OSCA consensus statement on the assessment of obese children & adolescents for paediatricians

Authors:

OSCA (Obesity Services for Children and Adolescents) Network Group

Affiliations: See Appendix F.

Address for correspondence:

Dr. Russell Viner
Institute of Child Health
30 Guilford St.
London WC1N 3EH
Tel: 020 7905 2190
Email: R.Viner@ich.ucl.ac.uk

Summary

This expert opinion and review paper provides detailed guidance on assessing obesity in secondary paediatric practice in the UK. This guidance builds on existing recommendations from NICE, and is evidence-based where possible. Guidance is provided on which obese children and young people are appropriate to be seen in secondary care and necessary history and investigations, and guidance on when further investigation of causes and obesity-related co-morbidity is appropriate.

Background

Obese children and adolescents now form an increasing burden on children's health services, and paediatricians are increasingly called upon to assess and manage obesity children and adolescents. Yet there is little authoritative guidance to help with this task.

NICE recently (2006) systematically reviewed the literature and published high-level guidance on the management of obesity in children and young people.[1] However assessment and management of childhood obesity and its co-morbidities in secondary care was not covered in this guidance, largely because of a lack of quality evidence.

This current document builds on the NICE recommendations to provide detailed guidance on assessing obesity in secondary paediatric practice in the UK. This is not a systematic review of the evidence, as that task has already been undertaken by NICE. This is an expert review, building upon other available guidance, such as that of the American Academy of Pediatrics.[2]

The aim of this guidance is to provide paediatricians with an evidence-based algorithm to undertake the following tasks:

(a) identify which of the many overweight children require assessment
(b) identify causes of obesity where they are known
(c) recognise significant co-morbidities
(d) establish which treatments are appropriate for each obese child or adolescent

This guidance was authored by the Obesity Services for Children and Adolescents (OSCA) network, a network of paediatricians with special interest in the management of childhood obesity, linked to the Royal College of Paediatrics and Child Health (RCPCH) and to the Association for the Study of Obesity (ASO). OSCA was formed in 2005 and consists of general and community paediatricians, paediatric endocrinologists and gastroenterologist. The methods used to generate the guidance were solely those of expert review. We follow the NICE guidance in suggesting that the 98th BMI centile is an appropriate one around which to base assessment and management strategies.

This guidance on assessment is for use in secondary and tertiary care. While it may have some relevance for primary care, the management of childhood obesity in primary care should be guided by the NICE 2006 recommendations and the existing RCGP-RCPCHguidance for the management of obesity in primary care.[3]

We first discuss which children are appropriate for referral from primary to secondary care, then provide a schema for examination and investigation in secondary care, and then discuss issues of diagnosis. An accompanying document discusses the management of child and adolescent obesity in secondary care.

1. Who is appropriate to be seen by a Paediatrician

NICE guidance recommends that professionals "consider referral to a specialist if the child has significant comorbidity or complex needs…". We recommend that the following children are appropriate to be seen in secondary care, and are thus appropriate to be referred from primary care.

A. Children with BMI ≥98th centile who fulfil the following criteria:

i. the child or family are seeking help/treatment

ii. the child has one or more of the following risk factors for either possible underlying pathology or future morbidity:

Risk factor	Detail
A. Possible underlying pathology	
Relative short stature for degree of obesity	Short for midparent/genetic centile. Obese children are generally tall for their genetic potential.
Dysmorphic signs and/or significant learning difficulties	Any dysmorphic signs and/or significant learning difficulties associated with obesity are a reason for referral. For details of specific syndromes, see Appendix A.
B. Risk for co-morbidity	
Evidence of medical co-morbidity associated with obesity	Any of the following 1. hypertension: systolic or diastolic BP ≥98th centile for age using an appropriate sized cuff. (see Appendix B). 2. obstructive sleep apnoea (Appendix C for assessment and common symptoms) 3. significant mobility or joint problems 4. abnormal glucose or insulin metabolism: i. impaired fasting glucose ii. impaired glucose tolerance iii. hyperinsulinaemia (see Appendix D for definitions). Note that those with type 2 diabetes should be urgently referred to a specialist paediatrician. 5. acanthosis nigricans 6. dyslipidaemia i. low HDL

	ii. high triglycerides iii. high cholesterol/HDL ratio (see Appendix D) 7. ALT ≥ 70 is suggestive of non-alcoholic fatty liver disease (NAFLD) 8. features suggestive of polycystic ovarian syndrome (oligomenorrhoea, hirsuitism, acne, precocious or delayed menarche)
Evidence of psychological co-morbidity associated with obesity	1. Significant family/individual distress related to obesity, e.g. depression, self-harm and suicidal ideation. 2. Concerns regarding an eating disorder 3. child protection concerns
Family history of type 2 diabetes or premature cardiovascular disease in 1st or 2nd degree relatives	The following family histories particularly confer risk • early onset type 2 diabetes <40 years of age strong family history of cardiovascular disease before the 60s

NB. Referrers should have a higher index of suspicion to investigate and refer children and young people from black or south Asian ethnicities, because of increased metabolic risk.

B. Any child with extreme obesity.

Those extremely obese should be referred regardless of additional risk-factors. There are no currently agreed definitions for extreme obesity. We suggest that any child with either BMI >3.5 standard deviations (SD) above mean (see Appendix E for details at different ages) should be regarded as having extreme obesity, as this is equivalent at age 18 years to the adult definition of morbid obesity (BMI ≥40kg/m2).

2. Medical history and examination in secondary care

An appropriate medical history and examination should be undertaken, with special reference to the following:

Feature	Comments
1. Accurate height and weight and calculation of BMI.	Plot BMI on appropriate centile charts or calculate z-score.
2. Waist circumference	It is unclear whether waist circumference is helpful in the clinical situation. A waist circumference at assessment may be useful for assessing risk of comorbidity associated with central adiposity by comparison with published UK centiles.[4] However the clinical utility of change in waist over time is unclear due to very poor reproducibility in clinical settings.[5] We do not recommend waist circumference be used as a clinical marker of adiposity change in obese children.
3. Pattern of obesity: note whether generalised obesity, or whether adiposity is primarily central or upper body	Those with marked central adiposity may be at particular risk of adverse cardiovascular outcomes. Upper body fat, e.g. buffalo hump and neck, may be suggestive of Cushing syndrome.
4. Blood pressure	Note - use appropriately sized (large) cuff. Hypertension is defined as $\geq 95^{th}$ centile on recent UK reference data - see Appendix B.
5. Pubertal assessment and menstrual history	
6. Acanthosis nigricans	The thickened velvety darkened skin of acanthosis nigricans is indicative of, but not particularly sensitive for, significant insulin resistance. It is usually seen first around the neck and in the axillae, but in severe cases may occur in all flexures.
7. Symptoms of obstructive sleep apnoea	Two useful screening questions include the presence of: 1. Snoring 2. Difficulty in breathing during sleep A more detailed assessment of sleep apnoea is given in

	Section 3.2.
7. Signs of endocrinopathy	Hypothyroidism as a primary cause of obesity is rare, especially when stature is normal. Signs include: • short stature or reduced growth velocity • goitre • thickened yellow skin, skin & hair changes • psychomotor slowing, hung-up ankle jerks Steroid excess (e.g. Cushing syndrome) is a very rare cause of obesity. Signs include striae, hypertension, short stature, hirsutism and telangiectasia Note that striae are almost universal in obesity and by themselves are not a sign of Cushings.
8. Signs of genetic obesity syndromes	Particularly note early onset obesity, learning difficulties, deafness, epilepsy, retinitis, dysmorphic features, neuro-endocrine abnormalities including hypogonadism and red hair outside the context of family history. See Appendix A.
9. Concomitant drug use	Drugs as glucocorticoids (oral or high dose inhaled) and atypical antipsychotic medications are strongly associated with obesity and insulin resistance.

3. Investigations in secondary care

3.1. Routine tests appropriate in obese children and adolescents seen in secondary care

The investigation of obese children is a controversial area with little data available to guide practice. We suggest that investigations for assessment of co-morbidity should be routine, but that investigations for causes of obesity should only be done in specific cases. Application of the following recommendations must be guided by the clinical context.

	Detail
A. Investigations of the aetiology of obesity	Few investigations are routinely necessary for investigation of the causes of obesity. If there are no abnormalities on examination or history, these should be limited to thyroid function. Note that many obese children have a TSH at the top of or just above the upper limit of the normal range.
1. Thyroid function	
B. Investigation of obesity co-morbidities	
Fasting bloods after an 8 hour fast	
1. Glucose and insulin	Insulin should be measured in addition to glucose in order to assess insulin resistance, from fasting insulin or by calculating the HOMA-IR index of insulin resistance (see Appendix D).
2. Lipids, including total cholesterol, triglyceride (TG) and HDL	It is important to request a full lipid profile and not just total cholesterol. See Appendix D for definitions of dyslipidaemia.
3. Liver function	Raised ALT (≥twice normal range, e.g. ≥70) is the best indicator of probable NAFLD (non-alcoholic fatty liver disease), the hepatic manifestation of insulin resistance. If: • ALT ≥twice upper limit of normal range persistently (≥twice in 3 months) – suggest liver ultrasound and screening for other causes of hepatitis (e.g. Wilsons, autoimmune, infectious and alpha 1 antitrypsin deficiency) • ALT≥120 – suggest hepatology consultation

	for possible liver biopsy
4. FBC, U&E	FBC, U&E are not specifically indicated in obesity. However iron deficient anaemia is more common in those with disordered eating.

3.2. Additional investigations that may be appropriate in some children and adolescents

A For aetiology	**Detail**
1. Genetic studies	• Genetic studies for syndromes associated with obesity (See Appendix A). • Referral to geneticist if significant concerns. • Offer inclusion in the Genetics of Obesity (GOOS) study, which investigates monogenic causes of early onset obesity. See Appendix A for details.
2. Suspicion of secondary obesity e.g. Cushing syndrome	Refer to a paediatric endocrine clinic if you suspect Cushing syndrome. e.g. • Height deceleration • Obesity is of short duration or there has been rapid recent weight gain • Severe hypertension, acne or hirsuitism (although these are seen frequently in simple obesity)
3. Thyroid antibodies	If concerned, check anti-thyroid antibodies and If TSH is repeatedly elevated above normal range, refer to paediatric endocrinology.
4. Calcium and PO4 screen	Check calcium and phosphate if suspicion of pseudohypoparathyroidism.
B. For co-morbidity	
1. Oral glucose tolerance test (OGTT)	Note that the OGTT is undertaken to diagnose hyperinsulinaemia and pre-diabetes conditions more commonly than diabetes itself. We suggest that the following patients should be considered for an OGTT: 1. BMI≥98th centile and has ≥2 of the following: • Family history of type 2 diabetes (1st or 2nd degree relatives) • Ethnicity (South Asian, Middle-Eastern,

Hispanic, black Caribbean or black African)
- Clinical signs of potential insulin resistance syndrome (acanthosis nigricans, hypertension)
- Investigatory evidence of the insulin resistance syndrome (fasting hyperinsulinaemia, and/or dyslipidaemia)
- Signs and symptoms of PCOS

2. All subjects with extreme obesity

3. Clinical judgement can be used to test high-risk patients who do not meet these criteria.

(adapted from the American Diabetes Association Recommendations for children).

The most useful protocol would measure glucose and insulin every 30 minutes. If this is not possible, the priority values are the 0 and 120 min glucose, and the 0 and 60 minute insulins.

There are no data on the utility of repeating the OGTT. We suggest repeating the test every 2 years unless there has been significant weight loss.

2. Investigations for polycystic ovarian syndrome (PCOS)

PCOS should be suspected in girls with signs of insulin resistance (acanthosis nigricans), androgen excess (acne and hirsuitism) and oligo-amenorrhoea.

In pubertal girls with symptoms of polycystic ovarian syndrome, undertake the following:

Bloods

- Adrenal androgens (androstenedione, dehydroepiandrosterone sulphate (DHEAS) & testosterone)
- FSH & LH (baseline only)
- 17 hydroxy-progesterone
- Sex hormone binding globulin (SHBG)
- Prolactin

Pelvic ultrasound: This should be attempted in adolescents only if a skilled operator is available. Note that interpretation of pelvic ultrasounds by those inexperienced with adolescents may over diagnose polycystic changes. Diagnosis is not dependent on pelvic morphology.

3. Sleep investigations	We recommend use of the Pediatric Sleep Questionnaire (Appendix C) to assess obesity-related sleep problems such as obstructive sleep apnoea and short sleep duration. Those with significant symptoms of OSA, or who score positive answers on ≥8 of the 22 questions, should be considered for a formal sleep study.

4. Diagnostic issues

1. Obesity

It is useful to add some clarity to the diagnosis of obesity, as diagnosis should directly inform management. The current ICD10 categories are outdated, and the field is changing as we better understand the genetic underpinning of obesity. We suggest that division into three categories is useful as follows:

1. Primary obesity	This is the commonest category, accounting for >95% of cases. This should be the diagnosis if examination or history does not lead to further investigations, or if further investigations are negative. It is unhelpful to call this "nutritional obesity."
2. Monogenic causes of obesity	Note this category may expand with advances in knowledge. See Appendix A for genetic syndromes associated with obesity.
3. Secondary obesity	Secondary to or associated with endocrinopathy, CNS abnormalities, drugs or other medical pathology

2. Comorbidities:

Cut-offs for the diagnosis of glucose-insulin, blood pressure and lipid abnormalities are given in the Appendices. While glucose and insulin, blood pressure and lipid abnormalities clearly cluster together, often termed the metabolic or insulin resistance syndrome, it is unclear whether the diagnosis of this clustering in individuals is of clinical utility.

3. Polycystic ovarian syndrome

The internationally accepted Rotterdam 2003 consensus[6] for diagnosing PCOS required 2 of the following 3 criteria to be present:

1) Oligo- or anovulation:
2) Clinical and/or biochemical signs of hyperandrogenism (male pattern hirsuitism, alopecia)
3) Polycystic ovarian morphology

Note that there is some difficulty in applying this to adolescents, as oligomenorrhoea (a strict definition is bleeding intervals >35 days) is developmentally normal for some years after menarche. Furthermore, it is unclear whether a diagnosis of PCOS can be strictly made before menarche.

Biochemical signs of hyperandrogenism are adrenal and/or ovarian androgens (DHEA-S, androstenedione and testosterone) above the normal adult female range. Clinicians frequently regard an LH:FSH ratio of >3:1 to be suggestive of PCOS, however this is not supported in the Rotterdam guidelines.

Obstructive sleep apnoea

Obesity increases the risk of OSA approximately 5-fold. Diagnosis of OSA is based on clinical suspicion, history, and physical findings, with confirmation is made by polysomnography if needed.[7] Symptoms including significant snoring, paradoxical chest movements, excessive movement during sleep and frequent awakenings, daytime sleepiness, and behavioural and cognitive problems. Examination is usually unremarkable.[7] The most useful initial screening questions concern snoring and difficulty in breathing during sleep. If these are present, simple and convenient questionnaires such as the Chervin Pediatric Sleep Questionnaire[8] or the Cleveland Adolescent Sleepiness Questionnaire[9] can be useful to identify OSA and distinguish it from simple snoring. Significant symptoms plus a score of ≥8 on the Chervin questionnaire should prompt further investigation, such as overnight oximetry monitoring in the first instance. If positive, further dedicated respiratory sleep assessment should be undertaken.

Summary

This guidance provides expert opinion for the assessment of obesity and its co-morbidities in secondary care in the UK. Recommendations are based upon best available evidence, however it must be noted that in many cases, quality evidence is lacking and recommendations are based on clinical experience. This document should be read in conjunction with our forthcoming guidance on the management of childhood obesity in secondary care.

Acknowledgements

We would like to thank the Royal College of Paediatrics and Child Health for supporting OSCA with funds for meetings and travel. We would also like to thank the Association for the Study of Obesity (ASO) for supporting us with an initial small grant for travel. Individuals who have contributed outside the OSCA group include Prof. Barry Taylor, Dunedin School of Medicine, New Zealand, who provided general advice on the guidance, and Dr. Shahrad Taheri Senior Lectuer in Medicine, Diabetes and Endocrinology, University of Birmingham, who provided advice on the management of obstructive sleep apnoea.

Competing Interests

Nil declared for all authors.

Funding

OSCA meetings were funded by the Royal College of Paediatrics and Child Health, and the Association for the Study of Obesity (UK).

Appendix A: Dysmorphic and Monogenic syndromes associated with obesity

MAIN CLINICAL OBESITY-ASSOCIATED SYNDROMES

Chromosomal	Prader-Willi syndrome
	Down's syndrome
Autosomal dominant	Biemond syndrome (some cases)
Autosomal recessive	Aistrom syndrome
	Bardet-Biedl syndrome
	Biemond syndrome (some cases)
	Carpenter syndrome
	Cohen syndrome
X-linked inheritance	Borjeson-Forssman-Lehmann syndrome
Single gene lesions affecting leptin metabolism	Congenital leptin deficiency
	truncated leptin protein
	missense mutation in leptin
	Leptin receptor mutation
	Prohormone convertase 1 mutation
	Melanocortin 4 receptor mutation

CLINICAL FEATURES SUGGESTING OBESITY MAY BE SECONDARY TO ANOTHER CONDITION OR SYNDROME

Severe unremitting obesity
Abnormal facies
Disorders of the eyes
colobomata
retinal problems, especially retinitis pigmentosa
narrow pelpebral fissures
abnormally position palpebral fissures
severe squint
Skeletal abnormalities
polydactyly
syndactyly
kyphoscoliosis
Sensorineural deafness
Microcephaly and/or abnormally shaped skull
Mental retardation
Hypotonia
Hypogonadism
cryptorchidism
micropenis
delayed puberty

Renal abnormalities

Cardiac abnormalities

Genetics of Obesity Study (GOOS)

The GOOS study is an ongoing study of monogenic causes of obesity, and has been highly successful in identifying both common (melanocortin 4 receptor defect) and uncommon (leptin receptor mutation) monogenic causes of obesity.

We suggest that any young people meeting the GOOS criteria be entered into the study, which may present clinical benefits for obese children in the future.

Inclusion criteria: Severe obesity of early onset, defined as BMI SD score >3 with onset before the age of 10 years.

What is needed:

1. clotted blood sample of 10 ml
2. A parental or patient signed consent form. Note that the study has MREC approval to recruit from all centres throughout the UK, and site specific permissions are not necessary.
3. A patient details form.

Forms and instructions on how and where to send the blood are available from:

Dr Sadaf Farooqi
Wellcome Trust Senior Clinical Fellow & Honorary Consultant Physician
Metabolic Research Laboratories
Level 4, Institute of Metabolic Science
Box 289
Addenbrooke's Hospital
Cambridge CB2 0QQ
Tel:+44-1223-762634
Fax:+44-1223-762657
Email:isf20@cam.ac.uk
www.mrl.ims.cam.ac.uk/staff/PI/Farooqi/

Note an excellent and authoritative free resource on genetic syndromes in obesity can be found at Endotext:
http://www.endotext.org/obesity/obesity8/obesityframe8.htm

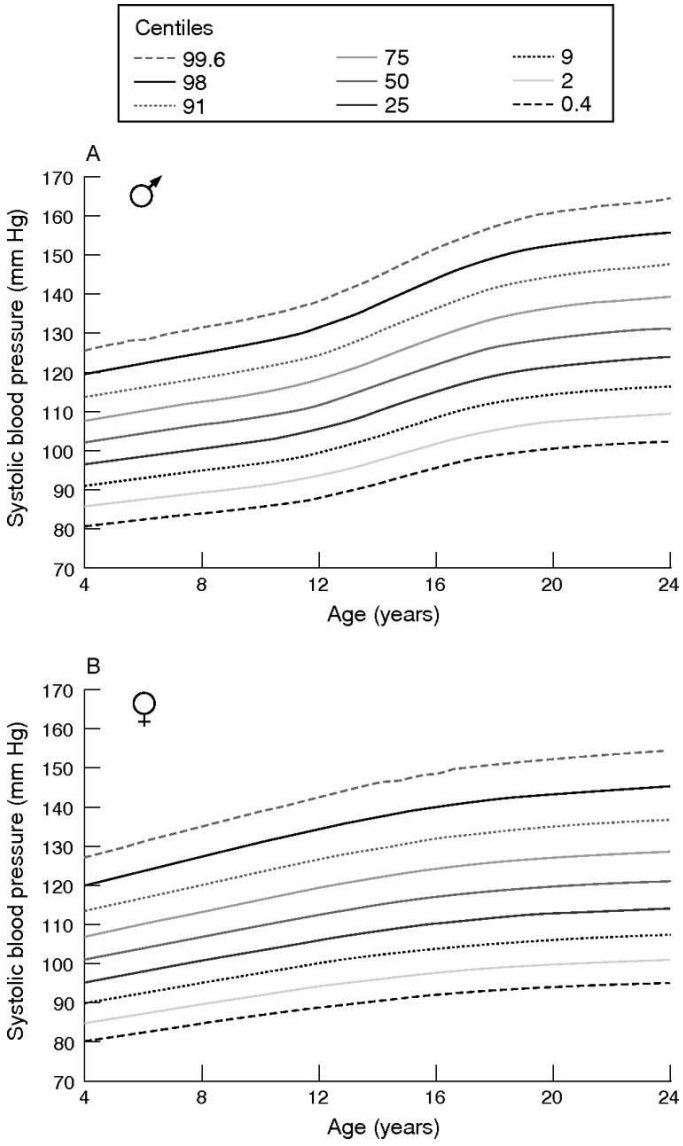
Appendix B. Hypertension and the UK blood pressure centiles

Recent recommendations suggest the following definitions are useful

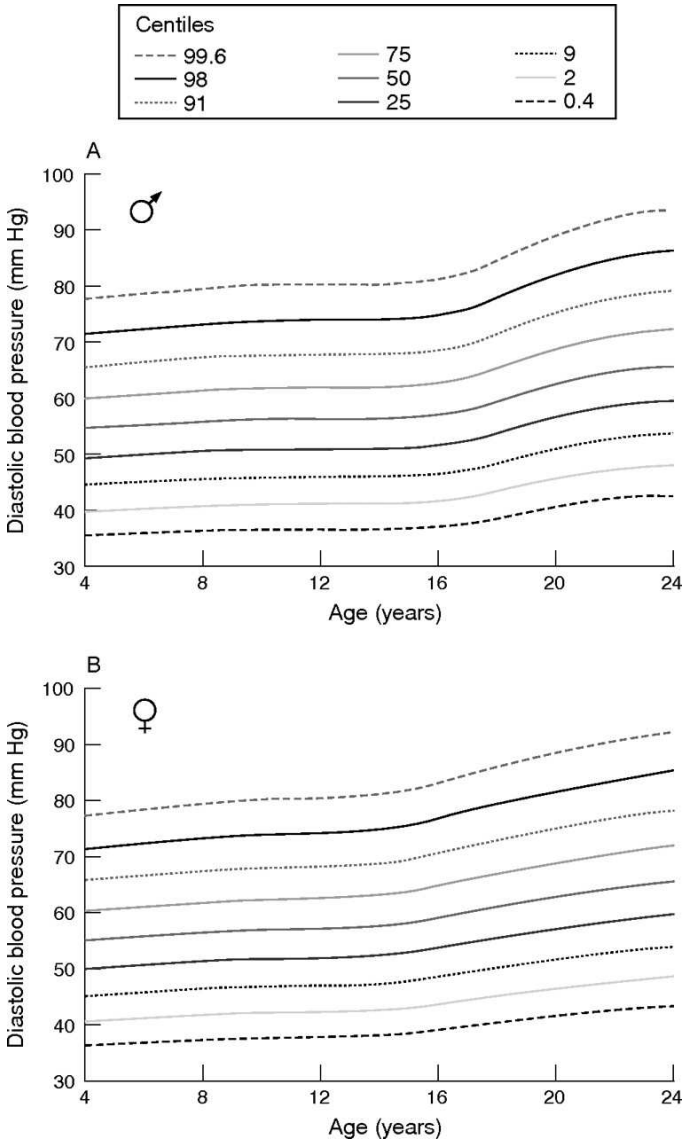
1. ≥98th centile = hypertension / high blood pressure
2. 91st to 98th centile = high normal BP for age

Note that the British Hypertension Society adult definition of hypertension (≥140/90 by age 24 years) represents approximately the 91st centile in 24 year old males and above the 98th centile for females.

Systolic



Diastolic



Reference and further information: Jackson & Cole. Arch Dis Child 2007; 92: 298-303

Measurement of BP and cuff size

Blood pressure must be measured using an appropriate sized cuff. In general, an appropriate cuff size is a cuff with an inflatable bladder width that is at least 40% of the arm circumference at a point midway between the olecranon and the acromion. For such a cuff to be optimal for an arm, the cuff bladder length should cover 80% to 100% of the circumference of the arm.[10]

For obese patients, this can be difficult to assess. A more accurate method is to measure the subject's mid-arm circumference, and use this to determine the appropriate cuff-size. The following data on recommended cuff sizes come from the US National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004.[10]

Recommended Dimensions for BP Cuff Bladders: Use the cuff size (left hand column) that fits with the patient's mid-arm circumference (right-hand column)

Age Range	Cuff width, cm	Cuff length, cm	Maximum Arm Circumference, cm*
Newborn	4	8	10
Infant	6	12	15
Child	9	18	22
Small adult	10	24	26
Adult	13	30	34
Large adult	16	38	44
Thigh	20	42	52

* Calculated so that the largest arm would still allow the bladder to encircle arm by at least 80%.

Reference: National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics 2004;114 (2):555-576,.

Appendix C: Sleep and obstructive sleep apnoea (OSA)

Typical symptoms of OSA include:

- Snoring
- morning headaches
- fatigue

The following 5 questions about sleep have been found to be very useful in assessing OSA (the **Chervin Pediatric Sleep Questionnaire)**

Scoring: 8 or more positive answers out of 22 indicates a high risk for sleep abnormality.

1. While sleeping, does your child...

1A. ... snore more than half the time?	Yes □	No □
1B. ... always snore?	Yes □	No □
1C ... snore loudly?	Yes □	No □
1D ... have ``heavy'' or loud breathing?	Yes □	No □
1E ... have trouble breathing, or struggle to breathe?	Yes □	No □
1F Have you ever seen your child stop breathing during the night?	Yes □	No □

2. Does your child

2A .... tend to breathe through the mouth during the day?	Yes □	No □
2B .... have a dry mouth on waking up in the morning?	Yes □	No □
2C ... occasionally wet the bed?	Yes □	No □

3. Does your child ...

3A ... wake up feeling unrefreshed in the morning?	Yes □	No □
3B .... have a problem with sleepiness during the day?	Yes □	No □
3C Has a teacher or other supervisor commented that your child appears sleepy during the day?	Yes □	No □
3D Is it hard to wake your child up in the morning?	Yes □	No □
3E Does your child wake up with headaches in the morning?	Yes □	No □

4. General questions.

4A Did your child stop growing at a normal rate at any	Yes □	No □

time since birth?		
4B Is your child overweight?	Yes □	No □

Please answer the following about your child's behaviour in the day...

5 My child often....

5A .... does not seem to listen when spoken to directly	Yes □	No □
5B .... has difficulty organizing tasks and activities	Yes □	No □
5C ... is easily distracted by extraneous stimuli	Yes □	No □
5D ... fidgets with hands or feet or squirms in seat	Yes □	No □
5E... is `on the go' or often acts as if `driven by a motor'	Yes □	No □
5F .... interrupts or intrudes on others (e.g. butts into conversations or games)	Yes □	No □

Reference: Chervin RD, Hedger K, Dillon JE, Pituch KJ. Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. Sleep Medicine 2000;**1**:21-32.

Appendix D. Metabolic and cardiovascular risk factor definitions

Abnormal glucose insulin metabolism

Fasting state:

1. Glucose

    a. impaired fasting glucose 6.1- 6.9 mMol

    b. diabetes ≥7.0 mMol

2. Insulin

The definition of fasting hyperinsulinaemia in children and adolescents is not yet settled. Puberty affects insulin sensitivity and therefore fasting insulin levels to some extent ?age dependent.

Normative values from large samples are only available from the US: in 1802 adolescents across the BMI range without diabetes, mean insulin was 12mU/L at age 12 years, 13 at 13 years, 15 at 14 years, falling back to 12-13 mU/L by 16-19 year (Lee JM et al. Prevalence and determinants of insulin resistance among U.S. adolescents: a population-based study. Diabetes Care 2006;29:2427-32)

We recommend using the following thresholds for hyperinsulinaemia by pubertal stage:

	mU/L	pmol/L	
• pubertal stage 1 & 2	≥15	90	
• pubertal stage 3& 4	≥30	180	
• pubertal stage 5	≥20	120	(note this is the WHO adult threshold)

Note that these are conservative by comparison to the US reference data above.

Note that insulin may be expressed as mU/L or as picomoles. For conversion, 1mU/L = 6.0 pmol/L

(Reference: Diabetes Care 1993;16:555-6)

Post glucose challenge (oral glucose tolerance test)

1. Glucose

    a. impaired glucose tolerance ≥7.8mMol

    b. diabetes ≥11.1 mMol

2. Insulin

There is no clear definition of hyperinsulinaemia in response to glucose challenge. Peak insulin ≥100mU/L (600pmol/L) may be used as a marker of OGTT hyperinsulinism.

3. Measures of insulin resistance

The gold standard measures of insulin sensitivity are not practical in clinical samples. A number of estimates of insulin sensitivity and beta-cell function have been developed from fasting insulin and glucose in adults, of which the homeostatic model assessment (HOMA) is the most widely used. There is some data to support

the use of the HOMA estimate of insulin resistance (HOMA-IR) in children and adolescents, although not to support the beta-cell function estimates. There is little evidence that HOMA-IR is more useful than simple fasting insulin levels as a measure of insulin resistance.

The equation is HOMA-IR = insulin*glucose /22.5.
(Note that insulin must be in mU/L)

Population reference data has only recently been published and only for adolescents: the 98th centile for 12-19 year olds is 4.4 (Lee JM et al. Prevalence and determinants of insulin resistance among U.S. adolescents. Diabetes Care 2006; 29:2427–2432), which we recommend as the most practical definition of insulin resistance in the current state of knowledge.

Dyslipidaemia

The table below shows the US National Cholesterol Education Program (NCEP) Report of the Expert Panel on Blood Cholesterol Levels in Children and Adolescents and the American Heart Association (AHA) recommendations for abnormal lipids in children and adolescents. In the absence of UK guidance, we recommend their use.

	NCEP		AHA
	Borderline	Adverse	
HDL	0.91 – 1.16mmol/L in both sexes	≤0.9mmol/L	<0.90
Triglycerides	1.02 -1.46mmol/L	≥1.47 mmol/L	No guidance
LDL	2.85 – 3.35mmol/L	≥3.35mmol/L	As for NCEP
Total cholesterol	4.40 – 5.15 mmol/L	≥5.2 mmol/L	≥5.2 (approx 95th centile for 4-19 yrs)

Detailed growth curves for lipoproteins throughout adolescence, providing reference ranges linked to the NCEP adult thresholds (in a similar way to derivation of the International Obesity Task Force growth curves) can be found at: Jolliffe CJ, Janssen I. Distribution of lipoproteins by age and gender in adolescents. Circulation. 2006;114:1056-1062.

The total cholesterol : HDL-C ratio is used in adult medicine as an integrative marker of lipid risk, with ratios of 2.5 being normal and >4.0 being associated with risk of adverse cardiovascular events. Published normative data for this ratio are not available in children and adolescents. However, data from the ALSPAC

study in 8 year olds supports the use of the adult ratios with children and adolescents (50th centile for ratio was 2.54, with the 95th centile being 3.6 and the 99th centile being 4.3).

References

1. National Cholesterol Education Panel. *Report of the Expert Panel on Blood Cholesterol Levels in Children and Adolescents*. Bethesda, Md: National Institutes of Health; 1991. NIH Publication No. 91-2732.
2. Williams CL, Hayman LL, Daniels SR et al. Cardiovascular health in childhood: A statement for health professionals from the Committee on Atherosclerosis, Hypertension, and Obesity in the Young (AHOY) of the Council on Cardiovascular Disease in the Young, American Heart Association. Circulation 2002; 106(1):143-160
3. Jolliffe CJ, Janssen I. Distribution of lipoproteins by age and gender in adolescents. circulation. 2006;114:1056-1062.

The "Metabolic syndrome"

There is currently an ongoing debate about the diagnosis and the utility of diagnosis of the insulin resistance syndrome or metabolic syndrome (MS) in children and adolescents. It remains unclear whether it is clinically helpful to identify an MS-like clustering of cardiovascular risk in childhood. However there is evidence that an MS-like syndrome in childhood is predictive of both the MS and actual cardiovascular disease in adult life; the Princeton Lipid Research Clinics study suggested that the MS in childhood increased risk of adult cardiovascular disease approximately 15-fold.[11]

Practically, we suggest that obese children and young people with ≥2 of the following cardiovascular risk factors are very likely to constitute a high risk group:

i. impaired fasting glucose or impaired glucose tolerance
ii. hyperinsulinaemia
iii. abnormal lipids – low HDL or high total cholesterol, LDL or TG
iv. hypertension

Population-based data from the US suggest that 22% of children and adolescents with BMI ≥98th centile have ≥2 risk factors in addition to their obesity, rising to 33% of those ≥99th centile (Freedman et al. 2007).

Clinic based data in UK children suggest that around 20-25% of obese children and adolescents have 2 or more of the above risk factors in addition to obesity (Viner et al 2005)

References:

1. Freedman D et al. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. J Pediatr 2007;150:12-17

2. Viner D et al. Prevalence of the insulin resistance syndrome in obesity. Arch Dis Child 2005;90: 10-14.

3. Brambilla P et al. Metabolic risk-factor clustering estimation in children: to draw a line across pediatric metabolic syndrome. Int J Obesity 2007; 31: 591-600

Appendix E. Definitions of extreme Obesity

BMI thresholds for extreme obesity, using a definition of BMI ≥3.5 SD above mean. Note that this is equivalent at age 18 years to the WHO definition of morbid obesity (BMI≥40kg/m2).

	Male	Female
2 yrs	22.7	22.7
5yrs	22	23.5
10 yrs	32	33
15 yrs	38	38
18 years	40	40

Appendix F: OSCA members

In alphabetical order:

Russell Viner, OSCA Coordinator	Reader in Adolescent Health, Consultant in Adolescent Medicine & Endocrinology, UCL Institute of Child Health, London
Tim Barrett	Professor of Paediatric Endocrinology, Birmingham Children's Hospital
David Candy	Consultant Paediatric Gastroenterologist, Royal West Sussex NHS Trust, Visiting Professor, University of Chichester
Penny Gibson	RCPCH Obesity Advisor & Community Paediatrician, Guildford
John Gregory	Professor of Paediatric Endocrinology, Cardiff
Catherine Hall	Consultant Paediatric Endocrinologist, Royal Manchester Children's Hospital
Chris Kelnar	Professor of Paediatric Endocrinology, Hospital for Sick Children Edinburgh
Krystyna Matyka	Consultant Paediatrician, Warwick
Ken Ong	MRC group leader in paediatric epidemiology, and Consultant Paediatric Endocrinologist at Addenbrooke's Hospital.
Edna Roche	Senior Lecturer in Paediatric Endocrinology, Trinity College Dublin
Mary Rudolf	Professor of Child Health, Leeds
Julian Shield	Reader in Diabetes & Metabolic Endocrinology, University of Bristol & Bristol Royal Hospital for Children
Jerry Wales	Senior Lecturer in Paediatric Endocrinology, Sheffield Children's Hospital

Reference List

(1) National Institute for Health and Clinical Excellence. Obesity: guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children. NICE Clinical Guideline 43; December 2006. 2006.
Ref Type: Report

(2) Barlow SE, Dietz WH. Obesity Evaluation and Treatment: Expert Committee Recommendations. Pediatrics 1998; 102:e29.

(3) Gibson P, Edmunds L, Haslam DW, Poskitt E. An approach to weight management in children and adolescents (2-18 years) in Primary Care. London: Royal College of Paediatrics; 2002.

(4) McCarthy HD, Ellis SM, Cole TJ. Central overweight and obesity in British youth aged 11-16 years: cross sectional surveys of waist circumference. BMJ 2003; 326(7390):624.

(5) Rudolf MC, Walker J, Cole TJ. What is the best way to measure waist circumference? Int J Pediatr Obes 2007; 2(1):58-61.

(6) The Rotterdam ESHRE/ASRM-sponsored PCOS consensus workshop group. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome (PCOS). Human Reproduction 2004; 19(1):41-47.

(7) Muzumdar H, Arens R. Diagnostic issues in pediatric obstructive sleep apnea. Proc Am Thorac Soc 2008; 5(2):263-273.

(8) Chervin RD, Hedger K, Dillon JE, Pituch KJ. Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. Sleep Med 2000; 1(1):21-32.

(9) Spilsbury JC, Drotar D, Rosen CL, Redline S. The Cleveland adolescent sleepiness questionnaire: a new measure to assess excessive daytime sleepiness in adolescents. J Clin Sleep Med 2007; 3(6):603-612.

(10) National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics 2004; 114(2):555-576.

(11) Morrison JA, Friedman LA, Gray-McGuire C. Metabolic syndrome in childhood predicts adult cardiovascular disease 25 years later: the Princeton Lipid Research Clinics Follow-up Study. Pediatrics 2007; 120(2):340-345.