NR)
Wickramasinghe (2005) ^{2,04}	Sri Lankan girls	5–14.99	CDC	95th centile	D ₂ O	30% BF	15	14.3 (NR)	100 (NR)
Wickramasinghe (2005) ^{2,04}	All Sri Lankan children	5–14.99	CDC	95th centile	D ₂ O	Boys 20% BF; girls 30% BF	42	13 (3 to 34)	100 (82 to 100) ^a
Wickramasinghe (2009) ^{2,05}	Sri Lankan boys	5–15	CDC	95th centile	D ₂ O	25% BF	158	19.5 (NR)	100 (NR)
Wickramasinghe (2009) ^{2,05}	Sri Lankan girls	5–15	CDC	95th centile	D ₂ O	30% BF	124	16.2 (NR)	100 (NR)
Wickramasinghe (2009) ^{2,05}	All Sri Lankan children	5–15	CDC	95th centile	D ₂ O	Boys 25% BF; girls 30% BF	282	18 (12 to 24)	100 (97 to 100) ^a
Sproule (2009) ¹⁸⁶	Spinal muscular atrophy	5–18	CDC	95th centile	DEXA	95th centile	25	40 (NR)	100 (NR)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Wickramasinghe (2009) ²⁰⁵	Sri Lankan boys	5–15	IOTF	95th centile	D ₂ O	25% BF	158	12.5 (NR)	100 (NR)
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	IOTF	95th centile	D ₂ O	30% BF	124	8 (NR)	100 (NR)
Wickramasinghe (2009) ²⁰⁵	All Sri Lankan children	5–15	IOTF	95th centile	D ₂ O	Boys 25% BF; girls 30% BF	282	10 (6 to 15)	100 (97 to 100) ^a
Field (2003) ¹⁷⁸	Unselected	10 (SD 2.2)	SD	2	DEXA	90th centile	596	51 (NR)	100 (NR)
Wickramasinghe (2005) ²⁰⁴	White boys	5–14.99	SD	2	D ₂ O	20% BF	44	6.9 (NR)	93 (NR)
Wickramasinghe (2005) ²⁰⁴	Sri Lankan boys	5–14.99	SD	2	D ₂ O	20% BF	27	12.5 (NR)	100 (NR)
Wickramasinghe (2005) ²⁰⁴	White girls	5–14.99	SD	2	D ₂ O	30% BF	52	5.2 (NR)	100 (NR)
Wickramasinghe (2005) ²⁰⁴	Sri Lankan girls	5–14.99	SD	2	D ₂ O	30% BF	15	14.3 (NR)	100 (NR)
Wickramasinghe (2009) ²⁰⁵	Sri Lankan boys	5–15	SD	2	D ₂ O	25% BF	158	23.6 (NR)	100 (NR)
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	SD	2	D ₂ O	30% BF	124	16.2 (NR)	100 (NR)
Taylor (2003) ²⁰⁰	Boys	8.5–15.5	Optimal z-score (adjusted for age)	?	DEXA	25% BF	179	85.7 (NR)	89.2 (NR)
Taylor (2003) ²⁰⁰	Girls	8.5–15.5	Optimal z-score (adjusted for age)	?	DEXA	35% BF	189	86 (NR)	96.6 (NR)

continued

TABLE 67 Sensitivity and specificity: diagnosing obesity (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Taylor (2003) ²⁰⁰	Boys	8.5–15.5	Optimal z-score (adjusted for age and pubertal status)	?	DEXA	25% BF	179	89.8 (NR)	92.3 (NR)
Taylor (2003) ²⁰⁰	Girls	8.5–15.5	Optimal z-score (adjusted for age and pubertal status)	?	DEXA	35% BF	189	88.4 (NR)	92.5 (NR)
Harrington (2013) ¹⁸⁵	Unselected	5–18	Optimal	96th centile	DEXA	?	369	90 (NR)	89 (NR)
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	97th centile	DEXA	95th centile	25	40 (NR)	100 (NR)
Harrington (2013) ¹⁸⁵	AA boys	5–18	Optimal	97th centile	DEXA	?	79	100 (NR)	98 (NR)
Harrington (2013) ¹⁸⁵	AA girls	5–18	Optimal	98th centile	DEXA	?	113	93 (NR)	93 (NR)
Fujita (2011) ¹⁸¹	Girls	10	Optimal	19.6	DEXA	95th centile	196	100 (NR)	92 (NR)
Fujita (2011) ¹⁸¹	Boys	10	Optimal	20.8	DEXA	95th centile	226	100 (NR)	96 (NR)
Telford (2008) ²⁰¹	Boys	8	IOTF	21.6	DEXA	Mueller	375	87.5 (NR)	95.6 (NR)
Telford (2008) ²⁰¹	Girls	8	IOTF	21.6	DEXA	Mueller	366	78.1 (NR)	97.6 (NR)
Telford (2008) ²⁰¹	All children	8	IOTF	21.6	DEXA	Mueller	741	80 (64 to 91)	97 (95 to 98) ^a
Telford (2008) ²⁰¹	Boys	8	IOTF	21.6	DEXA	McCarthy	375	26.1 (NR)	100 (NR)
Telford (2008) ²⁰¹	Girls	8	IOTF	21.6	DEXA	McCarthy	366	25.4 (NR)	100 (NR)
Telford (2008) ²⁰¹	All children	8	IOTF	21.6	DEXA	McCarthy	741	26 (20 to 32)	100 (99 to 100) ^a
Neovius (2005) ¹⁹³	Girls	17	Optimal	26.5	ADP	95th centile	274	86 (NR)	98 (NR)
Neovius (2005) ¹⁹³	Boys	17	Optimal	29.2	ADP	95th centile	200	40 (NR)	98 (NR)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Zhang (2004) ²⁰⁶	City/suburb-residing girls	13.5	IOTF	30	DEXA	35% BF	414	100 (69 to 100) ^b	69 (64 to 73) ^b
Zhang (2004) ²⁰⁶	Rural-residing girls	10.1	IOTF	30	DEXA	35% BF	165	100 (48 to 100) ^b	81 (74 to 86) ^b
Zhang (2004) ²⁰⁶	City/suburb-residing boys	13.7	IOTF	30	DEXA	25% BF	172	100 (59 to 100) ^b	82 (75 to 87) ^b
Wickramasinghe (2005) ²⁰⁴	White boys	5–14.99	IOTF	30	D ₂ O	20% BF	44	0 (NR)	100 (NR)
Wickramasinghe (2005) ²⁰⁴	Sri Lankan boys	5–14.99	IOTF	30	D ₂ O	20% BF	27	0 (NR)	100 (NR)
Wickramasinghe (2005) ²⁰⁴	White girls	5–14.99	IOTF	30	D ₂ O	30% BF	52	0 (NR)	100 (NR)
Wickramasinghe (2005) ²⁰⁴	Sri Lankan girls	5–14.99	IOTF	30	D ₂ O	30% BF	15	0 (NR)	100 (NR)
Relative BMI									
Marshall (1991) ¹⁸⁹	Unselected	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	71.1 (NR)	91.6 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	25% BF	274	74.2 (NR)	90.5 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	20% BF	266	68.9 (NR)	92.8 (NR)

continued

TABLE 67 Sensitivity and specificity: diagnosing obesity (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Relative weight									
Marshall (1991) ¹⁸⁹	Unselected	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	51.6 (NR)	95 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	25% BF	274	58.1 (NR)	95.1 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	20% BF	266	48.9 (NR)	95 (NR)
Johnston (1985) ¹⁸⁷	Boys	12–17	–	?	Underwater (hydrostatic) weighting	25% BF	169	52 (33 to 70) ^b	86 (79 to 92) ^b
Johnston (1985) ¹⁸⁷	Girls	12–17	–	?	Underwater (hydrostatic) weighting	30% BF	66	29 (10 to 56) ^b	94 (83 to 99) ^b
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Subscapular	85th centile	Underwater (hydrostatic) weighting	90th centile	159	38 (18 to 61)	99 (97 to 100)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Subscapular	85th centile	Underwater (hydrostatic) weighting	90th centile	157	30 (15 to 48)	99 (96 to 100)
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Sum SFT	85th centile	Underwater (hydrostatic) weighting	90th centile	159	57 (35 to 78)	85 (78 to 90)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Sum	85th centile	Underwater (hydrostatic) weighting	90th centile	157	80 (63 to 92)	82 (75 to 88)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Triceps	85th centile	Underwater (hydrostatic) weighting	90th centile	159	24 (8 to 45)	100 (99 to 100)
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Triceps	85th centile	Underwater (hydrostatic) weighting	90th centile	157	23 (10 to 40)	97 (93 to 99)
Marshall (1991) ¹⁸⁹	Unselected	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	86.8 (NR)	90.1 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	25% BF	274	96.8 (NR)	90.5 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	20% BF	266	80 (NR)	89.6 (NR)
Marshall (1991) ¹⁸⁹	Unselected	7–14	Triceps	85th centile	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	65.8 (NR)	94 (NR)
Marshall (1991) ¹⁸⁹	Girls	7–14	Triceps	85th centile	Underwater (hydrostatic) weighting	25% BF	274	67.7 (NR)	93.4 (NR)
Marshall (1991) ¹⁸⁹	Boys	7–14	Triceps	85th centile	Underwater (hydrostatic) weighting	20% BF	266	64.4 (NR)	94.6 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–18	Triceps	95th centile	DEXA	95th centile	1196	89.6 (NR)	93.2 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–18	Subscapular	95th centile	DEXA	95th centile	1196	89.6 (NR)	94 (NR)
Freedman (2013) ¹⁸⁰	Boys	8–19	Sum	Elevated: prevalence matched to BMI	DEXA	?	4519	80 (77 to 83) ^b	96 (95 to 96) ^b

continued

TABLE 67 Sensitivity and specificity: diagnosing obesity (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Freedman (2013) ¹⁸⁰	Girls	8–19	Sum	Elevated: prevalence matched to BMI	DEXA	?	2846	79 (75 to 83) ^b	96 (95 to 96) ^b
Freedman (2013) ¹⁸⁰	All children	8–19	Sum	Elevated: prevalence matched to BMI	DEXA	?	7365	80 (77 to 82)	96 (95 to 96) ^a
Johnston (1985) ¹⁸⁷	Boys	12–17	Triceps	?	Underwater (hydrostatic) weighting	25% BF	169	48 (30 to 67) ^b	96 (91 to 98) ^b
Johnston (1985) ¹⁸⁷	Girls	12–17	Triceps	?	Underwater (hydrostatic) weighting	30% BF	66	24 (7 to 50) ^b	100 (93 to 100) ^b
Johnston (1985) ¹⁸⁷	All children	12–17	Triceps	?	Underwater (hydrostatic) weighting	Boys 25% BF; girls 30% BF	235	40 (26 to 55)	97 (93 to 99) ^a
WC									
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	85th centile	ADP	95th centile	274	64 (NR)	98 (NR)
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	95th centile	ADP	95th centile	200	50 (NR)	98 (NR)
Reilly (2010) ¹⁹⁵	Boys	9.9	UK 1988 reference	95th centile	DEXA	90th centile	3809	97 (95 to 99) ^b	81 (79 to 82) ^b
Reilly (2010) ¹⁹⁵	Girls	9.9	UK 1988 reference	95th centile	DEXA	90th centile	3913	98 (95 to 99) ^b	81 (79 to 82) ^b
Wickramasinghe (2009) ²⁰⁵	Sri Lankan boys	5–15	WC smallest between ribs and iliac crest	98th centile	D ₂ O	25% BF	158	34.7 (NR)	98.8 (NR)
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	WC smallest between ribs and iliac crest	98th centile	D ₂ O	30% BF	124	38.4 (NR)	100 (NR)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	WC smallest between ribs and iliac crest	98th centile	D ₂ O	Boys 25% BF; girls 30% BF	282	37 (30 to 45)	99 (95 to 100) ^a
Fujita (2011) ¹⁸¹	Boys	10	WC umbilical	76.5	DEXA	95th centile	226	100 (NR)	97 (NR)
Fujita (2011) ¹⁸¹	Girls	10	WC umbilical	73	DEXA	95th centile	196	100 (NR)	96 (NR)
WHR									
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	0.9	ADP	95th centile	200	40 (NR)	97 (NR)
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	1.02	ADP	95th centile	274	0 (NR)	100 (NR)
WHR									
Fujita (2011) ¹⁸¹	Boys	10	WC umbilical	0.519	DEXA	95th centile	226	100 (NR)	95 (NR)
Fujita (2011) ¹⁸¹	Girls	10	WC umbilical	0.499	DEXA	95th centile	196	100 (NR)	95 (NR)

AA, African American; BF, body fat; NR, not reported.
 a Data for entire population derived from 2 x 2 tables of boys and girls separately.
 b Sensitivity and specificity calculated from 2 x 2 data.

TABLE 68 Sensitivity and specificity: diagnosing overweight

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
BMI									
Bartok (2011) ¹⁷⁴	White girls	9	CDC	73rd centile	DEXA	85th centile	173	92 (NR)	91 (NR)
Bartok (2011) ¹⁷⁴	White girls	13	CDC	77th centile	DEXA	85th centile	151	91 (NR)	89 (NR)
Bartok (2011) ¹⁷⁴	White girls	15	CDC	78th centile	DEXA	85th centile	160	69 (NR)	94 (NR)
Bartok (2011) ¹⁷⁴	White girls	11	CDC	81st centile	DEXA	85th centile	172	85 (NR)	96 (NR)
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Göteborg, Sweden	85th centile	ADP	25% BF	200	92 (NR)	93 (NR)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Göteborg, Sweden	85th centile	ADP	30% BF	274	39 (NR)	97 (NR)
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	Göteborg, Sweden	85th centile	ADP	Boys 25% BF; girls 30% BF	474	48 (40 to 57)	95 (92 to 97) ^a
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	WHO	85th centile	ADP	25% BF	200	68 (NR)	98 (NR)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	WHO	85th centile	ADP	30% BF	274	19 (NR)	100 (NR)
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	WHO	85th centile	ADP	Boys 25% BF; girls 30% BF	474	28 (20 to 36)	99 (97 to 100) ^a
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	85th centile	DEXA	85th centile	25	50 (NR)	100 (NR)
Freedman (2013) ¹⁸⁰	Boys	8–19	CDC	85th centile	DEXA	?	4518	83 (81 to 84) ^b	91 (90 to 92) ^b
Freedman (2013) ¹⁸⁰	Girls	8–19	CDC	85th centile	DEXA	?	2847	80 (77 to 82) ^b	90 (88 to 91) ^b
Freedman (2009) ¹⁷⁹	Boys	5–18	CDC	85th centile	DEXA	85th centile	626	84 (78 to 88) ^b	92 (89 to 95) ^b
Freedman (2009) ¹⁷⁹	Girls	5–18	CDC	85th centile	DEXA	85th centile	570	83 (77 to 88) ^b	92 (89 to 94) ^b
Freedman (2009) ¹⁷⁹	All children	5–18	CDC	85th centile	DEXA	85th centile	1196	83 (79 to 87)	92 (90 to 94) ^a
Moreno (2006) ¹⁹¹	Boys	13–17.9	AVENA	85th centile	DEXA	85th centile	116	53 (28 to 77)	88 (79 to 94)
Moreno (2006) ¹⁹¹	Girls	13–17.9	AVENA	85th centile	DEXA	85th centile	170	79 (58 to 93)	92 (86 to 96)
Moreno (2006) ¹⁹¹	All children	13–17.9	AVENA	85th centile	DEXA	85th centile	286	67 (53 to 78)	90 (86 to 94) ^a

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Moreno (2006) ¹⁹¹	Boys	13–17.9	IOTF	85th centile	DEXA	85th centile	116	71 (44 to 90)	86 (77 to 92)
Moreno (2006) ¹⁹¹	Girls	13–17.9	IOTF	85th centile	DEXA	85th centile	170	75 (53 to 90)	90 (84 to 95)
Moreno (2006) ¹⁹¹	All children	13–17.9	IOTF	85th centile	DEXA	85th centile	286	73 (60 to 84)	88 (84 to 92) ^a
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	85th centile	DEXA	85th centile	825	78 (71 to 85) ^b	91 (89 to 93) ^b
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	85th centile	DEXA	85th centile	815	64 (55 to 72) ^b	94 (92 to 96) ^b
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	85th centile	DEXA	85th centile	1640	72 (66 to 77)	93 (91 to 94) ^a
Khadgawat (2013) ¹⁸⁸	Boys	7–17	IOTF	85th centile	DEXA	Prevalence matched to BMI	825	77 (70 to 83) ^b	94 (92 to 95) ^b
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	85th centile	DEXA	Prevalence matched to BMI	815	65 (56 to 73) ^b	94 (92 to 96) ^b
Khadgawat (2013) ¹⁸⁸	All children	7–17	IOTF	85th centile	DEXA	Prevalence matched to BMI	1640	72 (67 to 77)	94 (93 to 95) ^a
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	85th centile	DEXA (adjusted for sex and ethnicity)	85th centile	406	92 (82 to 97) ^b	84 (79 to 87) ^b
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	85th centile	DEXA (adjusted for sex and ethnicity)	85th centile	573	92 (84 to 97) ^b	82 (78 to 85) ^b
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	85th centile	DEXA (adjusted for sex and ethnicity)	85th centile	979	92 (86 to 96)	83 (80 to 85) ^a
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	85th centile	DEXA (adjusted for sex)	85th centile	406	90 (80 to 96) ^b	83 (79 to 87) ^b
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	85th centile	DEXA (adjusted for sex)	85th centile	573	94 (87 to 98) ^b	83 (79 to 86) ^b

continued

TABLE 68 Sensitivity and specificity: diagnosing overweight (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	85th centile	DEXA (adjusted for sex)	85th centile	979	93 (87 to 96)	83 (80 to 85) ^a
Sarría (2001) ¹⁹⁷	Boys	7–16.9	z-scores	85th centile	Underwater (hydrostatic) weighting	85th centile	175	50 (30 to 70)	91 (85 to 95)
Warner (1997) ²⁰³	All children	?	SD scores	85th centile/1	DEXA	US 85th centile	143	66 (52 to 78)	94 (86 to 98)
Warner (1997) ²⁰³	Cancer survivors	12 (SD 3.7)	SD scores	85th centile/1	DEXA	US 85th centile	43	68 (47 to 85)	88 (62 to 98)
Warner (1997) ²⁰³	Growth hormone-deficient	15.7 (SD 1.2)	SD scores	85th centile/1	DEXA	US 85th centile	27	70 (35 to 93)	94 (71 to 100)
Warner (1997) ²⁰³	Inflammatory bowel disease	14.3 (SD 2.8)	SD scores	85th centile/1	DEXA	US 85th centile	33	55 (23 to 83)	96 (77 to 100)
Warner (1997) ²⁰³	Healthy	11.8 (SD 3.1)	SD scores	85th centile/1	DEXA	US 85th centile	40	67 (35 to 90)	96 (81 to 100)
Pandit (2009) ¹⁹⁴	Boys	6–17	CDC z-/SD score	1	DEXA	85th centile	316	77 (NR)	97 (NR)
Pandit (2009) ¹⁹⁴	Girls	6–17	CDC z-/SD score	1	DEXA	85th centile	250	83 (NR)	97 (NR)
Pandit (2009) ¹⁹⁴	All children	6–17	CDC z-/SD score	1	DEXA	85th centile	566	66 (59 to 72)	98 (96 to 99) ^a
Dung (2006) ¹⁷⁶	Boys referred for hospital treatment	11.9	German reference	90th centile	DEXA	90th centile	191	87 (79 to 93) ^b	92 (85 to 97) ^b
Dung (2006) ¹⁷⁶	Girls referred for hospital treatment	12.1	German reference	90th centile	DEXA	90th centile	202	82 (73 to 89) ^b	96 (90 to 99) ^b
Dung (2006) ¹⁷⁶	All children referred for hospital treatment	12.1	German reference	90th centile	DEXA	90th centile	393	85 (79 to 90)	94 (90 to 97) ^a

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	SD scores	1.99	DEXA	10 kg/m ²	58	97.2 (NR)	100 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	SD scores	2.13	DEXA	10 kg/m ²	50	96.9 (NR)	100 (NR)
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	95th centile	DEXA	85th centile	25	20 (NR)	100 (NR)
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	97th centile	DEXA	85th centile	25	20 (NR)	100 (NR)
Telford (2008) ²⁰¹	Boys	8	IOTF	18.4	DEXA	Mueller	375	78.5 (NR)	91 (NR)
Telford (2008) ²⁰¹	Girls	8	IOTF	18.4	DEXA	Mueller	366	85.5 (NR)	89.3 (NR)
Telford (2008) ²⁰¹	All children	8	IOTF	18.4	DEXA	Mueller	741	82 (75 to 88)	90 (87 to 92) ^a
Telford (2008) ²⁰¹	Boys	8	IOTF	18.4	DEXA	McCarthy	375	58.6 (NR)	100 (NR)
Telford (2008) ²⁰¹	Girls	8	IOTF	18.4	DEXA	McCarthy	366	49.2 (NR)	97 (NR)
Telford (2008) ²⁰¹	All children	8	IOTF	18.4	DEXA	McCarthy	741	54 (49 to 59)	99 (97 to 100) ^a
Alvero-Cruz (2010) ¹⁷³	Boys	12–18	?	23.07	D ₂ O	?	75	75.8 (57.7 to 88.9)	83.3 (68.6 to 93)
Alvero-Cruz (2010) ¹⁷³	Girls	12–18	?	23.18	D ₂ O	?	75	88.9 (51.7 to 98.2)	77.3 (65.3 to 86.7)
Vitolo (2007) ²⁰²	Boys	10–19	Conde and Monteiro	25	DEXA	25% BF	219	84.1 (NR)	84.6 (NR)
Vitolo (2007) ²⁰²	Boys	10–14	Conde and Monteiro	25	DEXA	25% BF	128	84.2 (NR)	82.2 (NR)
Vitolo (2007) ²⁰²	Boys	15–19	Conde and Monteiro	25	DEXA	25% BF	91	83.3 (NR)	87.1 (NR)

continued

TABLE 68 Sensitivity and specificity: diagnosing overweight (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Vitolo (2007) ²⁰²	Girls	10–19	Conde and Monteiro	25	DEXA	30% BF	199	34.5 (NR)	98.3 (NR)
Vitolo (2007) ²⁰²	Girls	10–14	Conde and Monteiro	25	DEXA	30% BF	132	44.2 (NR)	97.8 (NR)
Vitolo (2007) ²⁰²	Boys	10–19	Conde and Monteiro	25	DEXA	Boys 25% BF; girls 30% BF	418	46 (39 to 54)	88 (83 to 92) ^a
Vitolo (2007) ²⁰²	All children	10–19	IOTF	25	DEXA	Boys 25% BF; girls 30% BF	418	39 (32 to 47)	89 (85 to 93) ^a
Vitolo (2007) ²⁰²	All children	15–19	Conde and Monteiro	25	DEXA	30% BF	67	18.9 (NR)	100 (NR)
Vitolo (2007) ²⁰²	Boys	10–19	IOTF	25	DEXA	25% BF	219	79.5 (NR)	86.9 (NR)
Vitolo (2007) ²⁰²	Boys	10–14	IOTF	25	DEXA	25% BF	128	84.2 (NR)	86.7 (NR)
Vitolo (2007) ²⁰²	Boys	15–19	IOTF	25	DEXA	25% BF	91	50 (NR)	87.1 (NR)
Vitolo (2007) ²⁰²	Girls	10–19	IOTF	25	DEXA	30% BF	199	26.6 (NR)	96.7 (NR)
Vitolo (2007) ²⁰²	Girls	10–14	IOTF	25	DEXA	30% BF	132	32.6 (NR)	95.7 (NR)
Vitolo (2007) ²⁰²	Girls	15–19	IOTF	25	DEXA	30% BF	67	17 (NR)	100 (NR)
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	IOTF	25	ADP	25% BF	200	80 (NR)	95 (NR)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	IOTF	25	ADP	30% BF	274	24 (NR)	100 (NR)
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	IOTF	25	ADP	Boys 25% BF; girls 30% BF	474	34 (26 to 42)	97 (95 to 99) ^a
Neovius (2004) ¹⁹²	Boys	17	Optimal	25.2	ADP	25% BF	200	72 (NR)	98 (NR)
Neovius (2004) ¹⁹²	Girls	17	Optimal	22.2	ADP	30% BF	274	65 (NR)	88 (NR)
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Optimal	?	ADP	25% BF	200	92 (NR)	92 (NR)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Optimal	?	ADP	30% BF	274	77 (NR)	76 (NR)
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	Optimal	?	ADP	Boys 25% BF; girls 30% BF	474	79 (72 to 86)	84 (80 to 88) ^a

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Conicity index									
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8		80th centile	DEXA	1 SD	278	57 (42 to 72)	88 (83 to 92)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9		80th centile	DEXA	1 SD	302	61 (45 to 75)	88 (83 to 91)
FMI									
Alvero-Cruz (2010) ¹⁷³	Boys	12–18		4.58	D ₂ O	?	75	100 (89.3 to 100)	90.5 (77.4 to 97.3)
Alvero-Cruz (2010) ¹⁷³	Girls	12–18		7.76	D ₂ O	?	75	100 (66.2 to 100)	97 (89.5 to 99.5)
SFT									
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	Index	1.26	DEXA	10 kg/m ²	58	75 (NR)	77.3 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	Index	1.07	DEXA	10 kg/m ²	50	57.6 (NR)	76.5 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–18	Subscapular	85th centile	DEXA	95th centile	1196	98.5 (NR)	79.1 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–18	Triceps	85th centile	DEXA	95th centile	1196	98.5 (NR)	78 (NR)
Sarria (2001) ¹⁹⁷	Girls	7–16.9	Sum	85th centile	Underwater (hydrostatic) weighting	85th centile	175	58 (37 to 77)	93 (87 to 96)
Freedman (2013) ¹⁸⁰	Boys	8–19	Sum	Elevated/slightly elevated – prevalence matched to BMI	DEXA	?	4519	85 (83 to 87) ^b	92 (91 to 93) ^b

continued

TABLE 68 Sensitivity and specificity: diagnosing overweight (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI), %	Specificity (95% CI), %
Freedman (2013) ¹⁸⁰	Girls	8–19	Sum	Elevated/slightly elevated – prevalence matched to BMI	DEXA	?	2846	81 (78 to 83) ^b	90 (89 to 92) ^b
Freedman (2013) ¹⁸⁰	All children	8–19	Sum	Elevated/slightly elevated – prevalence matched to BMI	DEXA	?	7365	83 (82 to 85)	91 (91 to 92) ^a
WC									
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	Mid-point between ribs and iliac crest	66.5	DEXA	10 kg/m ²	50	84.8 (NR)	100 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	Umbilical	72	DEXA	10 kg/m ²	50	90.9 (NR)	100 (NR)
Neovius (2005) ¹⁹³	Girls	17	Smallest between ribs and iliac crest	73.3	ADP	30% BF	274	53 (NR)	89 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	Mid-point between ribs and iliac crest	77	DEXA	10 kg/m ²	58	88.9 (NR)	95.5 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	Umbilical	85	DEXA	10 kg/m ²	58	88.9 (NR)	100 (NR)
Neovius (2005) ¹⁹³	Boys	17	Smallest between ribs and iliac crest	85.9	ADP	25% BF	200	68 (NR)	99 (NR)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	Smallest between ribs and iliac crest	80th centile	DEXA	1 SD	278	89 (77 to 96)	94 (91 to 97)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	Smallest between ribs and iliac crest	80th centile	DEXA	1 SD	302	87 (74 to 95)	92 (88 to 95)
Sarría (2001) ¹⁹⁷	Boys	7–16.9	Smallest between ribs and iliac crest	85th centile	Underwater (hydrostatic) weighting	85th centile	175	58 (37 to 77)	93 (87 to 96)
WHR									
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	0.84	ADP	30% BF	274	17 (NR)	98 (NR)
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	0.9	ADP	25% BF	200	24 (NR)	98 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	0.91	DEXA	10 kg/m ²	58	72.2 (NR)	90.9 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	0.92	DEXA	10 kg/m ²	50	78.8 (NR)	70.6 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	WC umbilical	0.98	DEXA	10 kg/m ²	58	77.8 (NR)	95.5 (NR)

continued

TABLE 68 Sensitivity and specificity: diagnosing overweight (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	Sensitivity (95% CI), %	Specificity (95% CI), %
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	WC umbilical	0.99	DEXA	10 kg/m ²	50	66.7 (NR)	94.1 (NR)
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	278	47 (32 to 62)	85 (80 to 90)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	302	46 (31 to 61)	85 (80 to 89)
WHTR									
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	0.49	DEXA	10 kg/m ²	50	90.9 (NR)	100 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	0.5	DEXA	10 kg/m ²	58	97.2 (NR)	100 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – pubertal	6–16	WC umbilical	0.54	DEXA	10 kg/m ²	58	97.2 (NR)	100 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to an obesity centre and their siblings – prepubertal	6–16	WC umbilical	0.54	DEXA	10 kg/m ²	50	93.9 (NR)	100 (NR)

AVENA, *Alimentación y Valoración del Estado Nutricional en Adolescentes*; BF, body fat; NR, not reported.

a Data for entire population derived from 2 x 2 tables of boys and girls separately.

b Sensitivity and specificity calculated from 2 x 2 data.

TABLE 69 Diagnosing 'fat'

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	Sensitivity (95% CI)	Specificity (95% CI)
SFT									
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Ellis	?	4-C	?	114	96 (NR)	47 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Pennington	?	4-C	?	114	94 (NR)	82 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Slaughter	?	4-C	?	114	98 (NR)	71 (NR)
BIA									
Bray (2002) ¹⁷⁵	White and AA children	12	Deurenberg	?	4-C	?	114	65 (NR)	93 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Goran	?	4-C	?	114	100 (NR)	45 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Pennington	?	4-C	?	114	87 (NR)	84 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Schaefer	?	4-C	?	114	89 (NR)	84 (NR)
Bray (2002) ¹⁷⁵	White and AA children	12	Suprasongsin	?	4-C	?	114	100 (NR)	11 (NR)

AA, African American; NR, not reported.

TABLE 70 Diagnosing 'upper tertile'

Study	Population	Age at assessment (years)	Index test	Index test cut-off point	Reference standard	Reference standard cut-off point	1 to 1	1 to 2/3	2/3 to 1	2/3 to 2/3	Sensitivity	Specificity
Fuller (2002) ¹⁸³	Unselected	8–12	BIA	?	DEXA	?	9	3	3	22	75.0	88.0
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 940	?	4-C	?	9	4	4	21	69.2	84.0
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 950	?	4-C	?	9	4	4	21	69.2	84.0
Fuller (2001) ¹⁸²	Unselected	8–12	SFT	?	4-C	?	8	5	5	20	61.5	80.0

OD, optical density.

TABLE 71 Diagnosing 'upper or second tertile'

Study	Population	Age at assessment (years)	Index test	Index test cut-off point	Reference standard	Reference standard cut-off point	1/2 to 1/2	1/2 to 3	3 to 1/2	3 to 3	Sensitivity	Specificity
Fuller (2002) ¹⁸³	Unselected	8–12	BIA	?	DEXA	?	24	1	1	11	96.0	91.7
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 940	?	4-C	?	21	4	4	9	84.0	69.2
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 950	?	4-C	?	24	1	1	12	96.0	92.3
Fuller (2001) ¹⁸²	Unselected	8–12	SFT	?	4-C	?	24	1	1	12	96.0	92.3

OD, optical density.

TABLE 72 Likelihood ratios: diagnosing obesity

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>		LR-
							LR+	LR-	
BMI									
Bartok (2011) ¹⁷⁴	White girls	11	CDC	82nd centile	DEXA	95th centile	172	5.59	0.060 ^a
Bartok (2011) ¹⁷⁴	White girls	13	CDC	82nd centile	DEXA	95th centile	151	7.75	0.080 ^a
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	?	85th centile	Underwater (hydrostatic) weighting	90th centile	159	29.00	0.717 ^a
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	?	85th centile	Underwater (hydrostatic) weighting	90th centile	157	Infinite	0.770 ^a
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	?	85th centile	Underwater (hydrostatic) weighting	90th centile	316	Infinite	0.750 ^{a,b}
Bartok (2011) ¹⁷⁴	White girls	9	CDC	85th centile	DEXA	95th centile	173	15.00	0.106 ^a
Bartok (2011) ¹⁷⁴	White girls	15	CDC	85th centile	DEXA	95th centile	160	19.20	0.042 ^a
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	85th centile	DEXA	95th centile	25	16.00	0.211 ^a
Harrington (2013) ¹⁸⁵	White girls	5–18	Optimal	89th centile	DEXA	?	83	10.00	0.000 ^a
Harrington (2013) ¹⁸⁵	White boys	5–18	Optimal	94th centile	DEXA	?	94	33.33	0.000 ^a
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	95th centile	DEXA	95th centile	25	Infinite	0.600 ^a
Mei (2006) ¹⁹⁰	Unselected	5–18	CDC	95th centile	DEXA	95th centile	1196	8.73	0.084 ^a
Freedman (2013) ¹⁸⁰	Boys	8–19	CDC	95th centile	DEXA	?	4518	15.00	0.263 ^a
Freedman (2009) ¹⁷⁹	Healthy unselected boys	5–18	CDC	95th centile	DEXA	95th centile	626	15.00	0.263 ^a
Wickramasinghe (2005) ²⁰⁴	White boys	5–14.99	CDC	95th centile	D ₂ O	20% BF	44	Infinite	0.965 ^a
Wickramasinghe (2005) ²⁰⁴	Sri Lankan boys	5–14.99	CDC	95th centile	D ₂ O	20% BF	27	Infinite	0.875 ^a

continued

TABLE 72 Likelihood ratios: diagnosing obesity (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Wickramasinghe (2009) ^{2,05}	Sri Lankan boys	5-15	CDC	95th centile	D ₂ O	25% BF	158	Infinite	0.805 ^a
Wickramasinghe (2009) ^{2,05}	Sri Lankan girls	5-15	CDC	95th centile	D ₂ O	30% BF	124	Infinite	0.838 ^a
Wickramasinghe (2009) ^{2,05}	All Sri Lankan children	5-15	CDC	95th centile	D ₂ O	Boys 25% BF; girls 30% BF	282	Infinite	0.820 ^{a,b}
Freedman (2013) ¹⁸⁰	Girls	8-19	CDC	95th centile	DEXA	?	2847	15.20	0.253 ^a
Freedman (2013) ¹⁸⁰	All children	8-19	CDC	95th centile	DEXA	?	7365	15.20	0.253 ^{a,b}
Freedman (2009) ¹⁷⁹	Girls	5-18	CDC	95th centile	DEXA	95th centile	570	26.67	0.206 ^a
Freedman (2009) ¹⁷⁹	Girls	5-18	CDC	95th centile	DEXA	95th centile	1196	19.25	0.240 ^{a,b}
Wickramasinghe (2005) ^{2,04}	White girls	5-14.99	CDC	95th centile	D ₂ O	30% BF	52	Infinite	0.800 ^a
Wickramasinghe (2005) ^{2,04}	Sri Lankan girls	5-14.99	CDC	95th centile	D ₂ O	30% BF	15	Infinite	0.857 ^a
Khadgawat (2013) ¹⁸⁸	Boys	7-17	IOTF	95th centile	DEXA	95th centile	825	28.33	0.155 ^a
Khadgawat (2013) ¹⁸⁸	Boys	7-17	IOTF	95th centile	DEXA	Prevalence matched to BMVI	825	33.50	0.337 ^a
Wickramasinghe (2009) ^{2,05}	Sri Lankan boys	5-15	IOTF	95th centile	D ₂ O	25% BF	158	Infinite	0.875 ^a
Wickramasinghe (2009) ^{2,05}	Sri Lankan girls	5-15	IOTF	95th centile	D ₂ O	30% BF	124	Infinite	0.920 ^a
Wickramasinghe (2009) ^{2,05}	All Sri Lankan children	5-15	IOTF	95th centile	D ₂ O	Boys 25% BF; girls 30% BF	282	Infinite	0.900 ^{a,b}
Khadgawat (2013) ¹⁸⁸	Girls	7-17	IOTF	95th centile	DEXA	95th centile	815	Infinite	0.460 ^a
Khadgawat (2013) ¹⁸⁸	Girls	7-17	IOTF	95th centile	DEXA	95th centile	1640	33.00	0.347 ^{a,b}

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR-
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	95th centile	DEXA	Prevalence matched to BMI	815	81.00	0.192 ^a
Khadgawat (2013) ¹⁸⁸	Girls	7–17	IOTF	95th centile	DEXA	Prevalence matched to BMI	1640	72.00	0.283 ^{a,b}
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	95th centile	DEXA (adjusted for sex and ethnicity)	95th centile	406	8.44	0.264 ^a
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	95th centile	DEXA (adjusted for sex)	95th centile	406	7.89	0.319 ^a
Reilly (2010) ¹⁹⁵	Boys	9.9	UK90	95th centile	DEXA	90th centile	3809	19.20	0.042 ^a
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	95th centile	DEXA (adjusted for sex and ethnicity)	95th centile	573	7.67	0.341 ^a
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	95th centile	DEXA (adjusted for sex)	95th centile	573	11.25	0.109 ^a
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	95th centile	DEXA (adjusted for sex and ethnicity)	95th centile	979	8.00	0.308 ^{a,b}
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	95th centile	DEXA (adjusted for sex)	95th centile	979	10.25	0.196 ^{a,b}
Reilly (2010) ¹⁹⁵	Girls	9.9	UK90	95th centile	DEXA	90th centile	3913	23.50	0.063 ^a
Reilly (2010) ¹⁹⁵	Girls	9.9	UK90	95th centile	DEXA	90th centile	7722	19.00	0.053 ^{a,b}
Field (2003) ¹⁷⁸	Unselected	10 (SD 2.2)	?	95th centile	DEXA	90th centile	596	65.00	0.354 ^a
Field (2003) ¹⁷⁸	Unselected	10 (SD 2.2)	SD score	2	DEXA	90th centile	596	Infinite	0.490 ^a
Wickramasinghe (2005) ²⁰⁴	White boys	5–14.99	SD score	2	D ₂ O	20% BF	44	0.99	1.001 ^a
Wickramasinghe (2005) ²⁰⁴	Sri Lankan boys	5–14.99	SD score	2	D ₂ O	20% BF	27	Infinite	0.875 ^a
Wickramasinghe (2009) ²⁰⁵	Sri Lankan boys	5–15	SD score	2	D ₂ O	25% BF	158	Infinite	0.764 ^a

continued

TABLE 72 Likelihood ratios: diagnosing obesity (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Wickramasinghe (2005) ²⁰⁴	White girls	5–14.99	SD score	2	D ₂ O	30% BF	52	Infinite	0.948 ^a
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	SD score	2	D ₂ O	30% BF	124	Infinite	0.838 ^a
Wickramasinghe (2005) ²⁰⁴	Sri Lankan girls	5–14.99	SD score	2	D ₂ O	30% BF	15	Infinite	0.857 ^a
Wickramasinghe (2009) ²⁰⁵	All Sri Lankan children	5–15	SD score	2	D ₂ O	Boys 25% BF; girls 30% BF	282	Infinite	0.810 ^{a,b}
Wickramasinghe (2009) ²⁰⁴	All Sri Lankan children	5–14.99	SD score	2	D ₂ O	Boys 20% BF; girls 30% BF	42	Infinite	0.870 ^{a,b}
Wickramasinghe (2009) ²⁰⁴	White children	5–14.99	SD score	2	D ₂ O	Boys 20% BF; girls 30% BF	96	3.00	0.959 ^{a,b}
Taylor (2003) ²⁰⁰	Boys	8.5–15.5	Optimal z-score (adjusted for age)	?	DEXA	25% BF	179	7.94	0.160 ^a
Taylor (2003) ²⁰⁰	Boys	8.5–15.5	Optimal z-score (adjusted for age and pubertal status)	?	DEXA	25% BF	179	11.66	0.111 ^a
Taylor (2003) ²⁰⁰	Girls	8.5–15.5	Optimal z-score (adjusted for age)	?	DEXA	35% BF	189	25.29	0.145 ^a
Taylor (2003) ²⁰⁰	Girls	8.5–15.5	Optimal z-score (adjusted for age and pubertal status)	?	DEXA	35% BF	189	11.79	0.125 ^a
Harrington (2013) ¹⁸⁵	Unselected	5–18	Optimal	96th centile	DEXA	?	369	8.18	0.112 ^a
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	97th centile	DEXA	95th centile	25	Infinite	0.600 ^a
Harrington (2013) ¹⁸⁵	AA boys	5–18	Optimal	97	DEXA	?	79	50.00	0.000 ^a
Harrington (2013) ¹⁸⁵	AA girls	5–18	Optimal	98	DEXA	?	113	13.29	0.075 ^a

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Fujita (2011) ¹⁸¹	Girls	10	Optimal	19.6	DEXA	95th centile	196	12.50	0.000 ^a
Fujita (2011) ¹⁸¹	Boys	10	Optimal	20.8	DEXA	95th centile	226	25.00	0.000 ^a
Telford (2008) ²⁰¹	Boys	8	IOTF	21.6	DEXA	Mueller	375	19.89	0.131 ^a
Telford (2008) ²⁰¹	Boys	8	IOTF	21.6	DEXA	McCarthy	375	Infinite	0.739 ^a
Telford (2008) ²⁰¹	Girls	8	IOTF	21.6	DEXA	Mueller	366	32.54	0.224 ^a
Telford (2008) ²⁰¹	Girls	8	IOTF	21.6	DEXA	McCarthy	366	Infinite	0.746 ^a
Telford (2008) ²⁰¹	All children	8	IOTF	21.6	DEXA	McCarthy	741	Infinite	0.740 ^{a,b}
Telford (2008) ²⁰¹	All children	8	IOTF	21.6	DEXA	Mueller	741	26.67	0.206 ^{a,b}
Neovius (2005) ¹⁹³	Girls	17	Optimal	26.5	ADP	95th centile	274	37.10	0.200
Neovius (2005) ¹⁹³	Boys	17	Optimal	29.2	ADP	95th centile	200	25.30	0.600
Wickramasinghe (2005) ²⁰⁴	White boys	5–14.99	IOTF	30	D ₂ O	20% BF	44	Infinite	1.000 ^a
Wickramasinghe (2005) ²⁰⁴	Sri Lankan boys	5–14.99	IOTF	30	D ₂ O	20% BF	27	Infinite	1.000 ^a
Wickramasinghe (2005) ²⁰⁴	White girls	5–14.99	IOTF	30	D ₂ O	30% BF	52	Infinite	1.000 ^a
Wickramasinghe (2005) ²⁰⁴	Sri Lankan girls	5–14.99	IOTF	30	D ₂ O	30% BF	15	Infinite	1.000 ^a
Wickramasinghe (2005) ²⁰⁴	White children	5–14.99	IOTF	30	D ₂ O	Boys 20% BF; girls 30% BF	96	Infinite	1.000
Wickramasinghe (2005) ²⁰⁴	All Sri Lankan children	5–14.99	IOTF	30	D ₂ O	Boys 20% BF; girls 30% BF	42	Infinite	0.990
Zhang (2004) ²⁰⁶	City-/suburb-residing boys	13.7	IOTF	30	DEXA	25% BF	172	5.56	0.000 ^a

continued

TABLE 72 Likelihood ratios: diagnosing obesity (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Zhang (2004) ²⁰⁶	City/suburb-residing girls	13.5	IOTF	30	DEXA	35% BF	414	3.23	0.000 ^a
Zhang (2004) ²⁰⁶	Rural-residing girls	10.1	IOTF	30	DEXA	35% BF	165	5.26	0.000 ^a
Relative BMI									
Marshall (1991) ¹⁸⁹	Unselected	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	8.46	0.316 ^a
Marshall (1991) ¹⁸⁹	Girls	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	25% BF	274	7.81	0.285 ^a
Marshall (1991) ¹⁸⁹	Boys	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	20% BF	266	9.57	0.335 ^a
Relative weight									
Johnston (1985) ¹⁸⁷	Boys	12–17	–	?	Underwater (hydrostatic) weighting	25% BF	169	3.71	0.558 ^a
Johnston (1985) ¹⁸⁷	Girls	12–17	–	?	Underwater (hydrostatic) weighting	30% BF	66	4.83	0.755 ^a
Marshall (1991) ¹⁸⁹	Unselected	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	10.32	0.509 ^a
Marshall (1991) ¹⁸⁹	Girls	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	25% BF	274	11.86	0.441 ^a
Marshall (1991) ¹⁸⁹	Boys	7–14	–	≥ 120%	Underwater (hydrostatic) weighting	20% BF	266	9.78	0.538 ^a
SFT									
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Subscapular	85th centile	Underwater (hydrostatic) weighting	90th centile	159	38.00	0.626 ^a
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Subscapular	85th centile	Underwater (hydrostatic) weighting	90th centile	157	30.00	0.707 ^a

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR-
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Sum	85th centile	Underwater (hydrostatic) weighting	90th centile	159	3.80	0.506 ^a
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Sum	85th centile	Underwater (hydrostatic) weighting	90th centile	157	4.44	0.244 ^a
Himes (1989) ¹⁸⁶	Boys	8.4–18.99	Triceps	85th centile	Underwater (hydrostatic) weighting	90th centile	159	Infinite	0.760 ^a
Himes (1989) ¹⁸⁶	Girls	8.4–18.99	Triceps	85th centile	Underwater (hydrostatic) weighting	90th centile	157	7.67	0.794 ^a
Marshall (1991) ¹⁸⁹	Unselected	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	8.77	0.147 ^a
Marshall (1991) ¹⁸⁹	Girls	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	25% BF	274	10.19	0.035 ^a
Marshall (1991) ¹⁸⁹	Boys	7–14	Sum	85th centile	Underwater (hydrostatic) weighting	20% BF	266	7.69	0.223 ^a
Marshall (1991) ¹⁸⁹	Boys	7–14	Triceps	85th centile	Underwater (hydrostatic) weighting	20% BF	266	11.93	0.376 ^a
Marshall (1991) ¹⁸⁹	Unselected	7–14	Triceps	85th centile	Underwater (hydrostatic) weighting	Boys 20% BF; girls 25% BF	540	10.97	0.364 ^a
Marshall (1991) ¹⁸⁹	Girls	7–14	Triceps	85th centile	Underwater (hydrostatic) weighting	25% BF	274	10.26	0.346 ^a
Mei (2006) ¹⁹⁰	Unselected	5–18	Subscapular	95th centile	DEXA	95th centile	1196	14.93	0.111 ^a
Mei (2006) ¹⁹⁰	Unselected	5–18	Triceps	95th centile	DEXA	95th centile	1196	13.18	0.112 ^a
Freedman (2013) ¹⁸⁰	Boys	8–19	Sum	Elevated – prevalence matched to BMI	DEXA	?	4519	20.00	0.208 ^a
Freedman (2013) ¹⁸⁰	Girls	8–19	Sum	Elevated – prevalence matched to BMI	DEXA	?	2846	19.75	0.219 ^a

continued

TABLE 72 Likelihood ratios: diagnosing obesity (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR-
Johnston (1985) ¹⁸⁷	Boys	12–17	Triceps	?	Underwater (hydrostatic) weighting	25% BF	169	12.00	0.542 ^a
Johnston (1985) ¹⁸⁷	Girls	12–17	Triceps	?	Underwater (hydrostatic) weighting	30% BF	66	Infinite	0.760 ^a
Johnston (1985) ¹⁸⁷	All children	12–17	Triceps	?	Underwater (hydrostatic) weighting	Boys 2.5% BF; girls 30% BF	235	13.33	0.619 ^{a,b}
Freedman (2013) ¹⁸⁰	All children	8–19	Sum	Elevated – prevalence matched to BMI	DEXA	?	7365	20.00	0.208 ^{a,b}
WC									
Neovius (2005) ¹⁹³	Boys	17	Smallest between ribs and iliac crest	95	ADP	95th centile	200	23.80	0.500
Neovius (2005) ¹⁹³	Girls	17	Smallest between ribs and iliac crest	85	ADP	95th centile	274	27.90	0.400
Reilly (2010) ¹⁹⁵	Boys	9.9	UK 1988 reference	95th centile	DEXA	90th centile	3809	5.11	0.037 ^a
Reilly (2010) ¹⁹⁵	Girls	9.9	UK 1988 reference	95th centile	DEXA	90th centile	3913	5.16	0.025 ^a
Wickramasinghe (2009) ²⁰⁵	Sri Lankan boys	5–15	Smallest between ribs and iliac crest	98th centile	D ₂ O	25% BF	158	28.92	0.661 ^a
Wickramasinghe (2009) ²⁰⁵	Sri Lankan girls	5–15	Smallest between ribs and iliac crest	98th centile	D ₂ O	30% BF	124	Infinite	0.616 ^a
Wickramasinghe (2009) ²⁰⁵	All Sri Lankan children	5–15	Smallest between ribs and iliac crest	98th centile	D ₂ O	Boys 2.5% BF; girls 30% BF	282	37.00	0.636 ^{a,b}
Fujita (2011) ¹⁸¹	Boys	10	Umbilical	76.5	DEXA	95th centile	226	33.33	0.000 ^a
Fujita (2011) ¹⁸¹	Girls	10	Umbilical	73	DEXA	95th centile	196	25.00	0.000 ^a

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR-
WHR									
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	0.9	ADP	95th centile	200	15.20	0.600
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	1.02	ADP	95th centile	274	Infinite	1.000
WHTR									
Fujita (2011) ¹⁸¹	Boys	10	WC umbilical	0.519	DEXA	95th centile	226	20.00	0.000 ^a
Fujita (2011) ¹⁸¹	Girls	10	WC umbilical	0.499	DEXA	95th centile	196	20.00	0.000 ^a

AA, African American; BF, body fat.
a LRs calculated from sensitivity and specificity.
b Data for overall population derived from 2 x 2 data for boys and girls separately.

TABLE 73 Likelihood ratios: diagnosing overweight

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
BMI									
Bartok (2011) ¹⁷⁴	White girls	9	CDC	73rd centile	DEXA	85th centile	173	10.22	0.088 ^a
Bartok (2011) ¹⁷⁴	White girls	13	CDC	77th centile	DEXA	85th centile	151	8.27	0.101 ^a
Bartok (2011) ¹⁷⁴	White girls	15	CDC	78th centile	DEXA	85th centile	160	11.50	0.330 ^a
Bartok (2011) ¹⁷⁴	White girls	11	CDC	81st centile	DEXA	85th centile	172	21.25	0.156 ^a
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	WHO	85th centile	ADP	25% BF	200	34.00	0.327 ^a
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Göteborg, Sweden	85th centile	ADP	25% BF	200	13.14	0.086 ^a
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	WHO	85th centile	ADP	30% BF	274	Infinite	0.810 ^a
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Göteborg, Sweden	85th centile	ADP	30% BF	274	13.00	0.629 ^a
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	Göteborg, Sweden	85th centile	ADP	Boys 25% BF; girls 30% BF	474	9.60	0.547 ^{a,b}
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	WHO	85th centile	ADP	Boys 25% BF; girls 30% BF	474	28.00	0.727 ^{a,b}
Freedman (2009) ¹⁷⁹	Boys	5-18	CDC	85th centile	DEXA	85th centile	626	10.50	0.174 ^a
Freedman (2009) ¹⁷⁹	Girls	5-18	CDC	85th centile	DEXA	85th centile	570	10.38	0.185 ^a
Freedman (2009) ¹⁷⁹	All children	5-18	CDC	85th centile	DEXA	85th centile	1196	10.38	0.185 ^{a,b}
Khadgawat (2013) ¹⁸⁸	Boys	7-17	IOTF	85th centile	DEXA	85th centile	825	8.67	0.242 ^a
Khadgawat (2013) ¹⁸⁸	Girls	7-17	IOTF	85th centile	DEXA	85th centile	815	10.67	0.383 ^a
Khadgawat (2013) ¹⁸⁸	All children	7-17	IOTF	85th centile	DEXA	85th centile	1640	10.29	0.301 ^{a,b}
Khadgawat (2013) ¹⁸⁸	Boys	7-17	IOTF	85th centile	DEXA	Prevalence matched to BMI	825	12.83	0.245 ^a
Khadgawat (2013) ¹⁸⁸	Girls	7-17	IOTF	85th centile	DEXA	Prevalence matched to BMI	815	10.83	0.372 ^a
Khadgawat (2013) ¹⁸⁸	All children	7-17	IOTF	85th centile	DEXA	Prevalence matched to BMI	1640	12.00	0.298 ^{a,b}

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Freedman (2013) ¹⁸⁰	Boys	8–19	CDC	85th centile	DEXA	?	4518	9.22	0.187 ^a
Freedman (2013) ¹⁸⁰	Girls	8–19	CDC	85th centile	DEXA	?	2847	8.00	0.222 ^a
Freedman (2013) ¹⁸⁰	All children	8–19	CDC	85th centile	DEXA	?	7365	8.10	0.211 ^{a,b}
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	85th centile	DEXA (adjusted for sex and ethnicity)	85th centile	406	5.75	0.095 ^a
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	85th centile	DEXA (adjusted for sex and ethnicity)	85th centile	573	5.11	0.098 ^a
Ellis (1999) ¹⁷⁷	Boys	3–18	UK90	85th centile	DEXA (adjusted for sex)	85th centile	406	5.29	0.120 ^a
Ellis (1999) ¹⁷⁷	Girls	3–18	UK90	85th centile	DEXA (adjusted for sex)	85th centile	573	5.53	0.072 ^a
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	85th centile	DEXA (adjusted for sex and ethnicity)	85th centile	979	5.41	0.096 ^{a,b}
Ellis (1999) ¹⁷⁷	All children	3–18	UK90	85th centile	DEXA (adjusted for sex)	85th centile	979	5.47	0.084 ^{a,b}
Moreno (2006) ¹⁹¹	Boys	13–17.9	IOTF	85th centile	DEXA	85th centile	116	5.07	0.337 ^a
Moreno (2006) ¹⁹¹	Girls	13–17.9	IOTF	85th centile	DEXA	85th centile	170	7.50	0.278 ^a
Moreno (2006) ¹⁹¹	Boys	13–17.9	AVENA	85th centile	DEXA	85th centile	116	4.42	0.534 ^a
Moreno (2006) ¹⁹¹	Girls	13–17.9	AVENA	85th centile	DEXA	85th centile	170	9.88	0.228 ^a
Moreno (2006) ¹⁹¹	All children	13–17.9	IOTF	85th centile	DEXA	85th centile	286	6.08	0.307 ^{a,b}
Moreno (2006) ¹⁹¹	All children	13–17.9	AVENA	85th centile	DEXA	85th centile	286	6.70	0.367 ^{a,b}
Sproule (2009) ¹⁸⁸	Spinal muscular atrophy	5–18	CDC	85th centile	DEXA	85th centile	25	Infinite	0.500 ^a
Sarria (2001) ¹⁹⁷	Healthy unselected boys	7–16.9	z-score	85th centile	Underwater (hydrostatic) weighing	85th centile	175	5.56	0.549 ^a

continued

TABLE 73 Likelihood ratios: diagnosing overweight (*continued*)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Warner (1997) ²⁰³	All children	?	SD score	85th centile/1 SD	DEXA	US 85th centile	143	11.00	0.362 ^a
Warner (1997) ²⁰³	Cancer survivors	12 (SD 3.7)	SD score	85th centile/1 SD	DEXA	US 85th centile	43	5.67	0.364 ^a
Warner (1997) ²⁰³	Growth hormone-deficient	15.7 (SD 1.2)	SD score	85th centile/1 SD	DEXA	US 85th centile	27	11.67	0.319 ^a
Warner (1997) ²⁰³	Inflammatory bowel disease	14.3 (SD 2.8)	SD score	85th centile/1 SD	DEXA	US 85th centile	33	13.75	0.469 ^a
Warner (1997) ²⁰³	Healthy	11.8 (SD 3.1)	SD score	85th centile/1 SD	DEXA	US 85th centile	40	16.75	0.344 ^a
Pandit (2009) ¹⁹⁴	Boys	6–17	CDC z-/SD score	1	DEXA	85th centile	316	25.67	0.237 ^a
Pandit (2009) ¹⁹⁴	Girls	6–17	CDC z-/SD score	1	DEXA	85th centile	250	27.67	0.175 ^a
Pandit (2009) ¹⁹⁴	All children	6–17	CDC z-/SD score	1	DEXA	85th centile	566	33.00	0.347 ^{a,b}
Dung (2006) ¹⁷⁶	Boys referred for hospital treatment	11.9	German reference	90th centile	DEXA	90th centile	191	10.88	0.141 ^a
Dung (2006) ¹⁷⁶	Girls referred for hospital treatment	12.1	German reference	90th centile	DEXA	90th centile	202	20.50	0.188 ^a
Dung (2006) ¹⁷⁶	All children referred for hospital treatment	12.1	German reference	90th centile	DEXA	90th centile	393	14.17	0.160 ^{a,b}
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	95th centile	DEXA	85th centile	25	Infinite	0.800 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	SD scores	1.99	DEXA	10 kg/m ²	58	Infinite	0.028 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	SD scores	2.13	DEXA	10 kg/m ²	50	Infinite	0.031 ^a

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR-
Sproule (2009) ¹⁹⁸	Spinal muscular atrophy	5–18	CDC	97th centile	DEXA	85th centile	25	Infinite	0.800 ^a
Telford (2008) ²⁰¹	Boys	8	IOTF	18.4	DEXA	Mueller	375	8.72	0.236 ^a
Telford (2008) ²⁰¹	Boys	8	IOTF	18.4	DEXA	McCarthy	375	Infinite	0.414 ^a
Telford (2008) ²⁰¹	Girls	8	IOTF	18.4	DEXA	Mueller	366	7.99	0.162 ^a
Telford (2008) ²⁰¹	Girls	8	IOTF	18.4	DEXA	McCarthy	366	16.40	0.524 ^a
Telford (2008) ²⁰¹	All children	8	IOTF	18.4	DEXA	Mueller	741	8.20	0.200 ^{a,b}
Telford (2008) ²⁰¹	All children	8	IOTF	18.4	DEXA	McCarthy	741	54.00	0.465 ^{a,b}
Neovius (2005) ¹⁹³	Girls	17	Optimal	22.2	ADP	30% BF	274	5.40	0.400
Alvero-Cruz (2010) ¹⁷³	Boys	12–18	?	23.07	D ₂ O	?	75	4.55	0.290
Alvero-Cruz (2010) ¹⁷³	Girls	12–18	?	23.18	D ₂ O	?	75	3.91	0.140
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	IOTF	25	ADP	25% BF	200	16.00	0.211 ^a
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	IOTF	25	ADP	30% BF	274	Infinite	0.760 ^a
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	IOTF	25	ADP	Boys 25% BF; girls 30% BF	474	11.33	0.680 ^{a,b}
Vitolo (2007) ²⁰²	Boys	10–19	IOTF	25	DEXA	25% BF	219	6.07	0.236 ^a
Vitolo (2007) ²⁰²	Boys	10–19	IOTF	25	DEXA	25% BF	219	5.46	0.188 ^a
Vitolo (2007) ²⁰²	Boys	10–14	IOTF	25	DEXA	25% BF	128	6.33	0.182 ^a
Vitolo (2007) ²⁰²	Boys	10–14	Conde and Monteiro	25	DEXA	25% BF	128	4.73	0.192 ^a
Vitolo (2007) ²⁰²	Boys	15–19	IOTF	25	DEXA	25% BF	91	3.88	0.574 ^a
Vitolo (2007) ²⁰²	Boys	15–19	Conde and Monteiro	25	DEXA	25% BF	91	6.46	0.192 ^a

continued

TABLE 73 Likelihood ratios: diagnosing overweight (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
Vitolo (2007) ²⁰²	Girls	10–19	IOTF	25	DEXA	30% BF	199	8.06	0.759 ^a
Vitolo (2007) ²⁰²	Girls	10–19	Conde and Monteiro	25	DEXA	30% BF	199	20.29	0.666 ^a
Vitolo (2007) ²⁰²	Girls	10–14	IOTF	25	DEXA	30% BF	132	7.58	0.704 ^a
Vitolo (2007) ²⁰²	Girls	10–14	Conde and Monteiro	25	DEXA	30% BF	132	20.09	0.571 ^a
Vitolo (2007) ²⁰²	Girls	15–19	IOTF	25	DEXA	30% BF	67	Infinite	0.830 ^a
Vitolo (2007) ²⁰²	Girls	15–19	Conde and Monteiro	25	DEXA	30% BF	67	Infinite	0.811 ^a
Vitolo (2007) ²⁰²	All children	10–19	Conde and Monteiro	25	DEXA	Boys 25% BF; girls 30% BF	418	3.83	0.614 ^{a,b}
Vitolo (2007) ²⁰²	All children	10–19	IOTF	25	DEXA	Boys 25% BF; girls 30% BF	418	3.55	0.685 ^{a,b}
Neovius (2005) ¹⁹³	Boys	17	Optimal	25.2	ADP	25% BF	200	31.50	0.300
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Optimal	?	ADP	25% BF	200	12.00	0.090
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Optimal	?	ADP	30% BF	274	3.00	0.300
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Optimal	?	ADP	25% BF	200	11.50	0.087 ^a
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Optimal	?	ADP	30% BF	274	3.21	0.303 ^a
Neovius (2004) ¹⁹²	All children	16.9 (SD 0.4)	Optimal	?	ADP	Boys 25% BF; girls 30% BF	474	4.94	0.250 ^{a,b}
Conicity index									
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	–	80th centile	DEXA	1 SD	278	4.70	0.480
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	–	80th centile	DEXA	1 SD	302	4.90	0.450

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
FMI									
Alvero-Cruz (2010) ¹⁷³	Boys	12–18	–	4.58	D ₂ O	?	75	10.50	0.000
Alvero-Cruz (2010) ¹⁷³	Girls	12–18	–	7.76	D ₂ O	?	75	33.00	0.000
SFT									
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	SF index	1.26	DEXA	10 kg/m ²	58	3.30	0.323 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	SF index	1.07	DEXA	10 kg/m ²	50	2.45	0.554 ^a
Mei (2006) ¹⁹⁰	Unselected	5–18	Subscapular	85th centile	DEXA	95th centile	1196	4.71	0.019 ^a
Mei (2006) ¹⁹⁰	Unselected	5–18	Triceps	85th centile	DEXA	95th centile	1196	4.48	0.019 ^a
Sarria (2001) ¹⁹⁷	Boys	7–16.9	Sum	85th centile	Underwater (hydrostatic) weighting	85th centile	175	8.29	0.452 ^a
Freedman (2013) ¹⁸⁰	Boys	8–19	Sum	Elevated/slightly elevated – prevalence matched to BMI	DEXA	?	4519	10.63	0.163 ^a
Freedman (2013) ¹⁸⁰	Girls	8–19	Sum	Elevated/slightly elevated – prevalence matched to BMI	DEXA	?	2846	8.10	0.211 ^a
Freedman (2013) ¹⁸⁰	All children	8–19	Sum	Elevated/slightly elevated – prevalence matched to BMI	DEXA	?	7365	9.22	0.187 ^{ab}

continued

TABLE 73 Likelihood ratios: diagnosing overweight (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
WC									
Neovius (2005) ¹⁹³	Boys	17	Smallest between ribs and iliac crest	85.9	ADP	25% BF	200	59.50	0.300
Neovius (2005) ¹⁹³	Girls	17	Smallest between ribs and iliac crest	73.3	ADP	30% BF	274	4.90	0.500
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	Smallest between ribs and iliac crest	80th centile	DEXA	1 SD	278	15.90	0.110
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	Smallest between ribs and iliac crest	80th centile	DEXA	1 SD	302	11.10	0.140
Sarria (2001) ¹⁹⁷	Boys	7–16.9	Smallest between ribs and iliac crest	85th centile	Underwater (hydrostatic) weighting	85th centile	175	8.29	0.452 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	Umbilical	85	DEXA	10 kg/m ²	58	Infinite	0.111 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	Umbilical	72	DEXA	10 kg/m ²	50	Infinite	0.091 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	Mid-point between ribs and iliac crest	77	DEXA	10 kg/m ²	58	19.76	0.116 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	Mid-point between ribs and iliac crest	66.5	DEXA	10 kg/m ²	50	Infinite	0.152 ^a

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
WHR									
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	0.9	ADP	25% BF	200	14.00	0.800
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	0.84	ADP	30% BF	274	9.10	0.800
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	278	3.20	0.620
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	302	3.00	0.640
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC umbilical	0.98	DEXA	10 kg/m ²	58	17.29	0.232 ^a
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC umbilical	0.99	DEXA	10 kg/m ²	50	11.31	0.354 ^a
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	0.91	DEXA	10 kg/m ²	58	7.93	0.306 ^a
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	0.92	DEXA	10 kg/m ²	50	2.68	0.300 ^a

continued

TABLE 73 Likelihood ratios: diagnosing overweight (continued)

Study	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR-
WHiR									
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC umbilical	0.54	DEXA	10 kg/m ²	58	Infinite	0.028 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC umbilical	0.54	DEXA	10 kg/m ²	50	Infinite	0.061 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	0.5	DEXA	10 kg/m ²	58	Infinite	0.028 ^a
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	0.49	DEXA	10 kg/m ²	50	Infinite	0.091 ^a

AVENA, *Alimentación y Valoración del Estado Nutricional en Adolescentes*; BF, body fat.

a LRs calculated from sensitivity and specificity.

b Data for overall population derived from 2 x 2 data for boys and girls separately.

TABLE 74 Likelihood ratios: diagnosing 'fat'

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Total n	LR+	LR-
SFT									
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Ellis	?	4-C	?	114	1.8	0.1 ^a
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Pennington	?	4-C	?	114	5.2	0.1 ^a
Bray (2002) ¹⁷⁵	White and AA children	12	Sum Slaughtner	?	4-C	?	114	3.4	0.0 ^a
BIA									
Bray (2002) ¹⁷⁵	White and AA children	12	Deurenberg	?	4-C	?	114	9.3	0.4 ^a
Bray (2002) ¹⁷⁵	White and AA children	12	Goran	?	4-C	?	114	1.8	0.0 ^a
Bray (2002) ¹⁷⁵	White and AA children	12	Pennington	?	4-C	?	114	5.4	0.2 ^a
Bray (2002) ¹⁷⁵	White and AA children	12	Schaefer	?	4-C	?	114	5.6	0.1 ^a
Bray (2002) ¹⁷⁵	White and AA children	12	Suprasongsin	?	4-C	?	114	1.1	0.0 ^a
AA, African American. a LRs calculated from sensitivity and specificity.									

TABLE 75 Likelihood ratios: diagnosing 'upper tertile'

Study	Population	Age at assessment (years)	Index test	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR–
Fuller (2002) ¹⁸³	Unselected	8–12	BIA	?	DEXA	?	37	6.3	0.3 ^a
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 940	?	4-C	?	38	4.3	0.4 ^a
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 950	?	4-C	?	38	4.3	0.4 ^a
Fuller (2001) ¹⁸²	Unselected	8–12	SFT	?	4-C	?	38	3.1	0.5 ^a

OD, optical density.

a LRs calculated from sensitivity and specificity.

TABLE 76 Likelihood ratios: diagnosing 'upper and second tertile'

Study	Population	Age at assessment (years)	Index test	Index test cut-off point	Reference standard	Reference standard cut-off point	Total <i>n</i>	LR+	LR–
Fuller (2002) ¹⁸³	Unselected	8–12	BIA	?	DEXA	?	37	11.5	0.0
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 940	?	4-C	?	38	2.7	0.2
Fuller (2001) ¹⁸²	Unselected	8–12	NIR OD 950	?	4-C	?	38	12.5	0.0
Fuller (2001) ¹⁸²	Unselected	8–12	SFT	?	4-C	?	38	12.5	0.0

OD, optical density.

TABLE 77 Area under the curve: diagnosing obesity

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total n	AUC (95% CI)
BMI									
Neovius (2005) ¹⁹³	Boys	17	Optimal	29.2	ADP	95th centile	?	200	0.97 (0.94 to 1)
Neovius (2005) ¹⁹³	Girls	17	Optimal	26.5	ADP	95th centile	?	274	0.99 (0.97 to 1)
Bartok (2011) ¹⁷⁴	White girls	9	CDC	85th centile	DEXA	95th centile	29	173	0.93 (NR)
Bartok (2011) ¹⁷⁴	White girls	11	CDC	82nd centile	DEXA	95th centile	24	172	0.95 (NR)
Bartok (2011) ¹⁷⁴	White girls	13	CDC	82nd centile	DEXA	95th centile	20	151	0.94 (NR)
Bartok (2011) ¹⁷⁴	White girls	15	CDC	85th centile	DEXA	95th centile	17	160	0.98 (NR)
Taylor (2003) ²⁰⁰	Boys	8.5–15.5	Optimal z-score (adjusted for age)	?	DEXA	25% BF	?	179	0.95 (0.92 to 0.98)
Taylor (2003) ²⁰⁰	Boys	8.5–15.5	Optimal z-score (adjusted for age and pubertal status)	?	DEXA	25% BF	?	179	0.96 (0.94 to 0.99)
Taylor (2003) ²⁰⁰	Girls	8.5–15.5	Optimal z-score (adjusted for age)	?	DEXA	35% BF	?	189	0.98 (0.96 to 0.99)
Taylor (2003) ²⁰⁰	Girls	8.5–15.5	Optimal z-score (adjusted for age and pubertal status)	?	DEXA	35% BF	?	189	0.96 (0.93 to 0.99)
Sardinha (1999) ¹⁹⁶	Girls	10–11	?	?	DEXA	30% BF	?	54	0.95 (0.85 to 0.99)
Sardinha (1999) ¹⁹⁶	Girls	12–13	?	?	DEXA	30% BF	?	60	0.89 (0.79 to 0.96)
Sardinha (1999) ¹⁹⁶	Girls	14–15	?	?	DEXA	30% BF	?	49	0.9 (0.78 to 0.98)
Sardinha (1999) ¹⁹⁶	Boys	10–11	?	?	DEXA	25% BF	?	55	0.97 (0.88 to 0.99)
Sardinha (1999) ¹⁹⁶	Boys	12–13	?	?	DEXA	25% BF	?	52	0.86 (0.73 to 0.94)
Sardinha (1999) ¹⁹⁶	Boys	14–15	?	?	DEXA	25% BF	?	58	0.61 (0.47 to 0.72)
Mei (2006) ¹⁹⁰	5–11 years	5–18	CDC	95th centile	DEXA	95th centile	?	572	0.966 (SE 0.022)

continued

TABLE 77 Area under the curve: diagnosing obesity (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total <i>n</i>	AUC (95% CI)
Mei (2006) ¹⁹⁰	12–18 years	5–18	CDC	95th centile	DEXA	95th centile	?	624	0.97 (SE 0.021)
Mei (2006) ¹⁹⁰	Boys	5–18	CDC	95th centile	DEXA	95th centile	?	626	0.958 (SE 0.025)
Mei (2006) ¹⁹⁰	Girls	5–18	CDC	95th centile	DEXA	95th centile	?	570	0.977 (SE 0.018)
Mei (2006) ¹⁹⁰	White	5–18	CDC	95th centile	DEXA	95th centile	?	303	0.992 (SE 0.017)
Mei (2006) ¹⁹⁰	Black	5–18	CDC	95th centile	DEXA	95th centile	?	269	0.972 (SE 0.025)
Mei (2006) ¹⁹⁰	Hispanic	5–18	CDC	95th centile	DEXA	95th centile	?	250	0.947 (SE 0.034)
Mei (2006) ¹⁹⁰	Asian	5–18	CDC	95th centile	DEXA	95th centile	?	358	0.937 (SE 0.056)
Fujita (2011) ¹⁸¹	Boys	10	?	95th centile	DEXA	95th centile	?	226	0.98 (0.97 to 0.99)
Fujita (2011) ¹⁸¹	Girls	10	?	95th centile	DEXA	95th centile	?	196	0.98 (0.961 to 1)
Harrington (2013) ¹⁸⁵	Unselected	5–18	Optimal	96th centile	DEXA	?	33.1	369	0.97 (0.95 to 0.98)
Harrington (2013) ¹⁸⁵	White boys	5–18	Optimal	94th centile	DEXA	?	26.6	94	0.98 (0.96 to 1)
Harrington (2013) ¹⁸⁵	AA boys	5–18	Optimal	97th centile	DEXA	?	32.9	79	0.99 (0.99 to 1)
Harrington (2013) ¹⁸⁵	White girls	5–18	Optimal	89th centile	DEXA	?	20.5	83	0.98 (0.96 to 1)
Harrington (2013) ¹⁸⁵	AA girls	5–18	Optimal	98th centile	DEXA	?	47.8	113	0.98 (0.96 to 1)
SFT									
Mei (2006) ¹⁹⁰	Unselected	5–11	Subscapular	95th centile	DEXA	95th centile	?	572	0.952 (SE 0.026)
Mei (2006) ¹⁹⁰	Unselected	12–18	Subscapular	95th centile	DEXA	95th centile	?	624	0.962 (SE 0.024)
Mei (2006) ¹⁹⁰	Boys	5–18	Subscapular	95th centile	DEXA	95th centile	?	626	0.947 (SE 0.027)
Mei (2006) ¹⁹⁰	Girls	5–18	Subscapular	95th centile	DEXA	95th centile	?	570	0.967 (SE 0.022)
Mei (2006) ¹⁹⁰	White	5–18	Subscapular	95th centile	DEXA	95th centile	?	303	0.986 (SE 0.023)
Mei (2006) ¹⁹⁰	Black	5–18	Subscapular	95th centile	DEXA	95th centile	?	269	0.969 (SE 0.026)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total <i>n</i>	AUC (95% CI)
Mei (2006) ¹⁹⁰	Hispanic	5–18	Subscapular	95th centile	DEXA	95th centile	?	250	0.924 (SE 0.04)
Mei (2006) ¹⁹⁰	Asian	5–18	Subscapular	95th centile	DEXA	95th centile	?	358	0.922 (SE 0.062)
Sardinha (1999) ¹⁹⁶	Girls	10–11	Triceps	?	DEXA	30% BF	?	54	0.96 (0.87 to 0.99)
Sardinha (1999) ¹⁹⁶	Girls	12–13	Triceps	?	DEXA	30% BF	?	60	0.94 (0.85 to 0.98)
Sardinha (1999) ¹⁹⁶	Girls	14–15	Triceps	?	DEXA	30% BF	?	49	0.95 (0.84 to 0.99)
Sardinha (1999) ¹⁹⁶	Boys	10–11	Triceps	?	DEXA	25% BF	?	55	0.98 (0.91 to 0.99)
Sardinha (1999) ¹⁹⁶	Boys	12–13	Triceps	?	DEXA	25% BF	?	52	0.94 (0.84 to 0.98)
Sardinha (1999) ¹⁹⁶	Boys	14–15	Triceps	?	DEXA	25% BF	?	58	0.86 (0.74 to 0.93)
Mei (2006) ¹⁹⁰	Unselected	5–11	Triceps	95th centile	DEXA	95th centile	?	572	0.958 (SE 0.024)
Mei (2006) ¹⁹⁰	Unselected	12–18	Triceps	95th centile	DEXA	95th centile	?	624	0.955 (SE 0.026)
Mei (2006) ¹⁹⁰	Boys	5–18	Triceps	95th centile	DEXA	95th centile	?	626	0.96 (SE 0.024)
Mei (2006) ¹⁹⁰	Girls	5–18	Triceps	95th centile	DEXA	95th centile	?	570	0.954 (SE 0.025)
Mei (2006) ¹⁹⁰	White	5–18	Triceps	95th centile	DEXA	95th centile	?	303	0.975 (SE 0.03)
Mei (2006) ¹⁹⁰	Black	5–18	Triceps	95th centile	DEXA	95th centile	?	269	0.969 (SE 0.026)
Mei (2006) ¹⁹⁰	Hispanic	5–18	Triceps	95th centile	DEXA	95th centile	?	250	0.947 (SE 0.034)
Mei (2006) ¹⁹⁰	Asian	5–18	Triceps	95th centile	DEXA	95th centile	?	358	0.922 (SE 0.062)

continued

TABLE 77 Area under the curve: diagnosing obesity (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total <i>n</i>	AUC (95% CI)
WC									
Fujita (2011) ¹⁸¹	Boys	10	Umbilical	95th centile	DEXA	95th centile	?	226	0.987 (0.974 to 1)
Fujita (2011) ¹⁸¹	Girls	10	Umbilical	95th centile	DEXA	95th centile	?	196	0.986 (0.971 to 1)
Neovius (2005) ¹⁹³	Boys	17	Smallest between ribs and iliac crest	95th centile	ADP	95th centile	?	200	0.96 (0.92 to 1)
Neovius (2005) ¹⁹³	Girls	17	Smallest between ribs and iliac crest	85th centile	ADP	95th centile	?	274	0.95 (0.92 to 0.99)
WHR									
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	0.9	ADP	95th centile	?	200	0.8 (0.66 to 0.94)
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	1.02	ADP	95th centile	?	274	0.65 (0.49 to 0.8)
WHR									
Fujita (2011) ¹⁸¹	Boys	10	WC smallest between ribs and iliac crest	95th centile	DEXA	95th centile	?	226	0.981 (0.964 to 0.998)
Fujita (2011) ¹⁸¹	Girls	10	WC smallest between ribs and iliac crest	95th centile	DEXA	95th centile	?	196	0.992 (0.981 to 1)

AA, African American; BF, body fat; NR, not reported; SE, standard error.

TABLE 78 Area under the curve: diagnosing overweight

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total n	AUC (95% CI)
BMI									
Neovius (2004) ¹⁹²	Boys	16.9 (SD 0.4)	Optimal		ADP	25% BF	12.7	200	0.97 (0.94 to 1)
Neovius (2004) ¹⁹²	Girls	16.9 (SD 0.4)	Optimal		ADP	30% BF	42.5	274	0.84 (0.8 to 0.89)
Neovius (2005) ¹⁹³	Boys	17	Optimal	25.2	ADP	25% BF	?	200	0.97 (0.94 to 1)
Neovius (2005) ¹⁹³	Girls	17	Optimal	22.2	ADP	30% BF	?	274	0.84 (0.8 to 0.89)
Alvero-Cruz (2010) ¹⁷³	Boys	12–18	?	23.07	D ₂ O	?	?	75	0.842 (0.740 to 0.916)
Alvero-Cruz (2010) ¹⁷³	Girls	12–18	?	23.18	D ₂ O	?	?	75	0.828 (0.724 to 0.906)
Bartok (2011) ¹⁷⁴	White girls	9	CDC	73rd centile	DEXA	85th centile	42	173	0.96 (NR)
Bartok (2011) ¹⁷⁴	White girls	11	CDC	81st centile	DEXA	85th centile	41	172	0.95 (NR)
Bartok (2011) ¹⁷⁴	White girls	13	CDC	77th centile	DEXA	85th centile	30	151	0.94 (NR)
Bartok (2011) ¹⁷⁴	White girls	15	CDC	78th centile	DEXA	85th centile	33	160	0.88 (NR)
Mei (2006) ¹⁹⁰	5–11 years	5–11	CDC	85th centile	DEXA	85th centile	?	572	0.952 (SE 0.015)
Mei (2006) ¹⁹⁰	12–18 years	12–18	CDC	85th centile	DEXA	85th centile	?	624	0.954 (SE 0.016)
Mei (2006) ¹⁹⁰	Boys	5–18	CDC	85th centile	DEXA	85th centile	?	626	0.946 (SE 0.016)
Mei (2006) ¹⁹⁰	Girls	5–18	CDC	85th centile	DEXA	85th centile	?	570	0.96 (SE 0.014)
Mei (2006) ¹⁹⁰	White	5–18	CDC	85th centile	DEXA	85th centile	?	303	0.969 (SE 0.02)
Mei (2006) ¹⁹⁰	Black	5–18	CDC	85th centile	DEXA	85th centile	?	269	0.972 (SE 0.016)
Mei (2006) ¹⁹⁰	Hispanic	5–18	CDC	85th centile	DEXA	85th centile	?	250	0.956 (SE 0.02)
Mei (2006) ¹⁹⁰	Asian	5–18	CDC	85th centile	DEXA	85th centile	?	358	0.915 (SE 0.029)
Pandit (2009) ¹⁹⁴	Boys	6–17	CDC z-/SD score	1	DEXA	85th centile	?	316	0.919 (0.882 to 0.956)

continued

TABLE 78 Area under the curve: diagnosing overweight (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total n	AUC (95% CI)
Pandit (2009) ¹⁸⁴	Girls	6–17	CDC z-/SD score	1	DEXA	85th centile	?	250	0.961 (0.939 to 0.983)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	SD scores	1.99	DEXA	10 kg/m ²	?	58	0.99 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	SD scores	2.13	DEXA	10 kg/m ²	?	50	0.99 (NR)
Conicity index and trunk fat mass									
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8		80th centile	DEXA	1 SD	?	278	0.8 (0.72 to 0.86)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9		80th centile	DEXA	1 SD	?	302	0.81 (0.74 to 0.88)
FMI									
Alvero-Cruz (2010) ¹⁷³	Boys	12–18		4.58	D ₂ O	?	?	75	0.988 (0.93 to 0.998)
Alvero-Cruz (2010) ¹⁷³	Girls	12–18		7.76	D ₂ O	?	?	75	0.996 (0.943 to 1)
SFT									
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	SF index	1.26	DEXA	10 kg/m ²	?	58	0.835 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	SF index	1.07	DEXA	10 kg/m ²	?	50	0.649 (NR)
Mei (2006) ¹⁹⁰	Unselected	5–11	Subscapular	85th centile	DEXA	85th centile	?	572	0.961 (SE 0.014)
Mei (2006) ¹⁹⁰	Unselected	12–18	Subscapular	85th centile	DEXA	85th centile	?	624	0.947 (SE 0.016)
Mei (2006) ¹⁹⁰	Boys	5–18	Subscapular	85th centile	DEXA	85th centile	?	626	0.949 (SE 0.016)
Mei (2006) ¹⁹⁰	Girls	5–18	Subscapular	85th centile	DEXA	85th centile	?	570	0.959 (SE 0.015)
Mei (2006) ¹⁹⁰	White	5–18	Subscapular	85th centile	DEXA	85th centile	?	303	0.966 (SE 0.021)
Mei (2006) ¹⁹⁰	Black	5–18	Subscapular	85th centile	DEXA	85th centile	?	269	0.975 (SE 0.015)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total n	AUC (95% CI)
Mei (2006) ¹⁹⁰	Hispanic	5–18	Subscapular	85th centile	DEXA	85th centile	?	250	0.956 (SE 0.021)
Mei (2006) ¹⁹⁰	Asian	5–18	Subscapular	85th centile	DEXA	85th centile	?	358	0.935 (SE 0.026)
Mei (2006) ¹⁹⁰	Unselected	5–11	Triceps	85th centile	DEXA	85th centile	?	572	0.951 (SE 0.015)
Mei (2006) ¹⁹⁰	Unselected	12–18	Triceps	85th centile	DEXA	85th centile	?	624	0.952 (SE 0.016)
Mei (2006) ¹⁹⁰	Boys	5–18	Triceps	85th centile	DEXA	85th centile	?	626	0.954 (SE 0.015)
Mei (2006) ¹⁹⁰	Girls	5–18	Triceps	85th centile	DEXA	85th centile	?	570	0.95 (SE 0.016)
Mei (2006) ¹⁹⁰	White	5–18	Triceps	85th centile	DEXA	85th centile	?	303	0.968 (SE 0.021)
Mei (2006) ¹⁹⁰	Black	5–18	Triceps	85th centile	DEXA	85th centile	?	269	0.973 (SE 0.016)
Mei (2006) ¹⁹⁰	Hispanic	5–18	Triceps	85th centile	DEXA	85th centile	?	250	0.942 (SE 0.023)
Mei (2006) ¹⁹⁰	Asian	5–18	Triceps	85th centile	DEXA	85th centile	?	358	0.923 (SE 0.028)
WC									
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC umbilical	85	DEXA	10 kg/m ²	?	58	0.98 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC umbilical	72	DEXA	10 kg/m ²	?	50	0.972 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	77	DEXA	10 kg/m ²	?	58	0.962 (NR)
Gunttsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	66.5	DEXA	10 kg/m ²	?	50	0.967 (NR)
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	85.9	ADP	25% BF	?	200	0.94 (0.89 to 1)

continued

TABLE 78 Area under the curve: diagnosing overweight (continued)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total n	AUC (95% CI)
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	73.3	ADP	30% BF	?	274	0.81 (0.75 to 0.86)
WC and trunk fat mass									
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	?	278	0.97 (0.95 to 0.99)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	?	302	0.97 (0.95 to 0.99)
WHR									
Neovius (2005) ¹⁹³	Boys	17	WC smallest between ribs and iliac crest	0.9	ADP	25% BF	?	200	0.79 (0.69 to 0.89)
Neovius (2005) ¹⁹³	Girls	17	WC smallest between ribs and iliac crest	0.84	ADP	30% BF	?	274	0.63 (0.56 to 0.7)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC umbilical	0.98	DEXA	10 kg/m ²	?	58	0.915 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC umbilical	0.99	DEXA	10 kg/m ²	?	50	0.838 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	0.91	DEXA	10 kg/m ²	?	58	0.842 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	0.92	DEXA	10 kg/m ²	?	50	0.736 (NR)

Author	Population	Age at assessment (years)	Index test details	Index test cut-off point	Reference standard	Reference standard cut-off point	Prevalence (%)	Total <i>n</i>	AUC (95% CI)
WHR and trunk fat mass									
Taylor (2000) ¹⁹⁹	White girls	3.1–19.8	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	?	278	0.73 (0.64 to 0.81)
Taylor (2000) ¹⁹⁹	White boys	3.3–19.9	WC smallest between ribs and iliac crest	80th centile	DEXA	1 SD	?	302	0.71 (0.62 to 0.8)
WHR									
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC umbilical	0.54	DEXA	10 kg/m ²	?	58	0.99 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC umbilical	0.54	DEXA	10 kg/m ²	?	50	0.98 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – pubertal	6–16	WC mid-point between ribs and iliac crest	0.5	DEXA	10 kg/m ²	?	58	0.99 (NR)
Guntsche (2010) ¹⁸⁴	Children referred to obesity centre and siblings – prepubertal	6–16	WC mid-point between ribs and iliac crest	0.49	DEXA	10 kg/m ²	?	50	0.97 (NR)
BF, body fat; NR, not reported; SE, standard error.									

Review of the acceptability and ease of use of childhood measures of obesity

TABLE 79 Acceptability studies: study details, population characteristics and results

Study details	Population characteristics	Children's details	Results
Cloutier (2013) ²⁰⁷	Total $n = 278$ Number invited for interview = 259 Response rate 97%	Simple childhood measure: BMI (CDC growth chart), My Weight Ruler School grade of children: 2–4 Ethnicity of children: NR Sex of children: NR Weight status of children: NR	Participants in both the African American and Hispanic focus groups ($n = 27$) overwhelmingly preferred the My Weight Ruler 92% of the interviewed participants ($n = 251$) had previously seen a CDC BMI growth chart; none had seen the My Weight Ruler More respondents correctly classified two plotted measurements (one corresponding to the 50% centile and the other to the 97% centile) on the My Weight Ruler than on the CDC growth chart (92% vs. 37%) Significantly more participants provided incorrect answers to both plotted measurements on the CDC growth chart than on the My Weight Ruler (32% vs. 1%) Significantly more participants responded 'I don't know' to both of the CDC growth chart plots than to the My Weight Ruler (12% vs. 0.5%) Caregivers with higher education and higher household incomes were more likely to correctly identify the CDC BMI growth chart plots
Language of publication: English			
Data source: full paper			
Country in which study conducted: USA/Canada	Whose opinion?: caregivers (83% mothers, 17% grandparents) Source of sample: <ul style="list-style-type: none"> ● primary care clinics ● family centres ● head start and child care centres 		
Study/cohort name: none			
Study dates: start October 2009, finish March 2010	Method of obtaining opinions: <ul style="list-style-type: none"> ● focus groups $n = 27$ ● interviews $n = 251$ 		
Study design: qualitative	Method of recording opinions: <ul style="list-style-type: none"> ● paper questionnaire ● videotapes in focus groups 		
Analysis: prospective			
Setting for use of anthropometric measure: community GP clinic/primary care, outpatient/specialist clinic	Age: NR Sex: NR		There were no significant trends between the number of correct identifications and level of education, household income, ethnicity or first language for the My Weight Ruler 61% of participants understood the health risk and the need to take action associated with plots in the 97th centile on the My Weight Ruler, compared to 1% of participants using the CDC growth chart 79% of participants preferred the My Weight Ruler as the tool to educate them on their children's weight status during well-child visits; 17% preferred the CDC BMI growth chart using the CDC growth chart

Study details	Population characteristics	Children's details	Results
	<p>Ethnicity (%):</p> <ul style="list-style-type: none"> ● black 12 ● Hispanic 78 ● other 10 <p>Weight distribution (%):</p> <ul style="list-style-type: none"> ● healthy weight 30 ● overweight 23 ● obese 47 <p>Duration of obesity: NIR</p> <p>SFS (%):</p> <ul style="list-style-type: none"> ● low 21 (<\$15,000 income) ● medium 39 (\$15,000–30,000 income); 22 (\$30,000–49,000 income) ● high 14 (> \$50,000 income) 		
			continued

TABLE 79 Acceptability studies: study details, population characteristics and results (continued)

Study details	Population characteristics	Children's details	Results
Hendershot (2008) ⁷³	Total n = 2629 completed questionnaires	Simple childhood measure: BMI	67%: BMI should be measured in school
Language of publication: English	Number approached/invited = 6288	School grade of children: NR	62%: BMI results should be sent home
Data source: abstract	Response rate 42%	Ethnicity of children: NR	81%: nurses should be designing programmes to help overweight children
Country in which study conducted: other European	Whose opinion?: school nurses	Sex of children: NR	31%: measuring BMI was psychologically or socially damaging to the child
Study/cohort name: none	Source of sample: National Association of School Nurses Database	Weight status of children: NR	73%: BMI helped create awareness of the problem
Study dates: NR	Method of obtaining opinions: electronic survey		72%: measuring BMI provided evidence to change policies to reduce obesity levels
Study design: cross-sectional	Method of recording opinions: electronic/online		Largest barrier to measuring BMI: 57.6% – inadequate school resources; 55.2% – inadequate or inappropriate parental responses; 42% – not enough time to measure BMI
Analysis: prospective	Age: NR		94%: confident or very confident in measuring height and weight
Setting for use of anthropometric measure: school	Sex: male 3%		74%: confident or very confident in calculating BMI
	Ethnicity (%): ● white 91 ● other 9		93%: confident or very confident in helping parents to interpret BMI results
	Weight distribution: NR		School nurses with a mandate measured BMI for a year or more at a significantly higher rate than those without a mandate (77.9% vs. 21.3%) and had a higher rate of seriously considering measuring BMI (95.2% vs. 70.3%)
	Duration of obesity: NR		> 50% of nurses agreed or strongly agreed that tracking BMI would help administrators to address the childhood overweight/obesity issue
	SES: NR		

Study details	Population characteristics	Children's details	Results
<p>Kubik (2006)⁷⁴</p> <p>Language of publication: English</p> <p>Data source: full paper</p> <p>Country in which study conducted: USA/Canada</p> <p>Study/cohort name: none</p> <p>Study dates: start 2004, finish 2005</p> <p>Study design: cross-sectional</p> <p>Analysis: prospective</p> <p>Setting for use of anthropometric measure: school</p>	<p>Total <i>n</i> = 790 completed questionnaires</p> <p>Number approached/invited = 1133 (plus 53 not deliverable)</p> <p>Response rate 70%</p> <p>Whose opinion?: parents</p> <p>Source of sample: elementary school</p> <p>Method of obtaining opinions: self-administered survey</p> <p>Method of recording opinions: paper questionnaire</p> <p>Age: NR</p> <p>Sex: male 54.3%</p> <p>Ethnicity: NR</p> <p>Weight distribution: NR</p> <p>Duration of obesity: NR</p> <p>SES: low 21%</p>	<p>Simple childhood measure: BMI</p> <p>School grade of children:</p> <ul style="list-style-type: none"> ● kindergarten ● Grade 1 ● Grade 2 ● Grade 3 ● Grade 4 ● Grade 5 ● Grade 6 <p>Ethnicity of children (%):</p> <ul style="list-style-type: none"> ● white 76 ● minorities 24 <p>Sex of children (%): male 54</p> <p>Weight status of children (%):</p> <ul style="list-style-type: none"> ● normal weight 73 ● overweight/obese 27 	<p>78%: very (39%) or somewhat (39%) important for schools to include height/weight as part of annual student health screening</p> <p>78%: wanted to receive information on their child's height, weight and BMI every year</p> <p>Parents of girls were less likely to think height/weight screening was important than parents of boys</p> <p>Parents who worked full time were less likely to think screening was important than those who worked part time or stayed at home</p> <p>There were no differences by treatment condition, child's weight status or other sociodemographic characteristics</p> <p>Parents of older students and girls were less likely to want information than parents of younger students or boys</p> <p>Approximately 50% of parents received a BMI letter; 79% read all, and 16% most, of the letter</p> <p>55% of the parents chose not to discuss the letter with their child; 68% thought their child did not feel uncomfortable and 15% thought they felt slightly uncomfortable</p> <p>The information in the letter made 68% of parents feel not uncomfortable at all and 12% only slightly</p> <p>The information parents shared most often with their child was weight/BMI, followed by nutrition, physical activity and screen time</p> <p>In descending order, parents found the following information helpful: weight/BMI, physical activity, nutrition, screen time, health-related websites and community resources</p> <p>Of the parents who received the BMI letter and expressed a weight concern for their child, 8% planned to seek medical services, 8% to make diet-related changes, 27% to increase exercise and/or sign up their child for sports and 24% to sign up to other physical activity</p>

continued

TABLE 79 Acceptability studies: study details, population characteristics and results (continued)

Study details	Population characteristics	Children's details	Results
Kubik (2007) ⁷⁵	Total <i>n</i> = 71		General opinions about health screening:
Language of publication: English	Number approached/invited NR	Simple childhood measure details: BMI	<ul style="list-style-type: none"> nearly 50% were unaware that annual health screening was done at school
Data source: full paper	Response rate NR	Which measure(s)?: BMI	<ul style="list-style-type: none"> among parents familiar with the screening process, most were supportive of height and weight screening
Country in which study conducted: USA/Canada	Whose opinion?: parents	School grade of children: <ul style="list-style-type: none"> kindergarten Grade 1 Grade 2 Grade 3 Grade 4 Grade 5 Grade 6 	<ul style="list-style-type: none"> many parents questioned why height and weight screening was done if results were not shared with parents or used for a purpose, such as surveillance most parents felt that if schools were conducting height and weight screening, results should be reported to parents several parents felt that height and weight screening would aid in the early detection of important health conditions
Study/cohort name: none	Method of obtaining opinion: focus groups		Concerns about the screening process for height and weight:
Study dates: start 2004, finish 2005	Method of recording opinions: videotapes	Ethnicity of children: NR	<ul style="list-style-type: none"> location of the screening and the privacy of students during the measurement process the children's behaviour during the screening, especially teasing among children a few parents were concerned about the accuracy of the results very few were concerned with the out-of-classroom time required to conduct the screening
Study design: cross-sectional	Age (years): mean 39 (range 27–49)	Sex of children: NR	<ul style="list-style-type: none"> a few were concerned about the use of parent volunteers, as they had access to private health information of other children
Analysis: prospective	Sex: male 10%	Weight status of children: NR	Indications for height and weight screening at school:
Setting for use of anthropometric measure: school	Ethnicity (%): <ul style="list-style-type: none"> white 96 other 4 		<ul style="list-style-type: none"> several parents felt that school-based height and weight screening was more important for children and families who were without health insurance or had limited access to health care some indicated that their children did not need height and weight screening at school because they see a health-care provider regularly some felt that screening during elementary school was not necessary, as overweight usually resolves as children age a few felt that parents 'know' if their child is overweight; more believed that parents might be unaware of a child's emerging weight problem, whether underweight or overweight several parents believed that school-based height and weight screening was beneficial because older children and healthy children do not routinely visit a health-care provider
	Weight distribution: NR		
	Duration of obesity: NR		
	SES: low 17%		

TABLE 79 Acceptability studies: study details, population characteristics and results (continued)

Study details	Population characteristics	Children's details	Results
			<p>Reporting BMI:</p> <ul style="list-style-type: none"> ● many parents felt that BMI was a more meaningful indicator of a child's weight status than height and weight alone ● some felt that BMI and age- and sex-adjusted BMI were valuable because they were not measures they could easily calculate themselves ● others thought that parents could use BMI to assure a child overly concerned about weight issues that he or she is within a normal weight range ● several parents thought that BMI would be a 'wake-up call' or 'warning sign' for many parents, alerting them to an emerging weight problem that needs attention <p>Notification process:</p> <ul style="list-style-type: none"> ● most parents felt that all parents should be notified of the results from the height and weight screening and provided with BMI information; some felt that only parents of children with BMI values outside a healthy weight range should receive notification owing to budgetary concerns ● most believed that the information should be mailed directly to parents; other suggestions included teachers delivering the information at teacher-parent conferences, parents calling the school nurse and the child bringing the information home in a sealed envelope; few were OK with receiving an e-mail or including the information on a child's report card <p>Message content:</p> <ul style="list-style-type: none"> ● the notification should include a simple, easy-to-understand explanation of BMI and how to interpret results ● many felt that an impersonal 'nuts and bolts' message, containing a child's measurement and BMI information and a recommendation to follow-up with a health-care provider if concerned, would be better accepted by parents than a message 'labelling' a child as overweight and 'prescribing' a specific plan of action ● most participants felt that the majority of parents want to know about their child's BMI so that they can take care of their children and decide what they want to do with the information

continued

TABLE 79 Acceptability studies: study details, population characteristics and results (continued)

Study details	Population characteristics	Children's details	Results
<p>Woolford (2008)²⁰⁸</p> <p>Language of publication: English</p> <p>Data source: full paper</p> <p>Country in which study conducted: USA/Canada</p> <p>Study/cohort name: none</p> <p>Study dates: start 2006, finish 2006</p> <p>Study design: qualitative</p> <p>Analysis: prospective</p> <p>Setting for use of anthropometric measure: GP clinic/primary care</p>	<p>Total <i>n</i> = 267 in analysis</p> <p>Number approached/invited = 600</p> <p>Response rate 52% (after 21 were excluded; 50% of original sample)</p> <p>Whose opinion?:</p> <ul style="list-style-type: none"> • GPs • paediatricians <p>Source of sample: American Medical Association Masterfile</p> <p>Method of obtaining opinions: self-administered survey (12-item Likert scales and multiple-choice questions)</p> <p>Method of recording opinions: paper questionnaire</p> <p>Age: maximum 69 years</p> <p>Sex: NR</p>	<p>Simple childhood measure details: BMI</p> <p>Which measure(s)?: BMI</p> <p>School grade of children: preschool (ages 2 to 5 years)</p> <p>Ethnicity of children: NR</p> <p>Sex of children: NR</p> <p>Weight status of children: NR</p>	<p>Uses for BMI other than parent notification:</p> <ul style="list-style-type: none"> • several other uses for school-collected BMI data were identified: improving the school food environment; justifying increased 'gym time' and 'more recess' for students; 'partnering' with parents to provide a consistent message of support for healthy eating and physical activity; reporting prevalence data of overweight among school children to the school, general community and policy-makers to justify and procure budget support for healthy school meal programmes and more physical education; and tracking the weight status of individual students <p>37% of physicians generally did not use BMI charts for patients who are between the ages of 2 and 5 years; 24% indicated that they generally used BMI charts for this age group, and the remaining 39% endorsed the use of BMI charts for selected patients who are at the age of 2–5 years</p> <p>Among physicians reporting the use of BMI charts for selected patients, 87% indicated that they use BMI charts for children who appear overweight from height and weight curves, 72% for children who appear overweight by visual inspection and 68% for children who have crossed upwards between weight centiles</p> <p>The time to calculate and plot BMI were perceived as a barrier (major and small) by 65% of all respondents and 75% of respondents who did not use and who used it selectively</p> <p>Time and complexity of explaining the findings to parents was a barrier for 70% of all respondents and 76% of respondents who did not use and who used the BMI charts selectively</p> <p>Parental familiarity with height and weight curves was a barrier for 57% of all respondents and 59% of respondents who did not use and who used the BMI charts selectively</p> <p>Physicians who did not use BMI charts were more likely to report all measured factors as major barriers than physicians who did use BMI charts generally or selectively</p> <p>Colour-coded charts and the inclusion of management recommendations on BMI charts were considered strong influences on the likelihood of using BMI charts more frequently at preschool well-child visits, in 60% and 61%, respectively</p>

Study details	Population characteristics	Children's details	Results
Ethnicity: NR	Weight distribution: NR		Computerised calculation and plotting was endorsed by 35% of all respondents as a strong influence on use
Duration of obesity: NR	SES: NR		47% of respondents endorsed workshops at national and regional medical conferences, 45% endorsed online websites and 43% endorsed DVD training for addressing obesity. Online training was endorsed more often by recent graduates
			30% of all respondents indicated that they would participate in a 2-day behaviour management course; paediatricians were significantly more likely than family physicians to endorse this option (38% vs. 17%)
			5% of respondents indicated that they probably would not participate in any training activities related to behaviour management skills to address obesity
GP, general practitioner; NR, not reported.			

Appendix 4 Quality assessment tables

Review of adult morbidities

TABLE 80 Review of adult morbidities: quality assessment results

Study	Representative population?	Follow-up sufficiently complete?	Analysed sample representative of whole sample?	Valid prognostic factor used?	Prognostic factor measured appropriately?	Prognostic factor measured consistently across sample?
Ahlgren (2004) ¹⁴⁰	Yes	Yes	UC	Yes	UC	UC
	Municipality of Copenhagen	73%				
Baker (2007) ¹⁴²	Yes	UC	UC	Yes	UC	UC
	Public and private schools in Copenhagen					
Baker (2007) ¹⁴¹	Yes	Yes	UC	Yes	UC	UC
	Public and private schools in Copenhagen	88% in register				
Barker (2002) ¹⁴³	Yes	Yes	UC	Yes	UC	UC
		83% follow-up (8760/10,519)				
Barker (2005) ¹⁴⁴	Yes	Yes	Yes	Yes	UC	UC
Berentzen (2013) ¹⁴⁵	Yes	Yes	UC	Yes	Yes	UC
	Copenhagen school health records	77% at follow-up				
Bjorge (2004) ¹⁴⁶	Yes	Yes	Yes	Yes	Yes	Yes
					Trained staff	
Bjorge (2008) ¹⁴⁷	Yes	Yes	Yes	Yes	Yes	Yes
Cheng (2011) ¹¹⁷	Yes	No	No	Yes	Yes for BMI	Yes
	Typical of city-dwelling Chinese	Only 54.1% followed up	Statistically significantly higher weight, BMI and blood pressure in those followed up than in whole sample		No for WC	Trained personnel
Cheung (2004) ¹¹⁸	Yes	No	UC	Yes	Yes	Yes
		~ 50% of initial cohort for analyses				Medical personnel
De Stavola (2004) ¹⁴⁸	Yes	Yes	Yes	Yes	UC	UC
	Or selected because fewer (1/4) fathers were manual workers	86% at follow-up				

Was a valid outcome measure used?	Outcome measured appropriately?	Outcome measured consistently across sample?	Confounders described?	Confounders measured appropriately?	At least age and sex adjusted for?	Data presented and analysed appropriately?	Selective reporting of outcomes?
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Registry data						
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Registry data						
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Registry data	Registry data					
Yes	No	Yes	Yes	Yes	Yes	Yes	UC
	Hypertensive medication use (may exclude undiagnosed and include false positive)	Hypertensive drug prescription					
Yes	Yes	UC	Yes	Yes	Yes	Yes	UC
Yes	Yes	UC	Yes	Yes	Yes	Yes	UC
	National registry						
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Histology	Histology for all					
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Registry data						
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	BMI for tracking; hypertension for morbidities	Trained personnel	Age, sex, rural/urban		Age, sex, rural/urban		
No	No	Yes	Yes	Yes	No	Yes	UC
	Definitions for any of the morbidities	Self-report			Age only		
Yes	No	Yes	Yes	Yes	Yes	Yes	UC
	Self-report				By age for women only	Imputation method OK	

continued

TABLE 80 Review of adult morbidities: quality assessment results (continued)

Study	Representative population?	Follow-up sufficiently complete?	Analysed sample representative of whole sample?	Valid prognostic factor used?	Prognostic factor measured appropriately?	Prognostic factor measured consistently across sample?
Engeland (2003) ¹⁴⁹	Yes	Yes	Yes	Yes	Yes	Yes
		Large proportion (exact numbers NR)			Trained staff	Trained staff
Eriksson (2001) ¹⁵⁰	Yes	No	UC	Yes	UC	Yes
		64% at follow-up				Welfare clinics and school
Forsen (2000) ¹⁵¹	Yes	Yes	Yes	Yes	UC	UC
Forsen (2004) ¹⁵²	Yes	No	UC	Yes	UC	UC
		55%				
Goldhaber-Fiebert (2013) ¹²³	Yes	UC	UC	Yes	UC	UC
Gunnell (1998) ¹⁵³	Yes	UC	No.	Yes	Yes	UC
	No evidence of significant difference between eligible participants and non-participants	Insufficient reporting	Differences in sex and age between follow-up and complete cohort			
Hilakivi-Clarke (2001) ¹⁵⁴	Yes	UC	UC	Yes	UC	UC
Hypponen (2003) ¹⁵⁵	Yes	No	UC	Yes	UC	UC
		64% at follow-up				
Israeli (2007) ¹⁵⁶	Yes	UC	UC	Yes	Yes	Yes
	Military career service personnel (likely more athletic than average?)					
Janssen (2005) ¹⁵⁷	Yes	No	UC	Yes	Yes	UC
	Note: semi-rural, biracial with high proportion of black participants (35%)	44% at follow-up				
Jeffreys (2004) ¹⁵⁸	UC	Yes	UC	Yes	Yes	Yes
	Underprivileged and working class over-represented?	78%				
Lawlor (2005) ¹⁵⁹	Yes	Yes	UC	Yes	Yes	Yes
Lawlor (2006) ¹⁶⁰	Yes	No	UC	Yes	UC	UC
		52% attrition				

Was a valid outcome measure used?	Outcome measured appropriately?	Outcome measured consistently across sample?	Confounders described?	Confounders measured appropriately?	At least age and sex adjusted for?	Data presented and analysed appropriately?	Selective reporting of outcomes?
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	98% measured histologically	98% measured histologically					
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
			Age and birth weight				
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Diabetes requiring medication							
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	No	UC	Yes	Yes	Yes	Yes	No
	Self-reported for morbidities						
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	No	Yes	Yes	Yes	Yes	Yes	UC
	Self-report	Self-report					
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	Yes	Yes	Yes	UC	Yes	Yes	UC
			Age, race, sex, follow-up length				
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Registry data or death certificate						Site-specific cancer results NR
Yes	UC	UC	Yes	Yes	Yes	Yes	UC
No	UC	UC	Yes	Yes	Yes	Yes	UC
Self-report							

continued

TABLE 80 Review of adult morbidities: quality assessment results (continued)

Study	Representative population?	Follow-up sufficiently complete?	Analysed sample representative of whole sample?	Valid prognostic factor used?	Prognostic factor measured appropriately?	Prognostic factor measured consistently across sample?
Leiba (2012) ¹⁶¹	Yes	UC	UC	Yes	UC	UC
Leiba (2013) ¹⁶²	Yes	UC	UC	Yes	Yes Medical examination	UC
Levi (2011) ¹⁶³	Yes Males only, military recruitment centre	UC Loss to follow-up NR	UC	Yes	Yes	Yes
Levi (2012) ¹⁶⁴	Yes Male only	UC Loss to follow-up NR	UC	Yes	Yes	Yes
Li (2007) ¹⁶⁵	Yes	No 70%	Yes	Yes	Yes	Yes 'Standard protocols'
Magnussen (2010) ¹⁶⁶	UC Characteristics of large proportion of eligible non-participants in Bogalusa unknown	No 89% attrition in Bogalusa	UC	Yes	UC	UC
Mattsson (2008) ¹⁶⁷	Yes Although only 46% male	No 51% at follow-up	UC	Yes	UC	UC
Merten (2010) ¹²⁹	Yes	No (50% at follow-up)	UC	Yes	No Self-reporting data	No Self-reporting data
Morrison (2010) ¹⁶⁸	Yes Note: large proportion of black participants NGHS: girls only	No PFS: 53% of eligible at 22–30 years follow-up; NGHS: 80.2% at 9 years	UC only some covariates were reported to be similar between baseline and follow-up (some only after adjustments)	Yes	UC NGHS: UC how WC was measured	Yes
Osmond (2007) ¹⁶⁹	Yes	Yes National registry data used	Yes	Yes	Yes	Yes
Sachdev (2009) ¹⁷⁰	Yes	No 18% at follow-up UC. High proportion of boys	UC	Yes	Yes Trained personnel	Yes Trained personnel

Was a valid outcome measure used?	Outcome measured appropriately?	Outcome measured consistently across sample?	Confounders described?	Confounders measured appropriately?	At least age and sex adjusted for?	Data presented and analysed appropriately?	Selective reporting of outcomes?
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Histology	Histology					
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Most appear to have been measured histologically	Most classified according to standard coding					
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
		Histology					
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	Two nurses using standard tool						
Yes, IDF definition	Yes	Yes	Yes	Yes	Yes	Yes	UC
Yes	No	No	Yes	UC	Yes	Yes	UC for morbidity
	Self-reported	Self-reported					
Yes	No	No	Yes	Yes	No	Yes	UC
	No gold standard for distinguishing between type 2 and type 1 diabetes, and appears partially self-reported	Collected differently across cohorts					
Yes	UC	UC	Yes	Yes	No	Yes	UC
					Adjusted for sex		
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC
	IOTF criteria						

continued

TABLE 80 Review of adult morbidities: quality assessment results (continued)

Study	Representative population?	Follow-up sufficiently complete?	Analysed sample representative of whole sample?	Valid prognostic factor used?	Prognostic factor measured appropriately?	Prognostic factor measured consistently across sample?
Schmidt (2011) ¹⁷¹	Yes	No 26% of baseline group	No Follow-up group had lower BMI and were more likely to have lived in a higher SES area in childhood ($p \leq 0.01$)	Yes	Yes Or WC, BMI and waist-to-hip UC for sum of SFT	Yes
Tirosh (2011) ¹⁷²	Yes Military career service personnel (likely more athletic than average?)	Yes	Yes	Yes	UC	UC

NGHS, National Growth and Health study; NR, not reported; PFS, Princeton follow-up study; UC, unclear.

Was a valid outcome measure used?	Outcome measured appropriately?	Outcome measured consistently across sample?	Confounders described?	Confounders measured appropriately?	At least age and sex adjusted for?	Data presented and analysed appropriately?	Selective reporting of outcomes?
Yes	Yes	Yes	Yes	Yes	Yes Adjusted for sex and change in WC	Yes	UC
Yes	Yes	Yes	Yes	Yes	Yes	Yes	UC

Review of tracking of obesity into adulthood

TABLE 81 Tracking review: quality assessment results

Study	Representative population?	Follow-up sufficiently complete?	Analysed sample representative of whole sample?	Valid prognostic factor used?	Prognostic factor measured appropriately?	Prognostic factor measured consistently across sample?
Cheng (2011) ¹¹⁷	Yes Typical of city dwelling Chinese	No Only 54.1% followed up	No Statistically significantly higher weight, BMI and blood pressure in those followed up than whole sample	Yes	Yes for BMI, no for WC	Yes Trained personnel
Cheung (2004) ¹¹⁸	Yes	No Approximately 50% of initial cohort not available for analyses	Unclear	Yes	Yes	Yes Medical personnel
Engeland (2004) ¹¹⁹	Yes	No	Unclear	Yes	Yes	Unclear
Freedman (2001) ¹²⁰	Yes	No	Yes	Yes	Yes	Unclear
Freedman (2005) ¹²²	Yes	No	Yes	Yes	Yes	Yes
Freedman (2005) ¹²¹	Yes	No	Unclear	Yes	Yes	Yes
Goldhaber-Fiebert (2013) ¹²³	Yes	Unclear	Unclear	Yes	Unclear	Unclear
Gordon-Larsen (2004) ¹²⁴	Yes	No	Unclear	Yes	Yes	Yes
Juhola (2011) ¹²⁵	Yes	No 61.3%	Unclear	Yes	Unclear	Unclear
Juonala (2006) ¹²⁶	Yes	No	No There were more males than females in the dropouts. The people in the dropouts were older than participants	Yes	Yes	Unclear It was unclear whether or not the measurement was performed consistently across the sample
Liddle (2012) ¹²⁷	Yes	No	No Those who lost to follow-up were younger, less well educated and have lower family income	Yes	Yes	Yes

Was a valid outcome measure used?	Outcome measured appropriately?	Outcome measured consistently across sample?	Confounders described?	Confounders measured appropriately?	At least age and sex adjusted for?	Data presented and analysed appropriately?	Selective reporting of outcomes?
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear
BMI for tracking; hypertension for morbidities		Trained personnel	Age, sex, rural/urban		Age, sex, rural/urban		
No	No	Yes	Yes	Yes	Yes	Yes	Unclear
Definitions NR for any of the morbidities	Self-report				For tracking; no for morbidity: age only		
Yes	Yes	Unclear	Yes	Yes	Yes	Yes	No
Yes	Yes	Unclear	Yes	Unclear	Unclear	Yes	No
					The authors reported that they adjusted race and sex, but was unclear if they also adjusted age		
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Yes	No	Unclear	Yes	Yes	Yes	Yes	No
	Self-reported for morbidities; unclear for tracking						
Yes	Yes	No	Yes	Yes	Yes	Yes	No
		Self-reported data were used for a large number of respondents who refused measurements. 71 weighed in excess of the scale capacity.			But not the data we extracted		
Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	No
Yes	Yes	Unclear	No	Unclear	No	Yes	No
		The authors did not state whether or not the measurement was performed consistently across sample					
Yes	No	No	Yes	Yes	No	Yes	No
	Some self-report	Objective and subjective methods					

continued

TABLE 81 Tracking review: quality assessment results (*continued*)

Study	Representative population?	Follow-up sufficiently complete?	Analysed sample representative of whole sample?	Valid prognostic factor used?	Prognostic factor measured appropriately?	Prognostic factor measured consistently across sample?
Mamun (2005) ¹²⁸	Yes	No	Unclear	Yes	Yes	Yes
Merten (2010) ¹²⁹	Yes	No	Unclear	Yes	No Self-reporting data	No Self-reporting data
Nakano (2010) ¹³⁰	Yes	No	Unclear	Yes	Yes	Yes
Nakano (2010) ¹³¹	Yes	No	Unclear	Yes	Yes	Yes
Patton (2011) ¹³²	Yes	No	Unclear	Yes	Yes	No Self-reported data were used for those who had left school in the later teenage waves
Power (1997) ¹³³	Yes	Yes	Unclear	Yes	Yes	Yes
Reilly (2011) ¹³⁴	Yes	No	No	Yes	Yes	Yes
Starc (2010) ¹³⁵	Yes	No	Yes The authors reported that the mean values and SDs of the population sample and the subsample analysed were very similar	Yes	Yes	Yes
Stovitz (2010) ¹³⁶	Yes	No	Unclear	Yes	Yes	Yes
Thompson (2007) ¹³⁷	Yes	Yes	Unclear	Yes	Yes	Yes
Venn 2007 ¹³⁸	Yes	No	Yes	Yes	Yes	Unclear
Wang (2008) ¹³⁹	Yes	No	Yes	Yes	No Self-reported data	No Self-reported data

NR, not reported.

Was a valid outcome measure used?	Outcome measured appropriately?	Outcome measured consistently across sample?	Confounders described?	Confounders measured appropriately?	At least age and sex adjusted for?	Data presented and analysed appropriately?	Selective reporting of outcomes?
Yes	Yes	Yes	Yes	Yes	No	Yes	No
			The studies described age- or sex- adjusted values for other outcomes but not for tracking data		Tracking data were not stratified by age/sex		
Yes	No Self-reported	No Self-reported	No	No	No	Yes	No For tracking; unclear for morbidity
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Yes	No Self-reported data were used in the adult phase	No Self-reported data were used	Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	Yes	Unclear	Yes	Yes	No
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	Yes	Yes	No	Yes	No
Yes	No	No	Yes	Yes	Yes	Yes	No
	Self-reporting data	Self-reporting data	Age, race		Only girls included		
Yes	Yes	No	Yes	Yes	No	Yes	No
		It appears that some self-reported outcome data were included					
Yes	No Self-reported data	No Self-reported data	Yes	Yes	Yes	Yes	No

TABLE 82 Tracking review: risk of bias

Study	Risk of selection bias	Risk of attrition bias	Risk of bias associated with the prognostic factor	Risk of bias associated with outcome	Risk of bias due to confounders	Risk of reporting or analysis bias
All studies	All low	Most unclear, 3 high, 4 low	14 low, rest unclear	10 moderate/unclear, 10 low, 3 high	13 low, 2 high, 8 moderate/unclear	All low
Cheng (2011) ¹¹⁷	Low	High	Low	Low	Moderate/unclear	Low
Cheung (2004) ¹¹⁸	Low	High	Low	High	High	Low
Engeland (2004) ¹¹⁹	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low	Low
Freedman (2001) ¹²⁰	Low	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low
Freedman (2005) ¹²²	Low	Moderate/unclear	Low	Low	Low	Low
Freedman (2005) ¹²¹	Low	Low	Low	Low	Low	Low
Goldhaber-Fiebert (2013) ¹²³	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low	Low
Gordon-Larsen (2004) ¹²⁴	Low	Moderate/unclear	Low	High	Low	Low
Juhola (2011) ¹²⁵	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low	Low
Juonala (2006) ¹²⁶	Low	High	Moderate	Moderate/unclear	High	Low
Liddle (2012) ¹²⁷	Low	Moderate/unclear	Low	High	Moderate/unclear	Low
Mamun (2005) ¹²⁸	Low	Moderate/unclear	Low	Low	Moderate/unclear	Low
Merten (2010) ¹²⁹	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low
Nakano (2010) ¹³¹	Low	Moderate/unclear	Low	Low	Low	Low
Nakano (2010) ¹³⁰	Low	Moderate/unclear	Low	Low	Low	Low
Patton (2011) ¹³²	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low	Low

Study	Risk of selection bias	Risk of attrition bias	Risk of bias associated with the prognostic factor	Risk of bias associated with the outcome	Risk of bias due to confounders	Risk of reporting or analysis bias
Power (1997) ¹³³	Low	Moderate/unclear	Low	Low	Low	Low
Reilly (2011) ¹³⁴	Low	Moderate/unclear	Low	Low	Moderate/unclear	Low
Starc (2010) ¹³⁵	Low	Low	Low	Low	Low	Low
Stovitz (2010) ¹³⁶	Low	Moderate/unclear	Low	Low	Moderate/unclear	Low
Thompson (2007) ¹³⁷	Low	Moderate/unclear	Low	Moderate/unclear	Low	Low
Venn (2007) ¹³⁸	Low	Moderate/unclear	Moderate/unclear	Moderate/unclear	Moderate/unclear	Low
Wang (2008) ¹³⁹	Low	Low	Moderate/unclear	Moderate/unclear	Low	Low

Review of the diagnostic accuracy of childhood measures of obesity

TABLE 83 Diagnostics review: quality assessment results

Short title	1. Representative population	2. Progression bias	3. Partial verification bias	4. Differential verification bias	5. Incorporation bias	6. Description of selection criteria	7. Appropriateness of RS
Alvero-Cruz (2010) ¹⁷³	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Bartok (2011) ¹⁷⁴	No	UC	Avoided	Avoided	Avoided	Adequate	Imperfect
Bray (2002) ¹⁷⁵	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Gold standard
Dung (2006) ¹⁷⁶	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Ellis (1999) ¹⁷⁷	Yes	Probably avoided	Avoided	Avoided	Avoided	Inadequate	Imperfect
Field (2003) ¹⁷⁸	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Freedman (2009) ¹⁷⁹	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Freedman (2013) ¹⁸⁰	Yes	Probably avoided	Present ^d	Avoided	Avoided	Adequate	Imperfect
Fujita (2011) ¹⁸¹	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Fuller (2001) ¹⁸²	UC	Probably avoided	Avoided	Avoided	Avoided	Inadequate	Gold standard
Fuller (2002) ¹⁸³	UC	Probably avoided	Avoided	Avoided	Avoided	Inadequate	Imperfect
Guntsche (2010) ¹⁸⁴	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Harrington (2013) ¹⁸⁵	No ^f	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Himes (1989) ¹⁸⁶	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Johnston (1985) ¹⁸⁷	No	Probably avoided	Avoided	Avoided	Avoided	Inadequate	Imperfect
Khadgawat (2013) ¹⁸⁸	Yes ^g	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Marshall (1991) ¹⁸⁹	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Mei (2007) ¹⁹⁰	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Moreno (2006) ¹⁹¹	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Neovius (2004) ¹⁹²	Yes	UC	Avoided	Avoided	Avoided	Adequate	Imperfect
Neovius (2005) ¹⁹³	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Pandit (2009) ¹⁹⁴	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Reilly (2010) ¹⁹⁵	Yes	UC	Avoided	Avoided	Avoided	Adequate	Imperfect
Sardinha (1999) ¹⁹⁶	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Sarria (2001) ¹⁹⁷	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect

8. Description of index text	9. Used validated index text	10. Description of RS	11. Uninterpretable/intermediate results reported	12. Withdrawals explained	13. Measurement bias			
					13a. Training/experience Index test personnel	13b. Number of index text assessors	13c. Training/experience RS test personnel	13d. Number of RS assessors
Inadequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	No	UC	UC	UC	UC
Inadequate	Yes	Inadequate	Apparently none	No ^a	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	Yes ^b	Multi ^b	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Yes	None ^c	UC	UC	UC	UC
Adequate for BMI Inadequate for SFT	Yes	Inadequate	Yes	No ^d	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Adequate	Yes	Adequate	Completer analysis	Yes	UC	UC	UC	UC
Adequate	Yes	Inadequate	Completer analysis	Yes	UC	UC	UC	UC
Inadequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Inadequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	Yes ^h	2	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	Yes ^h	1
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Inadequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	1
Inadequate ⁱ	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Inadequate	Yes	Inadequate	Apparently none	None	Yes ^h	UC	UC	1
Adequate	Yes	Adequate	Yes	Yes	UC	UC	UC	UC

continued

TABLE 83 Diagnostics review: quality assessment results (*continued*)

Short title	1. Representative population	2. Progression bias	3. Partial verification bias	4. Differential verification bias	5. Incorporation bias	6. Description of selection criteria	7. Appropriateness of RS
Sproule (2009) ¹⁹⁸	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Taylor (2000) ¹⁹⁹	No ^j	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Taylor (2003) ²⁰⁰	No ⁱ	Probably avoided	Avoided	Avoided	Avoided	Inadequate	Imperfect
Telford (2008) ²⁰¹	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Vitolo (2007) ²⁰²	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Warner (1997) ²⁰³	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Wickramasinghe (2005) ²⁰⁴	No	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Wickramasinghe (2009) ²⁰⁵	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect
Zhang (2004) ²⁰⁶	Yes	Probably avoided	Avoided	Avoided	Avoided	Adequate	Imperfect

RS, reference standard; UC, unclear.

a 114/131 participated in follow-up study.

b Appropriately trained multiple assessors.

c Appropriate exclusions from subgroup analyses.

d DEXA was imputed for some children.

e 9.5% had missing data not at random.

f Restriction on ethnicity; exclusion of an outlier.

g Yes for India; no for UK.

h Suitably trained/experienced.

i Site for WC not reported.

j White children only.

8. Description of index text	9. Used validated index text	10. Description of RS	11. Uninterpretable/intermediate results reported	12. Withdrawals explained	13. Measurement bias			
					13a. Training/experience Index test personnel	13b. Number of index text assessors	13c. Training/experience RS test personnel	13d. Number of RS assessors
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	Yes ^h	2
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	Yes	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Adequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	None	UC	UC	UC	UC
Adequate	Yes	Inadequate	Apparently none	No	Yes	UC	UC	UC

BOX 1 Diagnostics review: guidance for quality assessment completion**Was the patient spectrum representative of the full range of patients who will receive the test in practice?**

Yes: unselected children, or children randomly selected from a representative population, recruited prospectively.

No: all other patient spectra including a retrospectively selected patient population.

Unclear: insufficient details were provided to make a judgement on whether or not the patient spectrum was representative.

Was the study subject to progression bias?

Avoided: the index test and reference standard were conducted within days or weeks of each other; therefore, progression bias was avoided.

Probably avoided: there was not specific information regarding the timing of the index test and reference standard, but the description of the study design makes progression bias unlikely.

Not avoided: there was a substantial delay between the index test and reference standard during which weight status could have changed.

Unclear: there was insufficient information to determine whether or not progression bias was present or absent.

Was the study subject to partial verification bias?

Avoided: all children had their adiposity determined using a reference standard and partial verification bias was avoided.

Not avoided: some children did not have their adiposity determined using a reference standard.

Unclear: there was insufficient information to determine whether or not all children had their adiposity determined using a reference standard.

Was the study subject to differential verification bias?

Avoided: all children had the same reference standard and differential verification bias was avoided.

Not avoided: children underwent different reference standards.

Unclear: there was insufficient information to determine whether or not all children had the same reference standard.

BOX 1 Diagnostics review: guidance for quality assessment completion (*continued*)**Was the study subject to incorporation bias?**

Avoided: the index test was independent of the reference standard and incorporation bias was avoided.

Not avoided: the results of the index test formed part of the reference standard.

Unclear: there was insufficient information to determine whether or not the index test was independent of the reference standard.

Was the description of the selection criteria adequately described to allow replication?

Adequate: sufficient details were reported.

Inadequate: insufficient details were reported.

Was the reference standard used appropriate?

Gold standard: a four or more component model was used.

Imperfect: underwater (hydrostatic) weighting, D₂O, ADP or DEXA alone was used.

Was the description of the conduct of the index test adequate to allow replication?

Adequate: sufficient details were reported.

Inadequate: insufficient details were reported.

Was the index test used a validated measure?

Yes: the index test used was validated and used recognised cut-off points and reference data.

No: the index test used was not validated.

Unclear: insufficient details were reported to determine whether or not the index test used was validated.

Was the description of the conduct of the reference standard adequate to allow replication?

Adequate: sufficient details were reported.

Inadequate: insufficient details were reported.

BOX 1 Diagnostics review: guidance for quality assessment completion (*continued*)**Were uninterpretable/intermediate results reported?**

None: there were no uninterpretable results.

Apparently none: given the data in the analysis, it seems that there were no uninterpretable results or they were accounted for but details not provided.

Yes: uninterpretable results occurred and these were reported and accounted for in the analysis.

Completer analysis: uninterpretable results occurred and only those with interpretable results were included in the analysis.

Unclear: it was not clear whether or not there were any uninterpretable/intermediate test results.

Were withdrawals from the study reported/explained?

None: there were no withdrawals.

Yes: withdrawals occurred, but these were explained.

No: there appeared to be patients who were recruited who were not accounted for.

Unclear: it was not clear whether or not any withdrawals occurred.

Did the study avoid measurement bias:

Yes: the study used a single, appropriately trained individual for the conduct of all childhood measures of obesity.

No: the study used multiple assessors, or inadequately trained individual(s).

Unclear: insufficient details were reported on the number and/or experience of assessors.

Review of the acceptability and ease of use of simple childhood measures of obesity

TABLE 84 Acceptability review: quality assessment results

Study	1. Clear statement of aims?	2. Appropriate methodology?	3. Appropriate research design?	4. Appropriate recruitment strategy?	5. Data collected appropriately?	6. Relationship between researcher and participants considered?	7. Ethical considerations considered?	8. Rigorous data analysis?	9. Clear statement of findings?	10. Research of value?
Cloutier (2013) ²⁰⁷	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Hendershot (2008) ⁷³	Yes	Yes	Yes	Yes	Yes	UC	NA	UC	Yes	Yes
Kubik (2006) ⁷⁴	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Kubik (2007) ⁷⁵	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Woolford (2008) ²⁰⁸	Yes	Yes	Yes	Yes	Yes	No	NA	Yes	Yes	Yes

BOX 2 Acceptability review: guidance for quality assessment completion**1. Clear statement of aims?**

Yes: the aims of the study were clearly stated and relevant.

No: the aims of the study were not clearly stated and/or were not relevant.

2. Qualitative methodology appropriate?

Yes: the study was seeking to interpret subjective experiences of participants, making qualitative methodology the correct methodology to use.

No: the study was not seeking to interpret subjective experiences of participants.

3. Appropriate research design?

Yes: a prospective cohort of children, parents/guardians and/or health professionals.

No: any other study design.

Unclear: insufficient details of the study methodology were reported.

4. Appropriate recruitment strategy

Yes: unselected consecutive participants, or randomly selected participants, from a population of children, parents/guardians and/or health professionals representative of those who will (whose children will) undergo the test(s) for which opinions were being sought in clinical practice.

No: non-consecutive or random selection, or selection from a population not representative of those who will undergo the test(s) for which opinions were being sought in clinical practice.

Unclear: insufficient details of recruitment were reported.

5. Data collected appropriately?

Yes: focus groups or structured interviews or questionnaires were used to elicit opinions.

No: other methods of elicitation.

Unclear: insufficient details of the method of elicitation of opinions were reported.

6. Relationship between researcher and participants considered?

Yes: the relationship between the researcher and participants, and the researcher's responses to events during the study, were discussed.

No: the relationship between the researcher and participants was not discussed.

BOX 2 Acceptability review: guidance for quality assessment completion (*continued*)**7. Ethical considerations considered?**

Yes: ethical considerations were discussed, or ethical approval obtained.

No: ethical considerations were neither discussed nor was ethical approval obtained.

Not applicable: the study was conducted in adults for whom ethical approval was not required, and ethical considerations were thought to be relevant.

8. Rigorous data analysis?

Yes: the methods used to evaluate findings was rigorous, although simple in some cases.

No: the methods used to evaluate findings was not rigorous, or insufficient data were presented to support the findings.

Unclear: insufficient details were reported as to how the synthesis was conducted.

9. Clear statement of findings?

Yes: the findings were explicitly stated.

No: the findings were not explicitly stated.

10. Research of value?

Yes: the value of the research was considered by the study authors, recommendations were reported and the research was considered to be of value by the review team.

No: the value of the research was either not considered by the study authors, or recommendations were not reported, and/or the research was considered to be of value by the review team.

Unclear: the value of the research was not discussed by the study authors and was unclear to the review team.

Appendix 5 Review of adult morbidities: additional results from the meta-analyses

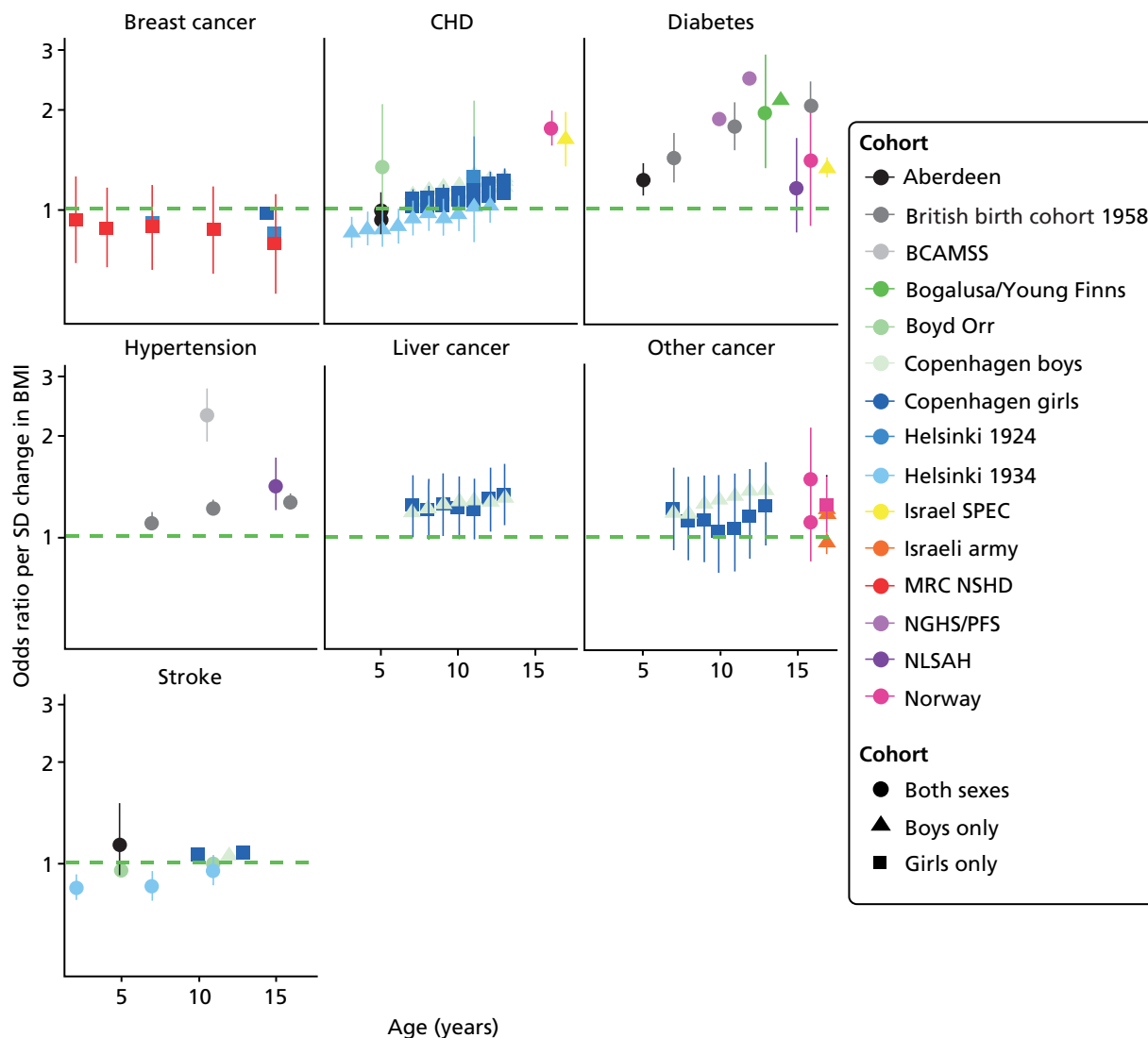


FIGURE 34 Odds ratios for all adult morbidities. BCAMSS, Beijing Child and Adolescent Metabolic Syndrome study; MRC NSHD, Medical Research Council National Survey of Health and Development; NGHS, National Growth and Health study; PFS, Princeton follow-up study; SPEC, Staff Periodic Examination Center.

A decorative graphic consisting of numerous thin, parallel green lines that curve from the left side of the page towards the right, creating a sense of movement and depth.

**EME
HS&DR
HTA
PGfAR
PHR**

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