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MEASUREMENT MATTERS

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Obesity prevention and treatment strategies that lead to sustained benefits for pediatric patients remain elusive (1–4). The authors of the AMA Expert Committee Recommendations emphasized the lack of a solid clinical evidence base for Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity (5). Most clinical studies are too small to have adequate power to detect differences in treatment and vary in description of participants, interventions, and outcomes (1–4). A recurring observation has been the lack of standardized estimates of fatness and change in fatness so that our capacity for comparison or meta-analysis is limited (1). Consistent characterization of study participants' phenotypes has the potential to identify predictors of response to specific interventions and markers to follow clinical progress. Obesity is a complex trait, but standardized and easily obtained estimates of total and regional fatness seem a fundamental place to start.

An elevated body mass index (BMI, kg/m²) for age, indicating total body adiposity, is now the generally recognized screening test for obesity in children and adolescents (5), although how best to track change in BMI as an outcome is still being debated. For regional fatness, waist circumference (WC), a surrogate marker circumscribing both subcutaneous abdominal and visceral fat and with clinical implications because of its association with metabolic consequences (6,7), looks promising, but its wide-spread acceptance and use has been held up for the most basic of reasons. There is no agreement about where it should be measured (measurement site), when it is important to measure WC (screening in all BMI ranges or to establish obesity phenotype), and what it means (no evidence-based reference or accepted centile cut-off, should it be part of a ratio or a stand-alone). There are multiple published pediatric WC for-age percentiles, each using different measurement protocols. Protocols for WC measurement vary in the landmarks used to define "waist." For example, the umbilicus, a level midway between the 10th rib and iliac crest, the uppermost lateral border of the right ilium, greatest frontal extension of abdomen between bottom of ribs and top of iliac crest, 2 cm above the umbilicus, and point of noticeable waist narrowing (8–13).

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In this issue of *The Journal*, the report by Johnson et al comparing measurements taken at four commonly used WC measurement sites is a small, but necessary first step toward the standardization of WC (14). It begins to address “a critical knowledge gap” by reporting differences in the relationship between WC sites and components of the metabolic syndrome, as well as significant sex-specific differences among measures. Differences between measurement sites have also been observed in adults, and even small absolute differences in measurement values can be important when cut-off values established for different WC protocols are used to define “abdominal obesity” or metabolic syndrome. (15–16).

There are, however, a number of limitations to this cross-sectional study, many of which were noted by the authors. Their 8–17 year old participants were recruited from a referral weight management program, and all but one had a BMI-for-age $\geq 95^{\text{th}}$ percentile (mean $98.7 \pm 1.0\%$); 88% were Caucasian. Future evaluation should be extended to a broader range of BMI categories and a more ethnically diverse population.

The observation that although almost 100% of the subjects in this study had “abdominal obesity” by WC criteria, only 34–57% had the metabolic syndrome depending on which criteria were used, is a reminder that WC is a screening, not a diagnostic, test. As such, it has the potential to be very sensitive across BMI ranges but will probably never be very specific. A report on 118 very obese adolescents with WC values greater than adult cut-off levels, who had MRI scans allowing assessment of the area of the abdominal subcutaneous and visceral fat components, makes the same point. (17). All subjects had similar WC values, but those in the highest tertile of visceral fat area had low abdominal subcutaneous fat area and a distinctly unfavorable metabolic phenotype compared with those in the lower two tertiles of visceral fat area. This might explain why measurements of WC taken at the narrowest point or minimal waist are better correlated with metabolic syndrome components than WC measurements taken using other protocols. At the narrowest waist, subcutaneous fat may contribute less to the dimension than the more risky visceral fat. The drawback, though, is that without a bony landmark (ribs, iliac crest) inter-observer reliability may suffer.

The importance of WC as an independent indicator of risk may be greater in populations with lower BMI-for-age values and may vary by race or ethnicity. For example, Sellers et al reported on the prevalence and characteristics of metabolic syndrome in 4–9 year old Australian Aboriginal children from a birth cohort. (18) Mean BMI z-score of the metabolic syndrome group was 0.67 SDU, and 50% had BMI-for-age less than the 85th percentile using CDC 2000 reference data, but their mean WC z-score was 2.69 using reference data appropriate for the WC measurement site (11). Consistent use of specific WC sites in diverse populations will help clarify their usefulness as a screening test and as an independent contributor to phenotypic assessment.

Johnson et al suggest future studies to address a “practical” issue and several physiological implications of pediatric WC sites. The comfort of the individual being measured with a specific WC protocol is an important practical feature, for both the participant who may have repeated measures and for the health professional who may not be willing to obtain measures that are upsetting to patients or research subjects. Technical differences between WC sites are additional practical issues to consider, including observations by technicians doing the measures and objective intra- and inter-observer comparisons. (17–18)

Establishing the sensitivity of WC sites to changes in subcutaneous abdominal and visceral fat distribution or risk factors could be accomplished by measuring WC at several sites during longitudinal observational or interventional studies as Johnson et al propose, and could be a major clinical contribution. WC measurements at specific sites may be important clinical endpoints or markers of progress if a clinically meaningful response to interventions earlier

than overall weight loss or BMI change is demonstrated. Understanding the relationships of WC sites to both risk factors and the abdominal fat components associated with health risk across the pediatric range of age and maturation, and the within individual consistency over time, would also be ideal. However, this may not be achieved in depth until a specific WC site (or sites) is (are) agreed upon.

Pediatric obesity is a complex heterogeneous condition with many features that need to be characterized in order to develop meaningful targeted interventions for treatment and prevention. Achieving consistency in anthropometry in research using methods with potential for wide application in clinical settings is a start, and a challenge in pediatrics. Johnson et al recommend that their study be used as a “platform” upon which to build a stronger evidence base in this area. It is probably less of a secure platform than a start to the conversation, but it is an important start. With the same goal of a stronger pediatric obesity evidence base, the NIH is sponsoring a Workshop of the Anthropometry and Body Composition Working Group (ABCWG) in October 2009 to begin the process of consensus on a core set of anthropometry-based variables applicable to pediatric obesity research in all settings, including WC measures.

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