Metabolism Clinical and Experimental 92 (2019) 6–10

Contents lists available at ScienceDirect

Metabolism Clinical and Experimental

journal homepage: www.metabolismjournal.com

The epidemiology of obesity☆

Yu Chung Chooi [a], Cherlyn Ding [a], Faidon Magkos [a,b,c,*]

[a] Clinical Nutrition Research Centre (CNRC), Singapore Institute for Clinical Sciences (SICS), Agency for Science, Technology and Research (A*STAR), National University Health System, Singapore
[b] Department of Physiology, Yong Loo Lin School of Medicine, National University of Singapore (NUS), Singapore
[c] Department of Nutrition, Exercise and Sports - Obesity Research, University of Copenhagen, Denmark

ARTICLE INFO

Article history:
Received 9 July 2018
Received in revised form 30 August 2018
Accepted 19 September 2018

Keywords:
Prevalence
BMI
Adiposity
Health risk

ABSTRACT

Obesity is a complex multifactorial disease. The worldwide prevalence of overweight and obesity has doubled since 1980 to an extent that nearly a third of the world's population is now classified as overweight or obese. Obesity rates have increased in all ages and both sexes irrespective of geographical locality, ethnicity or socioeconomic status, although the prevalence of obesity is generally greater in older persons and women. This trend was similar across regions and countries, although absolute prevalence rates of overweight and obesity varied widely. For some developed countries, the prevalence rates of obesity seem to have levelled off during the past few years. Body mass index (BMI) is typically used to define overweight and obesity in epidemiological studies. However, BMI has low sensitivity and there is a large inter-individual variability in the percent body fat for any given BMI value, partly attributed to age, sex, and ethnicity. For instance, Asians have greater percent body fat than Caucasians for the same BMI. Greater cardiometabolic risk has also been associated with the localization of excess fat in the visceral adipose tissue and ectopic depots (such as muscle and liver), as well as in cases of increased fat to lean mass ratio (e.g. metabolically-obese normal-weight). These data suggest that obesity may be far more common and requires more urgent attention than what large epidemiological studies suggest. Simply relying on BMI to assess its prevalence could hinder future interventions aimed at obesity prevention and control.

1. Introduction

The worldwide prevalence of overweight and obesity has doubled since 1980 to an extent that nearly a third of the world population is now classified as overweight or obese [1]. Obesity adversely affects nearly all physiological functions of the body and comprises a significant public health threat. It increases the risk for developing multiple disease conditions, such as diabetes mellitus [2], cardiovascular disease [2,3], several types of cancers [4], an array of musculoskeletal disorders [5], and poor mental health [6], all of which have negative effects on the quality of life, work productivity, and healthcare costs. In the US, it has been estimated that the health costs incurred by a single obese individual was US$1901 per annum in 2014, extrapolating to US$149.4 billion at the national level [7]. In Europe, the total direct and indirect cost attributable to overweight and obesity was equivalent to 0.47–0.61% of the GDP [8].

The World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that presents a risk to health [9]. The body mass index (BMI), calculated by dividing the body weight in kilograms by the square of height in meters, is a simple metric used to indicate overall body fatness [9]. For adults, current guidelines from the US Centers for Disease Control and Prevention (CDC) and the WHO define a normal BMI range as 18.5 to 24.9, whereas a BMI ≥ 25 kg/m^2 is considered to be overweight, and a BMI ≥ 30 kg/m^2 is classified as obese, with severe obesity defined as a BMI ≥ 40 kg/m^2 [9]. Despite this relatively simplistic definition, obesity is a multifactorial disease that results from chronic positive energy balance, i.e. when dietary energy intake exceeds energy expenditure. Excess energy is converted to triglyceride which is stored in adipose tissue depots that expand in size, thereby increasing body fat and causing weight gain. The globalization of food systems that produce more processed and affordable food, and promote passive overconsumption from energy-dense, nutrient-poor foods and beverages has been identified as a major driver of the obesity epidemic [10], although a decrease in physical activity owing to the modernization of lifestyles is also likely involved [11,12].

Obesity can occur at any age. Previous studies assessing trends in obesity found that its prevalence has increased in both adults and

Abbreviations: BMI, body mass index; GBD, Global Burden of Disease; CDC, US Centers for Disease Control and Prevention; IDF, International Diabetes Federation; MHO, Metabolically Healthy Obesity; MONW, Metabolically Obese Normal Weight; NCD, non-communicable disease; WHO, World Health Organization.

☆ Disclosure: The author reports no conflicts of interest in this work.

* Corresponding author at: University of Copenhagen, Faculty of Science, Department of Nutrition, Exercise and Sports - Obesity Research, Rolighedsvej 26, 1958 Frederiksberg C, Building 2-85, Room H134, Denmark.
E-mail address: fma@nexs.ku.dk (F. Magkos).

https://doi.org/10.1016/j.metabol.2018.09.005
0026-0495/

children of all ages, indiscriminate of geographical locality, ethnicity or socioeconomic status [1]. In low-income countries, obesity is generally more prevalent among middle-aged adults from wealthy and urban environments (especially women); whereas, in high-income countries, it affects both sexes and all ages, but its prevalence is disproportionately greater among disadvantaged groups [10].

In this article, we summarize the prevalence rates and secular trends of overweight and obesity in adults on a global scale.

2. Methods

We used the data provided by the Global Burden of Disease Study (Institute for Health Metrics and Evaluation, Seattle, WA) [1], which defines obesity as a BMI ≥ 30 kg/m^2, and overweight as a BMI ≥ 25 kg/m^2 (i.e. overweight rates include obesity); the full data file is available online from Global Health Data Exchange (http://ghdx.heathdata.org).

We divided the world into six regions according to WHO; namely African, Americas, Eastern Mediterranean, European, South East Asian and Western Pacific. We selected the data for the top five most populous countries from each region: the African region included Nigeria, Ethiopia, Congo, Tanzania and South Africa; Americas included the United States of America, Brazil, Mexico, Colombia and Argentina; the Eastern Mediterranean included Pakistan, Egypt, Iran, Iraq and Afghanistan; the European region included Russia, Germany, Turkey, United Kingdom and France; the South East Asian region included India, Indonesia, Bangladesh, Thailand and Myanmar; and the Western Pacific region included China, Japan, Philippines, Vietnam and South Korea. Overall, the countries selected for this study represented ~78% of the world's population.

We report prevalence rates (%) of overweight and obesity by sex, age, and region between 1980 and 2015.

3. Results

3.1. Prevalence of Overweight and Obesity by Sex and Age

Globally, a total of 1.9 billion and 609 million adults were estimated to be overweight and obese in 2015, respectively, representing approximately 39% of the world's population. Fig. 1 shows the global prevalence rates of overweight and obesity in 2015, for adult men and women aged > 20 years, by age group. In 2015, the prevalence of overweight was somewhat lower in women than in men among young adults (aged between 20 and 44 years) but this trend was reversed after age 45–49 years, perhaps coinciding with menopause in women. The prevalence of obesity was generally higher in women than in men in all age groups, with sex differences being maximal between 50 and 65 years old. The rates of both overweight and obesity increased with age from 20 years old onwards, reached their peak between the ages of 50 to 65 years, and declined slightly thereafter.

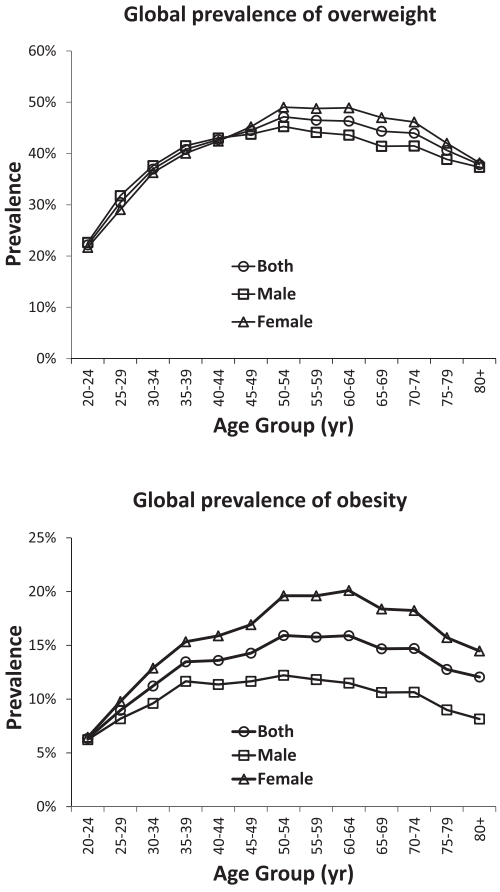

Fig. 1. Global prevalence of overweight (top) and obesity (bottom) in adults > 20 years old by age group and sex (ca. 2015).

3.2. Secular Trends in Overweight and Obesity

The age-standardised prevalence of overweight increased from 26.5% in 1980 to 39.0% in 2015, representing an almost 50% increase over the past 35 years (Fig. 2 top). The prevalence obesity likewise rose from 7% in 1980 to 12.5% in 2015, representing an almost 80% increase (Fig. 2 bottom). The prevalence rates of overweight and obesity were always greater in women than in men throughout this period; a pattern of diminishing sex differences in recent years was evident for overweight, but sex differences in obesity remained remarkably constant.

3.3. Regional Prevalence of Overweight and Obesity

The American and the European were the two regions with the highest prevalence of overweight and obesity (Fig. 3). In the Americas, the prevalence of overweight increased from 45.3% in 1980 to 64.2% in 2015 and the prevalence of obesity increased from 12.9% in 1980 to 28.3% in 2015. The US and Mexico had the highest prevalence rates for both overweight and obese. In the European region, the prevalence of overweight increased from 48% in 1980 to 59.6% in 2015 and that of obesity from 14.5% in 1980 to 22.9% in 2015. The prevalence rates of overweight and obesity were quite consistent among countries within each of these two regions. Turkey and the US had the highest prevalence rates of overweight and obesity in 2015 in the European and the American regions, respectively, whereas France and Columbia had the lowest, respectively.

In the Eastern Mediterranean region, the prevalence of overweight increased from 37.9% in 1980 to 49.6% in 2015 and that of obesity from 11.8% in 1980 to 19.6% in 2015. In the African region, the prevalence of overweight, and obesity have approximately doubled from 1980 to 2015, from 18.5% to 34.5% and from 6.2% to 12.7%, respectively. We observed a large variability among countries in the prevalence rates of overweight and obesity in the Eastern Mediterranean and African regions. For instance, the prevalence of overweight in Iraq remained rather constant but at a rather high level (from 62.6% in 1980 to 65.6% in 2015), but in Pakistan it increased from 24.1% in 1980 to 35.4% in 2015. Likewise, the prevalence of overweight in South Africa increased from 49.4% in 1980 to 57.8% in 2015, whereas in Ethiopia it increased from 7.1% in 1980 to 15.9% in 2015.

The trends in overweight and obesity also increased in the West Pacific region during the past 35 years, although the prevalence rates were the lowest globally. The prevalence of overweight increased from 9.7% in 1980 to 28.2% in 2015, and that of obesity increased from 0.8% in 1980 to 4.9% in 2015. For example, the prevalence of overweight in China approximately tripled from 7.8% to 29.9%. Similar trends were observed for the South East Asian region; the prevalence overweight

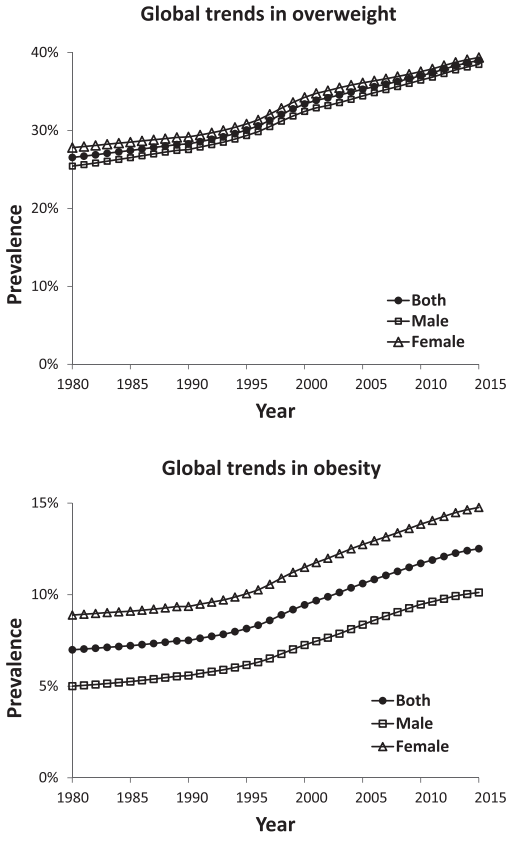

Fig. 2. Age-standardised global prevalence of overweight (top) and obesity (bottom) in men and women > 20 years old by year (ca. 1980–2015).

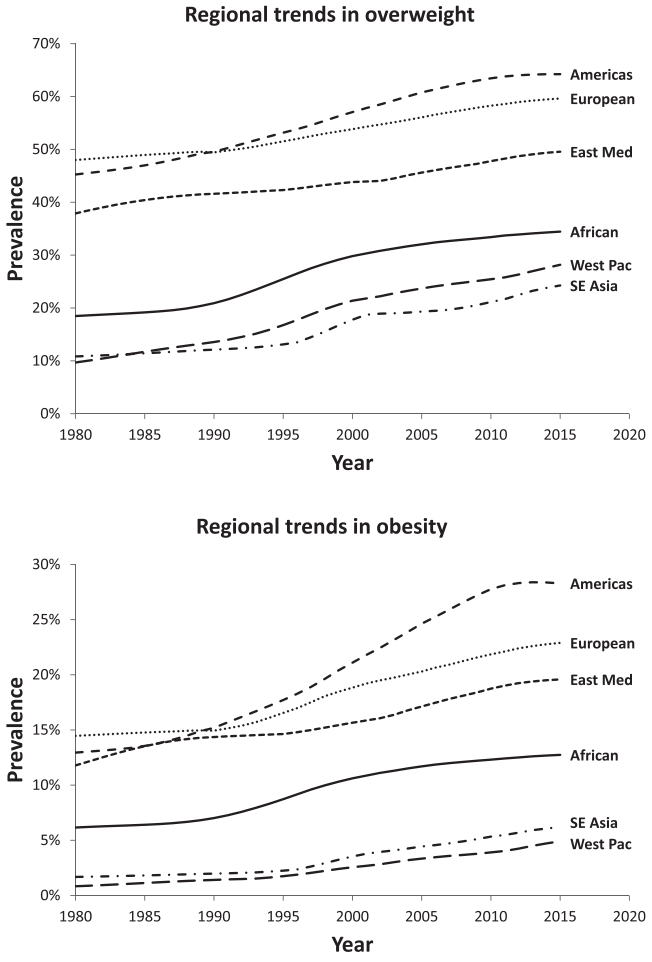

Fig. 3. Age-standardised prevalence of overweight (top) and obesity (bottom) in adults > 20 years old by geographical region and year (ca. 1980–2015).

increased from 10.9% in 1980 to 24.3% in 2015, and the prevalence of obesity from 1.7% in 1980 to 6.2% in 2015.

Overall, although there was a 5–6-fold variability among regions in the absolute prevalence rates of overweight and obesity, the rising trend was common for all regions during the past 35 years, with evidence of levelling off in some (e.g. Americas and African) but not all regions (Fig. 3).

4. Discussion

The worldwide prevalence rates of overweight and obesity have approximately doubled since 1980 to an extent that over one-third of the world's population is now classified as overweight or obese. Kelly et al. estimated that 57.8% of the world population will be overweight or obese by the year 2030 if the current trends continue [13]. Globally, the proportion of individuals with a BMI ≥ 25 kg/m^2 increased between 1980 and 2015 from 25.4% to 38.5% in men, and from 27.8% to 39.4% in women. The prevalence of obesity increased from 5% in 1980 to 10.1% in 2015 in men and from 8.9% to 14.8% in women. The rise in the prevalence of overweight and obesity was greatest between 1992 and 2002, and was always greater in women than in men throughout this period; a pattern of diminishing sex differences in recent years was evident for overweight, but sex differences in obesity remained remarkably constant over time. The non-communicable diseases (NCD) Risk Factor Collaboration estimated that by 2025, the prevalence of obesity will reach 18% in men and 21% in women [14]. In low-income countries, obesity is generally higher among middle-aged adults from wealthy and urban environments (especially women); whereas, in high-income countries, obesity affects both sexes and all ages, but is disproportionately greater in disadvantaged groups [10]. Generally, the prevalence of obesity is higher in women than men in all sociodemographic levels [15].

The absolute rates and trends in overweight and obesity varied substantially across regions and countries and are similar to those reported by Stevens et al. [16]. In 1980, the overweight and obesity prevalence rates ranged from 4.5% in Vietnam to 62.6% in Iraq (based on the data for 30 countries in the 6 geographical regions described in *Methods*). By 2015, overweight and obesity prevalence rates in 18 out of the 30 countries examined were >35%; and they were >51% in all five countries of the European and American regions. In 1980, only two countries had a prevalence of obesity above 20%: South Africa (22.6%) and Iraq (28.8%). By contrast, in 2015, 11 countries had a prevalence of obesity > 20%: Germany (20.9%), Brazil (22.6%), Argentina (23.2%), Russia (24%), United Kingdom (24.3%), Turkey (28.5%), Mexico (28.6%), South Africa (30.8%), Iraq (31.9%), US (33.6%), and Egypt (35.3%).

The obesity rates seem to have levelled off during the past 10 years in several developed countries. For example, the prevalence of obesity in the US and UK remained at around 30–34% and 23–24%, respectively, between 2005 and 2015. However, the global obesity rate is still increasing as the trends have accelerated in other regions of the world, where most people live. The increase in the prevalence of obesity in developing countries is mainly due to rapid changes in socioeconomic status and demographic, and the adoption of an energy- and fat-rich diet and a sedentary lifestyle [17]. In 1980, the South East Asian, Western Pacific and African regions were those with the lowest prevalence of obesity, which was as low as 0.4% in Vietnam and <2% in nine other countries: Bangladesh (0.6%), China (0.6%), Ethiopia (1.2%), Indonesia (1.4%), Myanmar (1.5%), Nigeria (1.7%), India (1.7%), Japan (1.8%), and South Korea (1.9%). By 2015, however, only one country still had an obesity

prevalence below 2%: Vietnam (1.6%). The robust rising trends will likely continue in developing countries, where 2 out of 3 of the world's obese individuals currently reside [18]. China (Pacific region) witnessed a nearly 9-fold increase in the prevalence of obesity over the past 35 years, from 0.6% in 1980 to 5.3% in 2015. Although the obesity rate is still much lower than that in the US, the net population of obese Chinese individuals is among the highest in the world [19]. The associations of risk factors with obesity differ between men and women [20]. Lifestyle and dietary factors appear to be the most important parameters that can explain the differences between urban and rural residents among women, whereas socioeconomic status, lifestyle, and dietary factors were equally important among men [21]. Mi et al. reported that both the prevalence of obesity and the combined prevalence of overweight and obesity increased more rapidly among men than women in China, and forecasted that the increases in body weight are continuing, particularly among men [19].

The standard WHO BMI classification criteria may have less clinical and epidemiological significance for some populations. In fact, for the same BMI, there is a large inter-individual variability (almost 2-fold) in the percent body fat, partly attributed to age, sex, and ethnicity [22,23]. In 2002, WHO Expert Consultation panel, using all available data from Asian countries, proposed to lower BMI cut-off points to trigger public health action for Asian populations, categorizing 23–27.5 kg/m^2 as overweight and BMI ≥ 27.5 kg/m^2 was obese [24]. Some Asian countries adjusted the criteria accordingly; for instance, in China, the Working Group on Obesity in China (WGOC) defined obesity as BMI ≥ 28.0 kg/m^2 and normal weight as BMI < 24.0 kg/m^2 [25]. And, in Singapore, it has been proposed that a BMI of 26–27 kg/m^2 and above is used to identify obese subjects [26]. A lowering of the BMI cut-off will translate directly into a much greater obesity prevalence in these populations. For instance, in a combined cohort study of minority groups living in the US, Hispanics, African-Americans, Chinese-Americans and South Asians carried significantly greater risk of developing metabolic abnormalities compared to Caucasians at similar BMIs in the overweight as well as in the normal weight ranges [27]. The analysis showed that for the equivalent prevalence of metabolic abnormalities at a BMI of 25 kg/m^2 in Caucasians, the corresponding BMIs were 22.9 kg/m^2 for African Americans, 21.5 kg/m^2 for Hispanics, 20.9 kg/m^2 for Chinese-Americans, and 19.6 kg/m^2 for South Asians [27]. For the equivalent prevalence of metabolic abnormalities at a BMI of 30 kg/m^2 in Caucasians, the corresponding BMI values were 24.5 kg/m^2 for Chinese-Americans and 23.3 kg/m^2 for South Asians. Unfortunately, we could not recalculate obesity rates in our study using lower BMI cut-offs, as the Global Burden of Disease Study Database only includes the absolute number and percentage of overweight and obesity. Notably, among people of Asian descent, apparently normal weight individuals with some degree of metabolic dysfunction have greater risk for cardiometabolic disease not only compared to their metabolically-healthy lean counterparts, but also compared to metabolically-healthy obese subjects [28]. This suggests that BMI alone cannot accurately convey the magnitude of risk to health, not only across different ethnic populations, but also for certain subgroups within the same population.

In summary, the prevalence of obesity is greater in women than men, and increases with age. Overweight and obesity rates have increased considerably during the past 35 years to the extent that more than one-third of the world's population is now classified as overweight or obese. Although there is some variability between countries and regions, these trends were relatively uniform worldwide. Estimates of obesity prevalence based on WHO BMI cut-offs may not adequately capture the full scale of the problem. The increase in obesity likely results from a complex interaction between changes in the food environment, physical activity, socioeconomic, environmental, and genetic factors. Prevention is a complex issue and requires collective efforts from the governments, the scientific and the medical communities, the industry, and various social organizations towards the changing of dietary and lifestyle habits.

Author Contributions

Y.C.C. and C.D. collected and analysed the data. Y.C.C. drafted the manuscript. All authors were involved in manuscript editing and approved the version submitted for publication.

Duality of Interest

The authors have no conflicts of interest relevant to the content of this article.

References

[1] Global Burden of Disease Study 2015. Global burden of disease study 2015 (GBD 2015) obesity and overweight prevalence 1980–2015. Seattle, United States: Institute for Health Metrics and Evaluation (IHME); 2017.
[2] Singh GM, Danaei G, Farzadfar F, et al. The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. PLoS One 2013;8(7):e65174.
[3] Czernichow S, Kengne AP, Stamatakis E, et al. Body mass index, waist circumference and waist-hip ratio: which is the better discriminator of cardiovascular disease mortality risk?: evidence from an individual-participant meta-analysis of 82 864 participants from nine cohort studies. Obes Rev 2011;12(9):680–7.
[4] Lauby-Secretan B, Scoccianti C, Loomis D, et al. Body fatness and cancer–viewpoint of the IARC working group. N Engl J Med 2016;375(8):794–8.
[5] Anandacoomarasamy A, Caterson I, Sambrook P, et al. The impact of obesity on the musculoskeletal system. Int J Obes 2008;32(2):211–22.
[6] Anstey KJ, Cherbuin N, Budge M, et al. Body mass index in midlife and late-life as a risk factor for dementia: a meta-analysis of prospective studies. Obes Rev 2011;12(5):e426–37.
[7] Kim DD, Basu A. Estimating the medical care costs of obesity in the United States: systematic review, meta-analysis, and empirical analysis. Value Health 2016;19(5):602–13.
[8] von Lengerke T, Krauth C. Economic costs of adult obesity: a review of recent European studies with a focus on subgroup-specific costs. Maturitas 2011;69(3):220–9.
[9] World Health Organization. Obesity and overweight. Fact sheet no 311 January 2015. [cited 2016 20 April 2016; Available from] http://www.who.int/mediacentre/factsheets/fs311/en/.
[10] Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. Lancet 2011;378(9793):804–14.
[11] Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. Obes Rev 2012;13(8):659–80.
[12] Ladabaum U, Mannalithara A, Myer PA, et al. Obesity, abdominal obesity, physical activity, and caloric intake in US adults: 1988 to 2010. Am J Med 2014;127(8):717–727.e712.
[13] Kelly T, Yang W, Chen CS, et al. Global burden of obesity in 2005 and projections to 2030. Int J Obes 2008;32(9):1431–7.
[14] NCD-RisC. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. Lancet 2016;387(10026):1377–96.
[15] Afshin A, Forouzanfar MH, Reitsma MB, et al. Health effects of overweight and obesity in 195 countries over 25 years. N Engl J Med 2017;377(1):13–27.
[16] Stevens GA, Singh GM, Lu Y, et al. National, regional, and global trends in adult overweight and obesity prevalences. Popul Health Metrics 2012;10(1):22.
[17] He Y, Pan A, Wang Y, et al. Prevalence of overweight and obesity in 15.8 million men aged 15–49 years in rural China from 2010 to 2014. Sci Rep 2017;7:5012.
[18] Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384(9945):766–81.
[19] Mi Y-J, Zhang B, Wang H-J, et al. Prevalence and secular trends in obesity among Chinese adults, 1991–2011. Am J Prev Med 2015;49(5):661–9.
[20] Wang H, Wang J, Liu M-M, et al. Epidemiology of general obesity, abdominal obesity and related risk factors in urban adults from 33 communities of Northeast China: the CHPSNE study. BMC Public Health 2012;12:967.
[21] Reynolds K, Gu D, Whelton PK, et al. Prevalence and risk factors of overweight and obesity in China. Obesity (Silver Spring) 2007;15(1):10–8.
[22] Gallagher D, Heymsfield SB, Heo M, et al. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr 2000;72(3):694–701.
[23] Gallagher D, Visser M, Sepulveda D, et al. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? Am J Epidemiol 1996;143(3):228–39.
[24] W. H. O. Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363(9403):157–63.
[25] Zhou BF. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults–study on optimal cut-off points of body mass index and waist circumference in Chinese adults. Biomed Environ Sci 2002;15(1):83–96.

[26] Deurenberg-Yap M, Schmidt G, van Staveren WA, et al. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. Int J Obes Relat Metab Disord 2000;24(8):1011–7.
[27] Gujral UP, Vittinghoff E, Mongraw-Chaffin M, et al. Cardiometabolic abnormalities among normal-weight persons from five racial/ethnic groups in the United States: a cross-sectional analysis of two cohort studies. Ann Intern Med 2017;166(9):628–36.
[28] Ding C, Chan Z, Magkos F. Lean, but not healthy: the 'metabolically obese, normal-weight' phenotype. Curr Opin Clin Nutr Metab Care 2016;19(6):408–17.