Physical Examination Findings Among Children and Adolescents With Obesity: An Evidence-Based Review

Sarah Armstrong, MD,^a Suzanne Lazorick, MD, MPH,^b Sarah Hampl, MD,^c Joseph A. Skelton, MD, MS,^d Charles Wood, MD, MPH,^e David Collier, MD, PhD,^b Eliana M. Perrin, MD, MPH^e

abstract

Overweight and obesity affects 1 in 3 US children and adolescents. Clinical recommendations have largely focused on screening guidelines and counseling strategies. However, the physical examination of the child or adolescent with obesity can provide the clinician with additional information to guide management decisions. This expert-based review focuses on physical examination findings specific to children and adolescents with obesity. For each physical examination element, the authors define the finding and its prevalence among pediatric patients with obesity, discuss the importance and relevance of the finding, describe known techniques to assess severity, and review evidence regarding the need for additional evaluation. The recommendations presented represent a comprehensive review of current evidence as well as expert opinion. The goal of this review is to highlight the importance of conducting a targeted physical examination during pediatric weight management visits.

BACKGROUND

Despite recent declines in the prevalence of obesity in certain populations, the overall number of children and adolescents affected by obesity is 17%, or 12.7 million nationally. The clinical care of children and adolescents with obesity is challenging. Current clinical recommendations encourage clinicians to discuss weight status in a sensitive, nonjudgmental manner, assess lifestyle habits, provide patient-centered counseling to facilitate change, and identify chronic health conditions; the physical examination has received limited attention.

A comprehensive understanding of physical examination findings associated with obesity can aid the clinician in several ways. First, many findings can be quantified, helping the clinician triage further evaluation and management. Second, explaining

physical findings may raise parent awareness of the consequences of obesity. Finally, longitudinal tracking of findings can help the clinician monitor response to treatment.

METHODS

The authors include clinical and research faculty specializing in childhood obesity. Authors identified and prioritized the key physical examination findings collectively, then performed a literature search from 1975 to present using 2 databases (PubMed and Cochrane) and structured MESH search terms ("condition"[tiab] AND "obesity" AND ["clinical exam" OR "exam findings"] limited to studies published in English, and age 0 to 18 years. The strength of the evidence was low. Most published data are observational and thus associative rather than predictive.

^aDuke University Medical Center, Durham, North Carolina; ^bEast Carolina University, Greenville, North Carolina; ^cChildren's Mercy Hospital and Center for Children's Healthy Lifestyles and Nutrition, Kansas City, Missouri; ^dWake Forest School of Medicine, Winston-Salem, North Carolina; and ^eUniversity of North Carolina at Chapel Hill School of Medicine, Chapel Hill, North Carolina

Drs Armstrong conceptualized the review, designed the review criteria and section headings, conducted the literature search and literature review, drafted portions of the manuscript, revised the manuscript, reviewed references for accuracy, and contributed critical review of content and structure; Dr Skelton conceptualized the review, conducted the literature search and literature review, drafted portions of the manuscript, and revised the manuscript; Dr Perrin conceptualized the review, conducted the literature search and literature review, drafted portions of the manuscript, revised the manuscript, and contributed resources for administrative help;

To cite: Armstrong S, Lazorick S, Hampl S, et al. Physical Examination Findings Among Children and Adolescents With Obesity: An Evidence-Based Review. *Pediatrics*. 2016;137(2):e20151766

The resultant expert-based review summary does not aim to provide screening recommendations but rather to alert the clinician to the presence of physical findings and to provide a framework for managing identified conditions. The authors have purposefully chosen physical examination findings that are most prevalent and are most likely to affect clinical decision-making. A summary is provided in Table 1.

VITAL SIGNS

Hypertension

Normal systolic (SBP) and diastolic (DBP) blood pressure is defined as <95th percentile for the child's age, gender, and height percentile.¹ Stage 1 hypertension (HTN) is SBP and/or DBP $\geq$ 95th percentile but <99th percentile+5 mm Hg; Stage 2 HTN is SBP and/or DBP $>$ 99th percentile +5 mm Hg. It is important to measure BP by auscultation with a cuff that covers $\geq$ 80% of the midarm circumference; a smaller cuff can result in artificially high readings.¹ Ambulatory BP monitoring demonstrates that daytime SBP, DBP, and mean arterial BP increase significantly with increasing BMI.²⁵ Although the pathophysiology of HTN in children with obesity is not fully understood,²⁶ hyperinsulinemia, adipokine activation, perinephric fat effects on the kidney and cytokine action on the vascular endothelium, and cortisol and nitric oxide levels are contributory.^{27–29}

Diagnosing and managing HTN quickly and effectively may affect long-term morbidity. Increased BMI in childhood predicts arterial stiffening in adulthood, and that effect is mediated by the presence or absence of HTN.³⁰ Early management may prevent renal complications; albuminuria³¹ and end-stage renal disease³² are more common in patients with obesity and HTN compared with obesity alone.

The evaluation of a child with obesity and HTN (confirmed by averaging three readings during the same encounter) should include a urinalysis, blood creatinine, and a renal and cardiac ultrasound.³³ Almost half of children with high BP demonstrate left ventricular hypertrophy (LVH) by echocardiogram; children with higher BMI z scores are 3 times more likely to demonstrate LVH than healthy-weight peers.^{34,35} The presence of LVH indicates more severe or long-standing disease and should prompt the clinician to manage BP aggressively.³³ Weight loss is the primary recommended treatment of youth with obesity and HTN and may be aided by the use of a Cardiovascular Health Integrated Lifestyle Diet (CHILD-1) diet.³³ Pharmacologic treatment is recommended for children with stage 2 HTN, LVH, or stage 1 HTN persisting for $>$ 6 months.³³

Elevated Resting Heart Rate

Tachycardia is commonly defined as a heart rate (HR) $>$ 140 beats/minute for children and $>$ 100 beats/minute for adolescents.³⁶ Resting HR increases with higher BMI^{37,38} because of impaired autonomic nervous system function with increased sympathetic tone and decreased β -adrenergic responsiveness.^{38,39} Routine HR surveillance is recommended because tachycardia may predict later development of HTN in children.¹⁵ Although the long-term complications of high resting HR among children are unknown, tachycardia among adults is a strong predictor of excessive cardiovascular mortality and is associated with other risk factors, including HTN, elevated blood glucose, hyperinsulinemia, and lipid abnormalities.⁴⁰

Changes in Height Velocity

Between ages 2 to 8, each 1 unit of BMI increase is related to a modest

increase in height (+0.23 cm in boys and +0.29 cm in girls). In addition, children who develop obesity early in life demonstrate an earlier onset of peak height velocity, $\sim$ 1.5 months earlier per BMI unit increase.⁴¹ At this time of peak height velocity, precocious puberty may emerge, leading to significant slowing of height growth between ages 8 and 18. Overall, this results in net shorter adult height for children who develop obesity before the onset of puberty (4.79 and 3.08 cm for boys and girls, respectively).⁴¹ The clinician should carefully monitor height velocity and correlate with pubertal staging.

HEAD, EYE, EAR, NOSE, AND THROAT EXAMINATION

Papilledema

An uncommon but concerning complication of obesity is pseudotumor cerebri, or idiopathic intracranial hypertension (IIH). Among adolescents, IIH presents most commonly in an adolescent female with obesity who complains of morning headache, headache with Valsalva, and nausea and vomiting. On examination, the patient may demonstrate blurred/decreased vision or diplopia, facial nerve palsies, pulsatile tinnitus, ataxia, dizziness, and upper back musculoskeletal pain.⁴² Although papilledema is present in only 50% of patients with IIH and elevated intracranial pressure,⁴³ it may be the only presenting sign/symptom of IIH in children.⁴⁴ Papilledema refers to swelling of the optic disc secondary to increased intracranial pressure. The Frisén Scale is used to score the severity of papilledema (Fig 1). A patient with an abnormal fundoscopic examination should be referred urgently to an ophthalmologist. A lumbar puncture can be safely performed on a conscious patient with no focal neurologic findings and normal brain

TABLE 1 Summary of Recommendations

	Physical Examination Finding	Definition	Other Causes/Differential
Vital signs	Hypertension	SBP or DBP $\geq$ 95th percentile on at least 3 readings ¹	Numerous, including essential, stress-induced, renal parenchymal or vascular disease, cardiovascular disorders, obstructive sleep apnea syndrome, substance abuse or medication side effect, pheochromocytoma, anemia, hyperthyroidism, Cushing syndrome, Williams syndrome, Turner syndrome ²
	Increased HR		Numerous, including fever, anemia, drugs, anxiety, pain, arrhythmia, myocarditis, substrate deficiency, hypovolemic shock, sepsis, anaphylaxis, toxic exposure, hyperthyroidism, Kawasaki disease, acute rheumatic fever, pheochromocytoma ³
Anthropometric	Changes in height velocity	Early height velocity increase	True pattern characteristic of obesity, but early height increases can also be: familial tall stature, precocious puberty, gigantism, pituitary gland tumor
		Earlier onset of peak height velocity	Slowing of height can be due to medications, inflammatory bowel disease, hypothyroidism, hypercortisolism, dysplastic or genetic syndrome, constitutional delay, growth hormone deficiency ⁴
HEENT	Papilledema	Slowing of height age 8–18 y Swelling of the optic disc secondary to increased intracranial pressure (Frisen scale)	Intracranial mass lesion, hydrocephalus, cerebral venous thrombosis, medications, autoimmune disorders, anemia, and cranial venous outflow abnormalities ⁵
	Dental caries	White, brown, or black spots (noncavitory) or eroded areas of enamel or dentin (cavitory)	Developmental disease of the tooth and gum, trauma, infection
	Tonsillar hypertrophy	Tonsils occupy at least 50% of the oropharynx (Brodsky classification 3+ and 4+).	Infectious causes, lodged foreign body
Chest	Gynecomastia	>2 cm of breast tissue in boys or men ⁶	Hyperaromatase syndrome ⁷ ; hypogonadism, hyperprolactinemia, chronic liver disease, and medications, particularly H2 antagonists ⁸
	Cervicodorsal hump	Fibrous fatty tissue over the upper back and lower neck	Endogenous (Cushing syndrome) or exogenous corticosteroid exposure, adrenal carcinoma, adrenal adenoma; HIV with secondary hyperinsulinemia ⁹
Gastrointestinal	Liver enlargement (hepatomegaly)	Liver span >5 cm in 5-y-olds and 15 cm in adults or liver edge palpable below the right costal margin by >3.5 cm in adults or >2 cm in children ^{10,11}	Multiple, including hepatitis, storage disorders, infiltrative, impaired outflow, and biliary tract disorders
Genitourinary	Buried penis	Suprapubic fat accumulation leading to the appearance of a shortened penile shaft	Trapped penis, webbed penis, and micropenis ¹²
Musculoskeletal	Gait	Collapse into hip (“waddle”) or Trendelenberg-like gait	Arthritis, Blount disease, SCFE
	Scoliosis	Lateral curvature of the spine >10 degrees on examination, 20 degrees on radiography	Infantile idiopathic scoliosis, juvenile idiopathic scoliosis, congenital vertebral anomaly, syndromic spinal deformity ¹³
	Lordosis	Trunk sway associated with postural adaptations	Spondylolisthesis, achondroplasia, muscular dystrophy, other genetic conditions
	SCFE	Knee or hip pain, subacute onset, pain with external rotation of hip	Multiple problems present with chronic hip, knee, or thigh pain including growing pains, femoral neck fracture, groin injury, Perthes disease, osteonecrosis associated with systemic disease, juvenile idiopathic arthritis, reactive arthritis, overuse injuries, chondrolysis, tumors, osteitis pubis ¹⁴
	Genu varum/valgum	Genu varum (bow legs)	Tibia vara (Blount disease), rickets, skeletal dysplasia, celiac sprue ¹⁵
		Genu valgum (knock-kneed)	Physiologic in children under 6 y; in older children and adolescents, consider postaxial limb deficiency, neoplasms, genetic and metabolic disorders, neurofibromatosis, and vitamin D-resistant rickets ¹⁵
	Pes planus	Rigid vs flexible, sometimes with pain	Posterior tibial tendon insufficiency, tarsal coalition, congenital vertical talus, rheumatoid arthritis, trauma, neuropathy ¹⁶
Skin	Acanthosis	AN is thickened and darker skin, occasionally pruritic, at nape of the neck (99%), axillae (73%), and less commonly, groin, eyelids, dorsal hands, and other areas exposed to friction ^{17,18}	Medication side effect, ¹⁸ and uncommonly, visceral malignancy. ¹⁹

TABLE 1 Continued

Physical Examination Finding	Definition	Other Causes/Differential
Hirsutism/acne	Burke scale to quantify ²⁰ PCOS is based on Rotterdam Consensus, requiring 2 of: clinical evidence of hyperandrogenism (acne, hirsutism, male-pattern alopecia), ovulatory dysfunction (chronic anovulation/irregular menses), and polycystic ovaries ²¹	Hirsutism: familial, Cushing syndrome, thyroid disorders
Striae	Linear, usually symmetrical smooth bands of atrophic skin that initially appear erythematous, progressing to purple then white; perpendicular to the direction of greatest tension in areas with adipose tissue ²²	Acne: physiologic, folliculitis, rosacea Pregnancy, Cushing syndrome, and topical corticosteroid use
Intertrigo	Macerated, erythematous plaques in skin folds ²³	Inflammatory diseases, metabolic disorders, malignancies (rare in pediatrics), and various infections by site
Pannus	Excess skin and subcutaneous fat below the umbilicus. ²⁴	Pregnancy, malignancy

HEENT, head, eye, ear, nose, and throat examination.

imaging, even in the presence of papilledema.⁴⁵

Dental Caries

Obesity and dental caries are strongly correlated,^{47,48} especially for permanent dentition.⁴⁸ This relationship is stronger with increasing age and lower socioeconomic status.⁴⁸ Children with obesity have decreased salivary flow rate,⁴⁹ lower concentrations of salivary phosphate, lower salivary peroxidase activity and higher concentrations of free sialic acid and proteins, all of which predispose to caries.⁵⁰ Children with Prader-Willi syndrome are at highest risk.^{51,52} In addition, children with obesity have more erupted teeth^{53,54} and their teeth erupt earlier⁵³ than children with healthy weight. Altered timing of tooth eruption can lead to malpositioned teeth and/or tooth crowding, which makes good oral hygiene difficult to maintain.⁵³ The dental examination should include careful inspection of all tooth surfaces for white, brown, or black

discolorations (noncavitated caries) and for erosions in the enamel or dentin (cavitated caries). Counseling to promote good oral hygiene should include limitations on sticky foods, sugary beverages and diet beverages containing citric acid. Children with caries should be referred for dental evaluation and treatment.

Wide Neck and Adenotonsillar Hypertrophy

In adults, large neck circumference (as measured just above the cricothyroid cartilage) is associated with cardiometabolic risk and obstructive sleep apnea (OSA).^{55–57} Among children, neck circumference is correlated with blood pressure, lipids, and insulin,⁵⁸ but not OSA.⁵⁹ Neck circumference measurement is of limited clinical value and not routinely recommended.

The presence of tonsillar hypertrophy does not increase the likelihood that a child with obesity has OSA but does predict severity.^{60,61} Obese children with tonsillar hypertrophy are more

likely to have noisy breathing, restless sleep, behavior difficulties, snoring, and daytime sleepiness.⁶² Tonsillar hypertrophy is considered significant when tonsils occupy at least 50% of the oropharynx (Brodsky classification 3+ and 4+, Table 2). The physical examination of the child with obesity should routinely include a quantification of tonsillar size. A Brodsky score of ≥ 3 should prompt evaluation for signs and symptoms consistent with OSA and, if positive, referral for overnight polysomnography.

CHEST AND BACK

Gynecomastia

Gynecomastia, defined as >2 cm of breast tissue in boys or men,⁶ is found in up to 40% of adolescent boys with obesity due to peripheral conversion of testosterone to estradiol in adipocytes.⁸ Gynecomastia is not limited to boys with obesity but increases with increasing body weight.⁶ Gynecomastia is typically bilateral

TABLE 2 Brodsky Classification of Tonsil Size

Grade	Finding
0	Tonsils in fossa or removed
1+	<25% oropharynx occupied
2+	25%–50% oropharynx occupied
3+	50%–75% oropharynx occupied
4+	>75% oropharynx occupied

(but can be unilateral), is correlated with increasing amount of body hair, and is associated with early sexual maturation.⁶

Gynecomastia is uncommon in prepubertal boys and when present should be evaluated to rule out underlying pathology such as hyperaromatase syndrome.⁷ Less common causes of gynecomastia include hypogonadism, hyperprolactinemia, chronic liver disease, and medications, particularly H2 antagonists.⁸ Breast cancer is rare among male children and adolescents. Klinefelter syndrome 47, XXY is the most common genetic cause of gynecomastia.⁶³

Most cases of gynecomastia can be managed with reassurance and may improve with BMI reduction. However, gynecomastia that persists past age 18 or is associated with significant obesity is less likely to resolve. Surgical correction is an available treatment option for cases that do not resolve by adulthood or for reasons of psychosocial stress.⁶⁴ Although patients with obesity typically require more extensive reconstruction, there is no difference in complications or patient satisfaction postoperatively compared with healthy-weight patients; thus, obesity should not be considered a contraindication to surgery.⁶⁵

Cervicodorsal Hump

Cervicodorsal hump (“buffalo hump”) is a well-defined clinical finding in patients with excess endogenous (Cushing syndrome) or

FIGURE 1

Frisén Graded Scale of papilledema. Fundus photographs representative of each Modified Frisén Scale grade.^{46,155} A, Grade 0: normal optic disc. B, Grade 1: C-shaped halo with a temporal gap. C) Grade 2: circumferential halo. D, Grade 3: obscuration of multiple major vessels as they exit the optic disc (arrows). E, Grade 4: obscuration of major vessels on the optic disc. F, Grade 5: complete obscuration of one major vessel and at least partial obscuration of the rest. (Photographs and descriptions kindly provided by Michael Wall, MD, Department of Ophthalmology and Visual Sciences, Carver School of Medicine, University of Iowa.)⁴⁶

exogenous corticosteroid exposure, and secondary hyperinsulinemia.⁹ It appears as a soft mound of tissue at the posterior nape of the neck. Although it can be a physical nuisance, it is generally a benign clinical finding. This localized adiposity is found in the majority of adults with obesity, regardless of comorbid conditions. Cervicodorsal hump occurs in children with obesity with no laboratory abnormalities.⁶⁶

This finding, in the absence of other clinical signs of steroid excess, should not prompt the clinician to conduct further investigation.

GASTROINTESTINAL

Right Upper Quadrant Pain and Hepatomegaly

Right upper quadrant pain and/or hepatomegaly may help identify

children with nonalcoholic fatty liver disease (NAFLD). NAFLD is a spectrum of disease from fatty infiltration, inflammation, nonalcoholic steatohepatitis, cirrhosis, and end-stage liver failure. NAFLD is present in 13% of the general pediatric population⁶⁷ but in >50% of adolescents who are overweight or obese. It is more common among boys and those of Hispanic ethnicity.⁶⁸

No physical examination finding is diagnostic for NAFLD; liver biopsy is the gold standard. However, among children with biopsy-diagnosed NAFLD, abdominal pain is the most common symptom (46%), followed by hepatomegaly (27%).⁶⁹ Right upper quadrant pain consistent with biliary colic should suggest cholelithiasis, also associated with obesity.⁷⁰

Hepatomegaly is defined as a liver span greater than age norms (5 cm in 5-year-olds and 15 cm in adults) or liver edge palpable below the right costal margin by >3.5 cm in adults or >2 cm in children.¹⁰ The difficulty of detecting hepatomegaly in patients with obesity, even by trained hepatologists, limits the identification of children with NAFLD.^{71,72} The “scratch” test may help identify the liver edge when palpation is difficult due to body habitus (Fig 2) but does not correlate well with liver span as measured by ultrasound, and discrepancies increase with increasing BMI.⁷³

Any symptoms of abdominal pain or the finding of hepatomegaly should prompt an evaluation, including measurement of transaminases and consideration of liver ultrasound or referral to a pediatric hepatologist where available.⁷⁴

GENITOURINARY

Inconspicuous Penis

Inconspicuous penis (“buried penis” or “hidden penis”) is the

FIGURE 2

Scratch test for hepatomegaly. Photographs courtesy of Joseph Skelton (coauthor).

result of an enlarged suprapubic fat pad that conceals a normally developed, normally sized penis. This should be distinguished from webbed penis (scrotal skin extends ventrally along penile shaft) and trapped penis (shaft is bound in scar tissue), which require surgical evaluation. Micropenis is penile length is <2.5 SD; this is likely related to underlying endocrine abnormalities and appears in infancy or early childhood. Inconspicuous penis presents in early childhood, as the suprapubic fat accumulates and leads to the appearance of a shortened penile shaft. Although there is no underlying penile abnormality, the fat pad may obstruct the urinary outlet, causing recurrent urinary tract infections, balanitis, and eventually penile adhesions.⁷⁵ Treatment should focus on hygiene and regular voiding. For patients with significant complications or quality-of-life impairment as a result of inconspicuous penis, surgical options may be considered.^{12,75–77}

MUSCULOSKELETAL

Gait

It is widely believed that children with obesity adapt their gait to accommodate increased mass.^{78,79} Kinematic studies show that, while walking, children with obesity collapse into hip adduction on the

weight-bearing side (“waddle” or Trendelenburg-like gait) and apply more genu valgum stresses. This gait increases the risk for knee pain and osteoarthritis.⁸⁰ Gait evaluation is a clinical tool to assess for the musculoskeletal conditions described later, and physical therapy evaluation should be considered when pain or abnormalities are present.

Scoliosis

Children with obesity have a similar prevalence of scoliosis to their healthy-weight peers.^{79,81} Scoliosis is a lateral curvature of the spine >10 degrees; most cases are idiopathic.⁸² Clinical examination includes evaluation of symmetry of shoulders and hips, and the Adam’s forward bending test. Posterior-anterior and lateral radiography provides measurement of Cobb angles. A Cobb angle >20 degrees is considered abnormal. Among adolescents, higher BMIs are protective against the development of scoliosis; however, the cases that do occur tend to be more severe with greater curvature of the spine,⁸¹ curve progression, less successful results with bracing (orthotics),⁸³ and increased perioperative complications.⁸⁴ Scoliosis may be more difficult to assess accurately in children with obesity; the clinician should quantify the degree of curvature with imaging and consider early

referral for orthotic management as indicated. Of note, as long as pain is not a factor, scoliosis should not limit physical activity.⁸⁵

Lordosis

Postural adaptations that occur in the developing spine in response to high body weight are also associated with low back pain. Lordosis, or excessive inward curvature of the spine, is common among adolescents with high BMI and a cause of low back pain. In photos of sagittal spine posture, adolescents with obesity have greater hyperlordotic posture and “trunk-sway.”^{79,86} Physical therapy may improve posture to delay or avoid chronic low-back pain.

Slipped Capital Femoral Epiphysis

Slipped capital femoral epiphysis (SCFE) is a condition in which the proximal femoral metaphysis separates from the epiphysis of the femoral head.⁸⁷ SCFE is the most common hip disorder of adolescence with a prevalence of 10.8 cases per 100 000 children. It is most common during early adolescence when children are growing rapidly.^{88,89} Although the exact cause is unknown, several risk factors have been identified, including obesity, femoral retroversion, and hormonal disorders (hormone deficiency, hypothyroidism, low testosterone).⁹⁰ Patients with SCFE present with chronic knee, hip, or thigh pain, or a limp. Rarely, it is noted after an acute traumatic episode.⁸⁷ SCFE is strongly correlated with high BMI, male gender, and early adolescence. The average age at occurrence (12–14 years) decreases with increasing obesity.^{79,91} Children with high BMIs are more likely to have bilateral SCFE. In a study of children with SCFE, 20% of children had bilateral disease, and every child with a BMI >35 eventually progressed to bilateral disease.⁹² SCFE is among the most commonly

missed diagnoses in children, with an average delay in diagnosis of 6 months.⁹⁰ Complications of a progressing slip include avascular necrosis, chondrolysis, and osteoarthritis; early diagnosis and treatment is critical.^{88,93} Diagnosis is suggested by acute or subacute onset of hip or knee pain in a child with obesity. The examination reveals pain with external rotation of the hip, and diagnosis is confirmed by bilateral hip radiography, which should include anteroposterior and frog-leg or cross-table lateral views. The patient should be made non-weight bearing to prevent progression to a more severe slip and referred for urgent orthopedic evaluation.⁹⁴ Treatment of SCFE is in situ placement of a cannulated screw across the physis under direct fluoroscopic guidance.⁹⁵ Prophylactic pinning of the contralateral hip should be considered in patients who are at a high risk for bilateral SCFE.⁹⁶

Genu Valgum/Varum

Genu valgum is more common among children with obesity than healthy-weight peers (55% vs 2%, respectively),⁹⁷ and adolescents with obesity tend to maintain abnormal genu valgus alignment of knees. Prolonged valgus is associated with lower activity levels; although whether this is secondary to pain, balance, endurance, or a combination is unknown.^{97,98} Genu valgum increases stress on the lateral knee, increasing risk for osteoarthritis.⁹⁹ Adolescent females with obesity are at risk for a rapidly progressive form of genu valgum.¹⁰⁰

A tibio-femoral angle (“Q angle”) >15 degrees on examination is abnormal (Fig 3). The intermalleolar distance is unreliable because thigh mass influences the intermalleolar distance. A weight-bearing anterior-posterior radiograph provides an accurate measure

FIGURE 3

Measurement of tibio-femoral angle (Q-angle). Photograph from PhysioPedia (http://www.physio-pedia.com/%27Q%27_Angle). Accessed February 21, 2015.

of the tibio-femoral angle and screens for skeletal dysplasias (hypophosphatemic rickets, multiple epiphyseal dysplasia, pseudoachondroplasia).¹⁰¹ Patients with Q-angle greater than 15 degrees, hip drop, pain, or imbalance should be referred to orthopedics for evaluation. Surgical correction of valgus can prevent progression in severe cases.

Pes Planus

Pes planus, or “flatfoot,” is common among children with obesity and may cause pain in the feet and lower legs,¹⁰² particularly after long walks or exercise.^{103,104} In cross-sectional studies^{105–116} prevalence ranges from 14% to 67% and increases with weight. Clinicians should distinguish between flexible and rigid pes planus.¹¹⁷ Rigid pes planus is present when standing (weight-bearing) and sitting (non-weight bearing) and is commonly indicative of underlying pathology. Flexible pes planus is present with standing (weight bearing) only, and is more

AN Stage	Photo Example of AN Stage	
1		Clearly present on close visual inspection. Not visible to the casual observer. Extent not measurable.
2		Mild. Limited to the base of the skull, does not extend to lateral margins of the neck. (<3 inches in breadth)
3		Moderate. Extending to the lateral margins of the neck (posterior border of the sternocleidomastoid (usually 3-6 inches), should not be visible when client viewed from the front.
4		Severe. Extending anteriorly (>6 inches), visible when client viewed from the front.

FIGURE 4
Burke Scale for AN quantification.²⁰

common and usually asymptomatic. Clinicians should investigate age of onset, family history, associated medical conditions, associated symptoms, trauma history, activity level, and any previous treatment.¹¹⁷ Pain may be reported in the medial foot, leg, or knee. Treatment includes orthotics, nonsteroidal antiinflammatory medications, and stretching.¹¹⁸ Children with rigid pes planus or any pes planus that

does not improve with conservative management should be referred to an orthopedist, podiatrist, or physical therapist.

SKIN

Acanthosis Nigricans

Acanthosis nigricans (AN) is thickened and dark skin, occasionally pruritic, at the nape of

the neck (99%), axillae (73%), and less commonly, groin, eyelids, dorsal hands, and other areas exposed to friction.^{17,18} "Acanthosis" refers to thickening of the superficial epithelium and not excess melanin as is commonly believed.¹⁸ The proposed biochemical mechanism involves local¹⁷ cutaneous and circulating¹¹⁹ growth factors.

The differential diagnosis includes medication side effects (glucocorticoids, niacin, insulin, oral contraceptives, or protease inhibitors¹⁸) and, uncommonly, visceral malignancy.¹⁹ However, among children with obesity, AN is strongly predictive of insulin resistance,¹²⁰⁻¹²² particularly among Native American, African American, and Hispanic children,¹²³ adolescents, and those with positive family history for type 2 diabetes mellitus.^{17,122,124-127} Clinicians can quantify the severity of AN using the Burke scale (Fig 4), which is a reliable and reproducible grading system but does not correlate directly with severity of insulin resistance or predict type 2 diabetes.¹²⁸ The presence of warts or skin tags within AN represents more severe disease.¹²⁹

The American Diabetes Association and the American Academy of Pediatrics recommend that children aged ≥ 10 with BMI ≥ 85 th percentile with ≥ 2 risk factors (BMI ≥ 95 th percentile, African American/Hispanic/Native American/Asian American/Pacific Islander, positive family history) should be screened every other year for diabetes using a fasting glucose or a 2-hour oral glucose tolerance test.¹³⁰

Acanthosis improves with BMI reduction. Tretinoin 0.1% gel, either alone or in combination with 12% ammonium lactate cream, may reduce AN severity. Among adolescents, metformin 500 mg 3 times daily may also lead to decreased severity rating.¹³¹

Hirsutism and Acne

Hirsutism and/or acne in an obese female adolescent may represent polycystic ovarian syndrome (PCOS). PCOS affects 4% to 12% of reproductive-age women and increases the risk of developing type 2 diabetes mellitus by three- to sevenfold.¹³² The revised clinical diagnosis of PCOS is based on the Rotterdam Consensus and requires 2 of the following: clinical evidence of hyperandrogenism (acne, hirsutism, male-pattern alopecia), ovulatory dysfunction (chronic anovulation/irregular menses), and polycystic ovaries.²¹ The odds of developing PCOS are 3 times higher for girls who are overweight, 6 times for girls who are obese, and 15 times for those who are severely obese.¹³² Adolescents are more likely than older women to present with hirsutism and more likely to have associated insulin resistance.^{133,134} The diagnosis is clinical and is supported by elevated free testosterone. The treatment of PCOS includes oral hormonal contraceptives and metformin, and referral to a pediatric endocrinologist where available is indicated.¹³⁵ Hirsutism may also be treated with spironolactone at a starting dose of 25 mg twice daily; potassium levels and blood pressure should be measured at baseline and monitored regularly. Acne, as part of PCOS, is likely to respond to oral hormonal therapy alone or in combination with topical treatments.

Striae

Striae (“stretch marks”) are linear, smooth bands of atrophic skin that initially appear erythematous, progressing to purple then white. They appear in lines perpendicular to the direction of greatest tension, lack hair follicles, and are generally symmetrical and bilateral.²² Striae are on multiple sites in 40% of patients,¹³⁶ most commonly on thighs (73%), arms (42%), and abdomen (30%) and less frequently on back, buttocks, and knees. Although their exact pathogenesis

is not completely understood, mechanical, hormonal, and genetic factors are implicated.²³

Striae are present in 40% of children with obesity,^{23,136} increasing with age and longer duration of obesity. The differential includes pregnancy, Cushing syndrome, and topical corticosteroid use. Striae secondary to exogenous obesity are lighter, narrower, and less atrophic than in those with Cushing syndrome.²³ Although Cushing syndrome is rare, clinicians should consider it among patients with short stature, obesity, striae, and HTN.¹³⁷ Treatment options for striae include topical tretinoin and laser treatment, which may decrease erythema; however, most treatments are not effective.²²

Intertrigo

Intertrigo refers to macerated, erythematous plaques that develop in genitocrural, abdominal, axillary, and inframamillary folds as the result of friction and moisture.²³ Obesity alters skin physiology, increasing the rate of transepidermal water loss¹³⁸ and raising the skin's pH.¹³⁹ These changes increase skin moisture and decrease resistance to colonization with *Candida albicans*. Symptoms of intertrigo include itching and burning. Physical findings may include scaling erythema with macules, papules, or pustules. Satellite lesions suggest candidiasis, and foul odor suggests bacterial superinfection. Clinicians should examine skin folds closely, particularly in adolescents with severe obesity. Intertrigo can be prevented by good skin hygiene and drying powders. Treatment includes topical antifungals or antibacterials.

Pannus

Pannus (or “panniculus”), refers to excess skin and subcutaneous fat below the umbilicus.²⁴ The

panniculus can become symptomatic when it folds over the waistline, or when it develops intertrigo.²⁴ The panniculus is a high-risk area for severe intertrigo, candidal or bacterial infections, folliculitis, abscesses, and gangrene.¹⁴⁰ Patients may not disclose pain or discomfort from panniculus because of embarrassment or shame. Clinicians can provide counseling regarding comfortable waistbands and hygienic (drying) measures.

PSYCHIATRIC

Flat Affect

Psychological complications are common among children with obesity who are seeking treatment.^{141,142} Nearly 40% of children with morbid obesity being evaluated for bariatric surgery report clinically significant symptoms of depression,¹⁴³ as do 11% to 34% of youth seeking traditional weight management treatment.¹⁴⁴ Adolescent girls with obesity are at increased risk for depression (55% vs 42%).¹⁴⁵ Adolescents who experience weight-related teasing are twice as likely to report depressive symptoms than those who were not teased.¹⁴⁶ The association is bidirectional; adolescents with depression are also more likely to have obesity.¹⁴⁷ Depression in childhood is associated with obesity in adulthood.¹⁴⁸

Depression impairs patients' ability to implement behavior change and medical recommendations¹⁴⁹ and is associated with higher rates of attrition from pediatric weight management programs.¹⁵⁰ Recommended primary care screening methods¹⁵¹ include the 9-item Patient Health Questionnaire—9¹⁵² and the 2-item Patient Health Questionnaire—2¹⁵³ for adolescents and the internalizing subscale items of the Pediatric Symptom Checklist for younger children.¹⁵⁴ Positive screens should

trigger referral to a mental health specialist for management.¹⁵¹

SUMMARY

The clinician is a critical part of the treatment of obesity among children and adolescents. Providers are encouraged to screen for obesity using the BMI, discuss weight status with parents and children, and offer dietary and activity counseling. A comprehensive and targeted physical examination will aid the clinician in assessing severity and need for further evaluation or treatment of comorbid conditions. Physical examination findings will guide the

clinician to detect and treat health conditions that may otherwise lead to future disability and inactivity, will provide a non-invasive mechanism to follow progression of weight-related co-morbidities, and will help to engage families in understanding effects of excess weight on their child's health.

ACKNOWLEDGMENTS

Amanda Kimburg, MS3 and Adam Van Mason, MD contributed to the literature review and initial drafting of portions of the manuscript. Janna Howard, BS, contributed to reference organization and formatting.

ABBREVIATIONS

AN: acanthosis nigricans
BP: blood pressure
DBP: diastolic blood pressure
HR: heart rate
HTN: hypertension
IIH: idiopathic intracranial hypertension
LVH: left ventricular hypertrophy
NAFLD: nonalcoholic fatty liver disease
OSA: obstructive sleep apnea
PCOS: polycystic ovarian syndrome
SCFE: slipped capital femoral epiphysis
SBP: systolic blood pressure
T2D: type 2 diabetes

Drs Hampl, Lazorik, Collier, and Wood conducted the literature search and literature review, drafted portions of the manuscript, and revised the manuscript; and all authors approved the final manuscript as submitted.

DOI: 10.1542/peds.2015-1766

Accepted for publication Aug 5, 2015

Address correspondence to Sarah Armstrong, MD, 4020 North Roxboro St, Durham NC 27704. E-mail: sarah.c.armstrong@duke.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: Dr Hampl is a consultant for SIMmersion. The other authors have indicated they have no potential conflicts of interest to disclose.

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Pediatrics 2016;137;

DOI: 10.1542/peds.2015-1766 originally published online January 27, 2016;

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