**Is BMI the best measure of obesity?**

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Obesity, defined as abnormal accumulation of fat such that health is impaired,1 is most commonly assessed using the body mass index (BMI). However is BMI the best method for measuring obesity?

To answer this question, we need to consider the objective of measurement (clinical assessment, surveillance, evaluating response to interventions), definition of “abnormal” fat accumulation and the characteristics of a good measurement tool (accuracy and acceptability). Accurate diagnosis of obesity is important, not only for the individual, where misdiagnosis could lead to under-treatment or potential stigma, but also at the population and policy levels. Inaccurate measurements could mislead our interpretation of the epidemiology of obesity or planning of services.

The most accurate direct measures for quantifying the amount and distribution of adipose tissue include dual energy X-ray absorptiometry (DXA) and imaging techniques. Increasing total body fat, measured by DXA, is associated with higher mortality risk.2 However, imaging techniques have shown that fat distribution (specifically visceral fat) is a more important predictor than total fat levels.3 Despite their accuracy, these cumbersome techniques are resource intensive, less acceptable for routine use and have no standardised thresholds to define high risk. Anthropometric measurements, which measure adiposity indirectly, are therefore more commonly used.

***Anthropometric measures in adults***

BMI (weight divided by height squared (kg/m2)) is a relatively simple and low-cost indirect measure for assessing obesity which provides reasonable height standardization. BMI cut-offs to define obesity are based on well-established risks for cardiometabolic morbidity and premature mortality.4 However, although BMI is strongly correlated with gold standard body fat measures, it cannot distinguish between lean and fat mass and provides no indication of body fat distribution. Compared to direct measures, BMI has high specificity (0.90) but low sensitivity (0.50) for assessing obesity.5 The relationships between BMI, total body fatness and cardiometabolic outcomes (particularly type-2 diabetes) differ by ethnic group, leading to recommendations for different obesity thresholds by ethnicity.6 The loss of muscle mass in the elderly means that BMI is also a less accurate predictor of body fat in this group.7

Several studies have suggested that compared with BMI, central obesity measures, including waist circumference (WC), waist to hip ratio (WHR) and waist-to-height ratio (WHtR) are superior in predicting visceral adiposity, cardiometabolic disease and mortality.8 In contrast, others have demonstrated that these measures are highly correlated with BMI and have a similar strength of association with cardiovascular disease risk, and so add little further information. 9 Nevertheless, measures of central obesity are associated with morbidity and mortality independently of BMI and recommended for clinical assessment, particularly at low BMI levels10 and are potentially more important in women.11 Among the central obesity measures, WHR and WHtR are probably better predictors than WC, though more complex to determine, and lack standardised measurement protocols, reference data and accuracy in very obese individuals (BMI>35).12

Other measurements include skinfold thickness (SFT), with subscapular/abdominal : biceps/triceps SFT a potential marker of central-to-peripheral fat distribution that is associated with cardiovascular morbidity,13 and bioelectrical impedance (BIA) which is highly correlated with direct measures of body fat, but dependent on several conditions for accuracy.14 The limited available evidence does not suggest these have better or additional predictive ability for disease risk in comparison with BMI, WC or WHR.

***Measurement in children***

In children the assessment of BMI needs to be standardised for age and sex to account for differential growth patterns. Obesity is defined using thresholds applied to one of several reference populations, each with certain advantages.15 Conventional statistical approaches are used to define obesity, with different thresholds being applied for clinical or epidemiological purposes (95th and 98th percentiles respectively in UK), although the International Obesity Taskforce thresholds are aligned to obesity cut-offs for adults (30kg/m2). It is also important to consider ethnicity16 and pubertal stage. Compared to direct measures, the use of BMI to diagnose obesity in children has high specificity and reasonable sensitivity (0.73).17

In addition to standardised BMI, WC, WHR, WHtR and SFT have been used as indirect measures of obesity in children. All are correlated with direct adiposity measures and with cardiovascular risk factors18. A systematic review of the diagnostic accuracy of these measures compared to reference body fat measures showed that for obesity all had reasonable discriminative ability, but they were less good at assessing the degree of adiposity19. Among measures of central obesity, WHtR was more accurate than WC or WHR. Where direct comparisons with BMI were undertaken, none were found to be superior in defining obesity although sum SFT (usually biceps, triceps, suprailiac and subscapular) is a useful supplementary measure19. BIA is also a potentially promising measure, but highly dependent on the device and prediction equation utilised.20 For children, parents and healthcare staff, BMI is the most familiar and acceptable measure of obesity, whereas WC measurement tends to lead to more embarrassment.19

**Summary**

BMI remains the most commonly used, widely accepted and practical measure of obesity. However given the lower sensitivity in predicting obesity in the elderly and some ethnic minority groups, alternative approaches are needed for these groups. In adults, measures of central adiposity in addition to BMI are valuable for assessing disease risk. In children, obesity surveillance programmes based on BMI provide a useful monitoring tool, but are less accurate measures of body fatness for some minority ethnic groups.

**Author contributions:**

All authors contributed to the content of this review. PA produced the first draft and finalised the manuscript with comments and contribution from MJP and PHW.

**Funding:** None

**Conflicts of interest:** PA and MJPare conducting a school based trial on childhood obesity prevention in China that has received a donation from Yong Ning Pharmaceuticals in China

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