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EDITORIALS

Is BMI the best measure of obesity?

It works for most people most of the time

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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). But some people have questioned whether BMI is the best diagnostic measure.

To answer this, we need to consider the objectives of measurement (clinical assessment, surveillance, evaluating response to interventions), the 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, when misdiagnosis could lead to undertreatment 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 of the amount and distribution of adipose tissue include dual energy x ray absorptiometry (DEXA) and imaging techniques. Increasing total body fat, measured by DEXA, 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 techniques are cumbersome and expensive, less acceptable for routine use, and have no standardised thresholds to define high risk. Indirect, anthropometric measures of adiposity are therefore more commonly used.

Measuring adults

BMI (weight in kg divided by the square of height in m) is a relatively simple and low cost indirect measure for assessing obesity with reasonable height standardisation. 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 with direct measures, BMI has high specificity (0.90) but low sensitivity (0.50) for assessing obesity.⁵ The relations between BMI, total body fatness, and cardiometabolic outcomes

(particularly type 2 diabetes) differ by ethnic group, leading to different recommendations for obesity thresholds by ethnicity.⁶ The loss of muscle mass in elderly people 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, waist:hip ratio, and waist:height ratio—are better at predicting visceral adiposity, cardiometabolic disease, and mortality.⁸ However, others have shown that these measures are highly correlated with BMI and have a similar strength of association with risk of cardiovascular disease, 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 in people with low BMI,¹⁰ and are potentially more important in women.¹¹ Among the central obesity measures, waist:hip and waist:height ratios are probably better predictors than waist circumference, though more complex to determine. They also lack standardised measurement protocols, reference data, and accuracy in people with severe obesity (BMI>35).¹²

Other measurements include skinfold thickness—with subscapular/abdominal:biceps/triceps ratio a potential marker of central-to-peripheral fat distribution that is associated with cardiovascular morbidity¹³—and bioelectrical impedance, which is highly correlated with direct measures of body fat but requires adjustment for environmental, medical, ethnicity, and other factors.¹⁴ The limited available evidence does not suggest these have better or additional predictive ability for disease risk in comparison with BMI, waist circumference, or waist:hip ratio.

Measuring children

In children, BMI measurements are standardised for age and sex to account for growth patterns. Obesity is defined using thresholds derived from one of several reference populations, each with advantages in different situations.¹⁵ Conventional statistical approaches are mostly used to define obesity, with separate thresholds applied to the reference population for clinical and epidemiological purposes (95th and 98th centiles

respectively using the UK1990 reference curves in UK. It is also important to consider ethnicity¹⁶ and pubertal stage. Compared with direct measures, the use of BMI to diagnose obesity in children has high specificity and reasonable sensitivity (0.73).¹⁷

Measures of central obesity and skinfold thickness have also been used to measure obesity in children. All are correlated with direct measures and with cardiovascular risk factors.¹⁸ A systematic review of the diagnostic accuracy of these measures compared with reference body fat measures showed that all were able to discriminate obese from non-obese children reasonably well, but they were less good at assessing the degree of adiposity.¹⁹ Among measures of central obesity, waist:height ratio was more accurate than waist circumference or waist:hip ratio. None performed better than BMI in direct comparisons, although sum of skinfold thickness (usually biceps, triceps, supra-iliac, and subscapular) was a useful supplementary measure.¹⁹ Bioelectric impedance is also promising but highly dependent on the device and prediction equation used.²⁰ Overall, BMI is the most familiar and acceptable measure among children, parents, and healthcare staff. Measurement of waist circumference tends to lead to more embarrassment.¹⁹

BMI remains the most commonly used, widely accepted, and practical measure of obesity in both children and adults, particularly for surveillance. However, interpretation should be ethnically sensitive, given the poorer diagnostic performance in some minority groups (including those of South Asian or African or Caribbean heritage). At the individual level, alternative approaches are needed for older adults, and measures of central adiposity in addition to BMI are valuable for assessing disease risk.

Competing interests: We have read and understood BMJ policy on declaration of interests and declare that PA and MJP are conducting a trial on prevention of childhood obesity in Chinese schools that has received a donation from Yong Ning Pharmaceuticals in China.

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- 1 WHO. Fact sheet on obesity and overweight. 2006. <http://www.who.int/mediacentre/factsheets/fs311/en/>
- 2 Padwal R, Leslie WD, Lix LM, Majumdar SR. Relationship among body fat percentage, body mass index, and all-cause mortality: a cohort study. *Ann Intern Med* 2016;164:532-41. 10.7326/M15-1181 26954388

- 3 Lee SW, Son JY, Kim JM, Hwang SS, Han JS, Heo NJ. Body fat distribution is more predictive of all-cause mortality than overall adiposity. *Diabetes Obes Metab* 2018;20:141-7. 10.1111/dom.13050 28671751
- 4 Aune D, Sen A, Prasad M, et al. BMI and all cause mortality: systematic review and non-linear dose-response meta-analysis of 230 cohort studies with 3.74 million deaths among 30.3 million participants. *BMJ* 2016;353:i2156. 10.1136/bmj.i2156 27146380
- 5 Okorodudu DO, Jumeau MF, Montori VM, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. *Int J Obes (Lond)* 2010;34:791-9. 10.1038/ijo.2010.5 20125098
- 6 NICE. Assessing body mass index and waist circumference thresholds for intervening to prevent ill health and premature death among adults from black, Asian and other minority ethnic groups in the UK. PH46. 2013. <https://www.nice.org.uk/guidance/ph46>
- 7 Chang S-H, Beason TS, Hunleth JM, Colditz GA. A systematic review of body fat distribution and mortality in older people. *Maturitas* 2012;72:175-91. 10.1016/j.maturitas.2012.04.004 22595204
- 8 Song X, Jousilahti P, Stehouwer CDA, et al. Comparison of various surrogate obesity indicators as predictors of cardiovascular mortality in four European populations. *Eur J Clin Nutr* 2013;67:1298-302. <https://www.nature.com/articles/ejcn2013203-supplementary-information10.1038/ejcn.2013.203> 24149442
- 9 Wormser D, Kaptoge S, Di Angelantonio E, et al. Emerging Risk Factors Collaboration. Separate and combined associations of body-mass index and abdominal adiposity with cardiovascular disease: collaborative analysis of 58 prospective studies. *Lancet* 2011;377:1085-95. 10.1016/S0140-6736(11)60105-0 21397319
- 10 Pischon T, Boeing H, Hoffmann K, et al. General and abdominal adiposity and risk of death in Europe. *N Engl J Med* 2008;359:2105-20. 10.1056/NEJMoa0801891 19005195
- 11 Peters SAE, Bots SH, Woodward M. Sex differences in the association between measures of general and central adiposity and the risk of myocardial infarction: results from the UK Biobank. *J Am Heart Assoc* 2018;7:e008507. 10.1161/JAHA.117.008507 29490971
- 12 NICE. *Obesity guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children*. National Institute for Health and Clinical Excellence, 2006.
- 13 Loh WJ, Johnston DG, Oliver N, Godsland IF. Skinfold thickness measurements and mortality in white males during 27.7 years of follow-up. *Int J Obes (Lond)* 2018 [Epub ahead of print]. 10.1038/s41366-018-0034-0 29491491
- 14 Dehghan M, Merchant AT. Is bioelectrical impedance accurate for use in large epidemiological studies? *Nutr J* 2008;7:26-26. 10.1186/1475-2891-7-26 18778488
- 15 Scientific Advisory Committee on Nutrition, Royal College of Paediatrics and Child Health. Consideration of issues around the use of BMI centile thresholds for defining underweight, overweight and obesity in children aged 2-18 years in the UK. SACN, RCPCH, 2012.
- 16 Hudda MT, Nightingale CM, Donin AS, et al. Body mass index adjustments to increase the validity of body fatness assessment in UK Black African and South Asian children. *Int J Obes (Lond)* 2017;41:1048-55. 10.1038/ijo.2017.75 28325931
- 17 Javed A, Jumeau M, Murad MH, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. *Pediatr Obes* 2015;10:234-44. 10.1111/ijo.242 24961794
- 18 Sardinha LB, Santos DA, Silva AM, Grøntved A, Andersen LB, Ekelund U. A Comparison between BMI, waist circumference, and waist-to-height ratio for identifying cardio-metabolic risk in children and adolescents. *PLoS One* 2016;11:e0149351. 10.1371/journal.pone.0149351 26901828
- 19 Simmonds M, Burch J, Llewellyn A, et al. 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. *Health Technol Assess* 2015;19:1-336. 10.3310/hta19430 26108433
- 20 Talma H, Chinapaw MJM, Bakker B, HiraSing RA, Terwee CB, Altenburg TM. Bioelectrical impedance analysis to estimate body composition in children and adolescents: a systematic review and evidence appraisal of validity, responsiveness, reliability and measurement error. *Obes Rev* 2013;14:895-905. 10.1111/obr.12061 23848977

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