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Body mass index and mortality in China: a 15-year prospective study of 220 000 men

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Background In China, there have been few large prospective studies of the associations of body mass index (BMI) with overall and cause-specific mortality that have simultaneously controlled for biases that can be caused by pre-existing disease and smoking.

Methods Prospective cohort study of 224 064 men, of whom 40 700 died during follow-up between 1990–91 and 2006. Analyses restricted to 142 214 men aged 40–79 years at baseline with no disease history and, to further reduce bias from pre-existing disease, at least 5 years of subsequent follow-up, leaving 17 800 deaths [including 4165 stroke, 1297 coronary heart disease (CHD), 3121 chronic obstructive pulmonary disease (COPD)]. Adjusted hazard ratios (HRs) and 95% confidence intervals (95% CIs) per 5 kg/m^2 calculated within either a lower (15 to <23.5 kg/m^2) or higher (23.5 to <35 kg/m^2) range.

Results The association between BMI and all-cause mortality was U-shaped with the lowest mortality at ∼22.5–25 kg/m^2. In the lower range, 5 kg/m^2 higher BMI was associated with 14% lower mortality (HR 0.86, 95% CI 0.82–0.91); in the upper range, it was associated with 27% higher mortality (HR 1.27, 95% CI 1.15–1.40). The absolute excess mortality in the lower range was largely accounted for by excess mortality from specific smoking-related diseases: 54% by that for COPD, 12% other respiratory disease, 13% lung cancer, 11% stomach cancer. The excess mortality in the upper BMI range was largely accounted for by excess mortality from specific vascular diseases: 55% by that for stroke, 16% CHD. In this range, 5 kg/m^2 higher BMI was associated with ∼50% higher mortality from stroke (HR 1.61, 95% CI 1.36–1.92) and CHD (HR 1.48, 95% CI 1.12–1.95).

Conclusions For China, previous evidence may have overestimated the excess mortality at low BMI but underestimated that at high BMI. The main way obesity kills in China appears to be stroke.

Keywords Obesity, body mass index, mortality, China, prospective studies

Introduction

In China,[1] an increasingly large proportion of the population has a body mass index (BMI) >25 kg/m^2. As BMI can be a useful indicator of general adiposity,[2,3] and greater adiposity has adverse metabolic effects,[4,5] it is essential that the prospective relationships of BMI with cause-specific and overall mortality in China be well understood. However, a potential barrier to clear understanding is that the relationships are easily biased[6,7] by pre-existing diseases which cause weight loss, and by smoking, since each is associated with lower BMI while in itself increasing future mortality. In prospective studies, these biases can be reduced by examining the relationships in people who did not have pre-existing disease at the start of follow-up[6–8] and did not die early on,[7,9] and in lifelong non-smokers.[6,7] To date, however, few large prospective studies of BMI and overall and cause-specific mortality in China have simultaneously[6] taken all these steps. To help fill this gap, we report here the results from a prospective study of 220 000 men across China, with 40 000 deaths after 15 years of follow-up. Our aims are to describe the association of a single BMI measurement during middle or old age with subsequent all-cause mortality, after taking rigorous steps to reduce the biases that can be caused by pre-existing disease and smoking; and to describe how much of the association is accounted for by each of the main specific causes of death.

Methods

Baseline survey

The study purpose and design are described elsewhere.[10,11] Briefly, 224 064 men were recruited in 1990–91 from 45 areas across China, chosen randomly from China's 145 Disease Surveillance Points (DSPs), which are nationally representative and cover ~1% of China's population. In each area (22 rural, 23 urban), two or three residential units (rural villages or urban street committee catchments) were randomly selected and all resident men aged ⩾40 years were invited, of whom ~80% accepted.

In local health screening clinics set up for the study, trained health workers administered a standardized questionnaire and took physical measurements. The questionnaire included tobacco, alcohol, education and self-reported medical history. Measurements included systolic and diastolic blood pressure (SBP/DBP, mean of three measurements), weight (from standard scales) and height (from a non-stretchable tape measure on a wall).

Mortality follow-up

Subsequently, vital status was monitored by DSP staff through their death registries, with regular cross-checks against local residential records kept at the Public Security Bureau, supplemented annually by active confirmation through street committees or village administrators. Causes were sought from official death certificates, supplemented, if necessary, by review of medical records. Underlying causes were coded according to the 9th International Classification of Diseases (ICD-9) by DSP staff in Beijing, blind to baseline information. In the relatively few deaths without recent medical attention (<5%), standardized procedures were used to determine probable causes from symptoms or signs described by informants. The ICD-9 definitions of the analysed endpoints are shown in Supplementary Table S1 available as Supplementary Data at *IJE* online. About 9% of the men were known to be lost to follow-up by the end of Year 15 (12 790 out of 142 214 men in the main analyses).

Statistical analysis

This report analyses deaths between baseline 1990–91 and 2006. Men were excluded if age at baseline was ⩾80 years (3365 men) or BMI was missing (154), <15 kg/m^2 (385) or ⩾35 kg/m^2 (113). To limit biases that can be caused by pre-existing disease,[6–8] most analyses also exclude participants who reported in 1990–91 that they had been diagnosed with chronic obstructive pulmonary disease (COPD, 29 687 men), asthma (3841), heart disease (7380), stroke (1788), cancer (922), peptic ulcer (11 979), cirrhosis (471), kidney disease (2853), hepatitis (3589) or tuberculosis (6280), and, for the same reason, analyses generally also exclude the first 5 years of follow-up.[7] These combined exclusions left 142 214 men in the main analyses with age at risk 45–79 years.

Associations between BMI and mortality were estimated by Cox regression, with stratification for age at risk (5-year groups), area (45 strata), tobacco (3 strata: current, ex- or never regular smoker), alcohol (at least weekly/not), units of alcohol per week (continuous covariate) and education (4 strata), for those men with data on all the stratifying variables. In analyses of BMI as a categorical variable, boundaries were chosen to include the standard international[12] cut-points of 18.5, 25 and 30 kg/m^2, thus enabling direct comparisons with results from many other countries. Values exactly on a boundary went above it. Hazard ratios (HRs) for particular BMI categories are presented as floating absolute risks,[13] which associate with each HR a 95% confidence interval (CI, calculated as the log risk ±1.96 times its floated standard error) reflecting the amount of data in that BMI category. In analyses with BMI as a continuous variable, log risk was regressed on BMI within two ranges: 15 to <23.5 kg/m^2 (termed the lower range) and 23.5 to <35 kg/m^2 (upper range), yielding HRs per 5 kg/m^2. The boundary 23.5 kg/m^2 was chosen because it is near the midpoint of the BMI category with the lowest overall mortality, and it had appreciable numbers of low-risk individuals on either side of it. Plots of log cumulative hazard against log survival time for categories of the explanatory variables indicate that the proportional hazards assumption held well. Interactions were assessed by inserting product terms into Cox models. Some results are reported separately for urban and rural areas because of important socio-cultural differences between urban and rural parts of China.

Ethics and consent

The study was approved by the Chinese Center for Disease Control and Prevention (CDC) ethics committee and by each provincial CDC research board. All participants gave oral informed consent.

Results

Distribution and correlates of BMI

For the 142 214 men who had no history of disease at baseline and survived the first 5 years of follow-up, mean (standard deviation) BMI at survey in 1990–91 was 21.8 (2.5) kg/m^2. It was ~2 kg/m^2 higher among the 31 373 men living in urban areas (23.3 kg/m^2) than among the 110 841 men living in rural areas (21.4 kg/m^2). Most men (83%) had a BMI of 18.5 to <25 kg/m^2; 7% had a lower BMI (15 to <18.5 kg/m^2) and 10% a higher BMI (25 to <35 kg/m^2). Just 0.6% had a BMI of 30 to <35 kg/m^2.

Height, alcohol consumption and education did not vary much by BMI, but mean age at survey was lowest at 20–25 kg/m^2 and prevalence of current smoking was somewhat higher at lower BMI (Table 1). Throughout its range, BMI was associated positively and strongly with blood pressure (Table 1), though the association was stronger in urban areas than rural areas: 7.2/4.7 mmHg SBP/DBP per 5 kg/m^2 versus 4.8/3.2 mmHg (adjusted for age and area; SBP interaction $P < 0.0001$).

All-cause mortality

Of the 142 214 men, 17 800 died between Years 5 and 15 of follow-up. Overall mortality had a U-shaped association with BMI, with the lowest mortality at a BMI of ~22.5–25 kg/m^2 both in rural and urban areas, and among ever- and never-smokers (Figure 1). In the lower BMI range (15 to <23.5 kg/m^2), each 5 kg/m^2 higher BMI was associated with 14% lower mortality (HR 0.86, 95% CI 0.82–0.91); in the upper BMI range (23.5 to <35 kg/m^2), it was associated with 27% higher mortality (HR 1.27, 95% CI 1.15–1.40). There was weak evidence (*P*-value for interaction = 0.03) that the inverse association in the lower range was steeper in urban areas (HR 0.73, 95% CI 0.63–0.86 per 5 kg/m^2) than in rural areas (HR 0.88, 95% CI 0.83–0.93 per 5 kg/m^2), but no evidence (*P*-value for interaction = 0.86) that the association differed between ever- and never-smokers (Supplementary Table S2 available as Supplementary Data at *IJE* online). In the upper BMI range, there was no evidence that the association differed between any of these subgroups.

In the only analyses in this report to include the other 77 833 men from the full cohort of 224 064 men (Table 2), which involves a further 22 900 deaths, the inverse association in the lower BMI range was more than twice as steep in those with a positive disease history (e.g. HR 0.60, 95% CI 0.55–0.65 per 5 kg/m^2 during the first 5 years) as in those without. For men with no disease history,

Table 1 Baseline distributions of disease risk factors by BMI in 142 214 men with at least 5 years of follow-up and no history of serious disease

	BMI, kg/m^2						
	15 to <18.5	18.5 to <20	20 to <22.5	22.5 to <25	25 to <27.5	27.5 to <30	30 to <35
Men (*n*)	10 204	23 783	60 828	33 084	10 373	3059	883
BMI, mean (kg/m^2)	17.7	19.3	21.3	23.6	26.0	28.4	31.3
Potential confounders							
Age, mean (years)	55.8	53.4	51.7	51.4	52.1	53.3	54.4
Education <6 years (%)[a,b]	69	70	68	67	64	65	66
Height, mean (m)[a,b]	1.66	1.65	1.65	1.64	1.64	1.64	1.62
Current smoker (%)[a,b]	69	68	66	62	57	54	48
Current drinker (%)[a,b]	32	32	33	34	36	36	32
Known intermediate factors[c]							
SBP,[a,b] mean (mmHg)	119.1	120.4	122.3	124.3	128.1	132.3	135.3
Diabetes (%)[a,b]	0.3	0.3	0.3	0.4	0.6	0.5	1.8

[a]Adjusted for baseline age and area.
[b]*P*-value for trend across BMI categories: all <0.001.
[c]No information available on blood lipids.

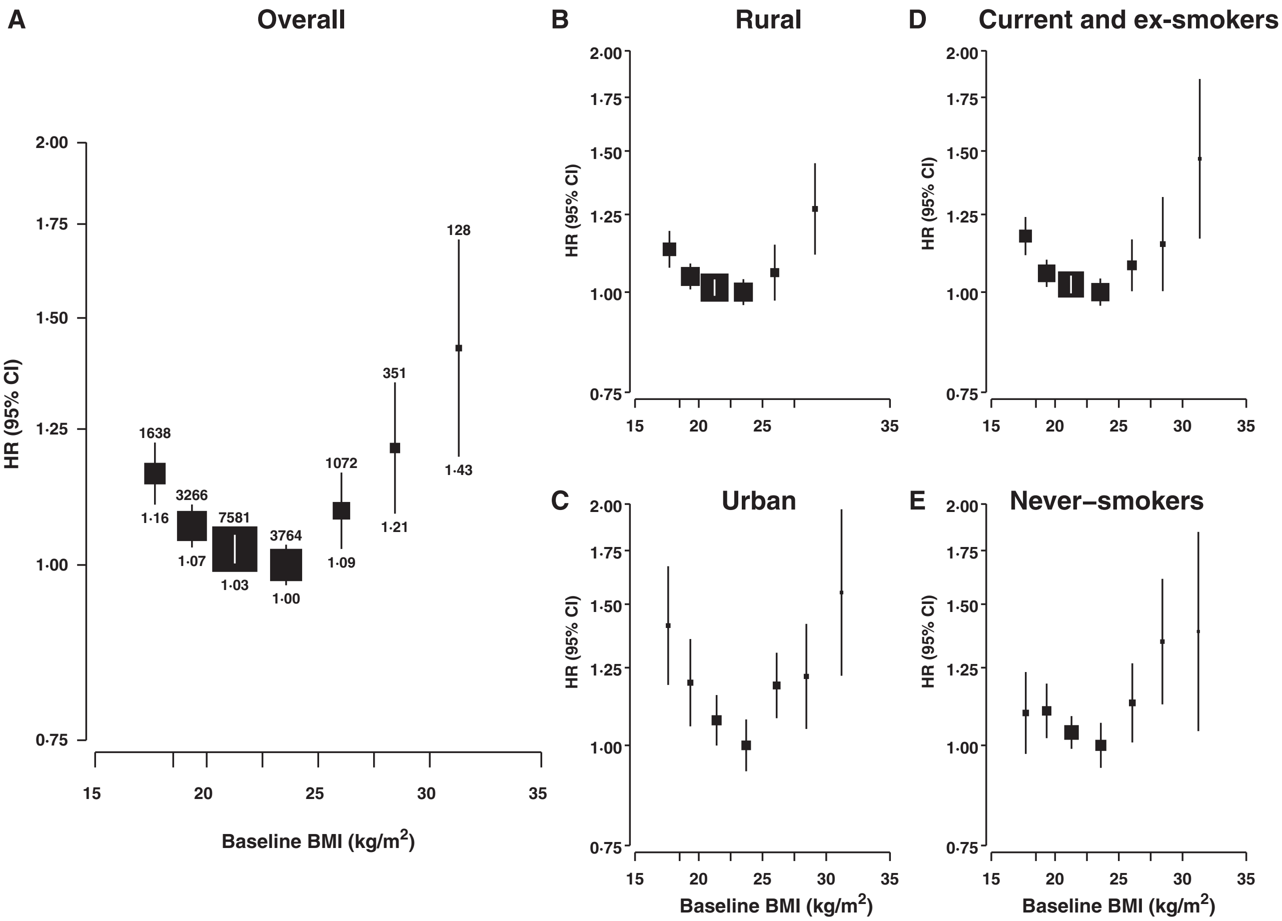


Figure 1 All-cause mortality versus baseline BMI in 142 214 men with at least 5 years of follow-up and no history of serious disease. HRs adjusted for age at risk (45–79 years), area, smoking, alcohol and education. First 5 years of follow-up excluded. Area of square inversely proportional to floated variance of log HR. Error bars indicate 95% CI. Boundaries of BMI groups indicated by notches. (A) Overall (17 800 deaths), (B) rural (15 196 deaths), (C) urban (2604 deaths), (D) current and ex-smokers (13 608 deaths) and (E) never-smokers (4192 deaths). Numbers above error bars indicate numbers of deaths; numbers below error bars indicate HRs

Table 2 All-cause mortality HR for 5 kg/m^2 higher baseline BMI, by BMI range, in 142 214 men with at least 5 years of follow-up and no history of serious disease, and in 77 833 other men

		BMI			
		15 to <23.5 kg/m^2		23.5 to <35 kg/m^2	
	Men[a]	Deaths	HR (95% CI)[b]	Deaths	HR (95% CI)[b]
No previous disease in 1990–91					
Follow-up (years)					
5–15	142 214	14 491	0.86 (0.82–0.91)	3309	1.27 (1.15–1.40)
0–4	22 370	8425	0.79 (0.74–0.84)	1678	1.08 (0.94–1.23)
Previous disease in 1990–91[c]					
Follow-up (years)					
5–15	44 034	5536	0.66 (0.61–0.72)	1466	1.39 (1.21–1.59)
0–4	11 429	4828	0.60 (0.55–0.65)	967	1.09 (0.92–1.31)

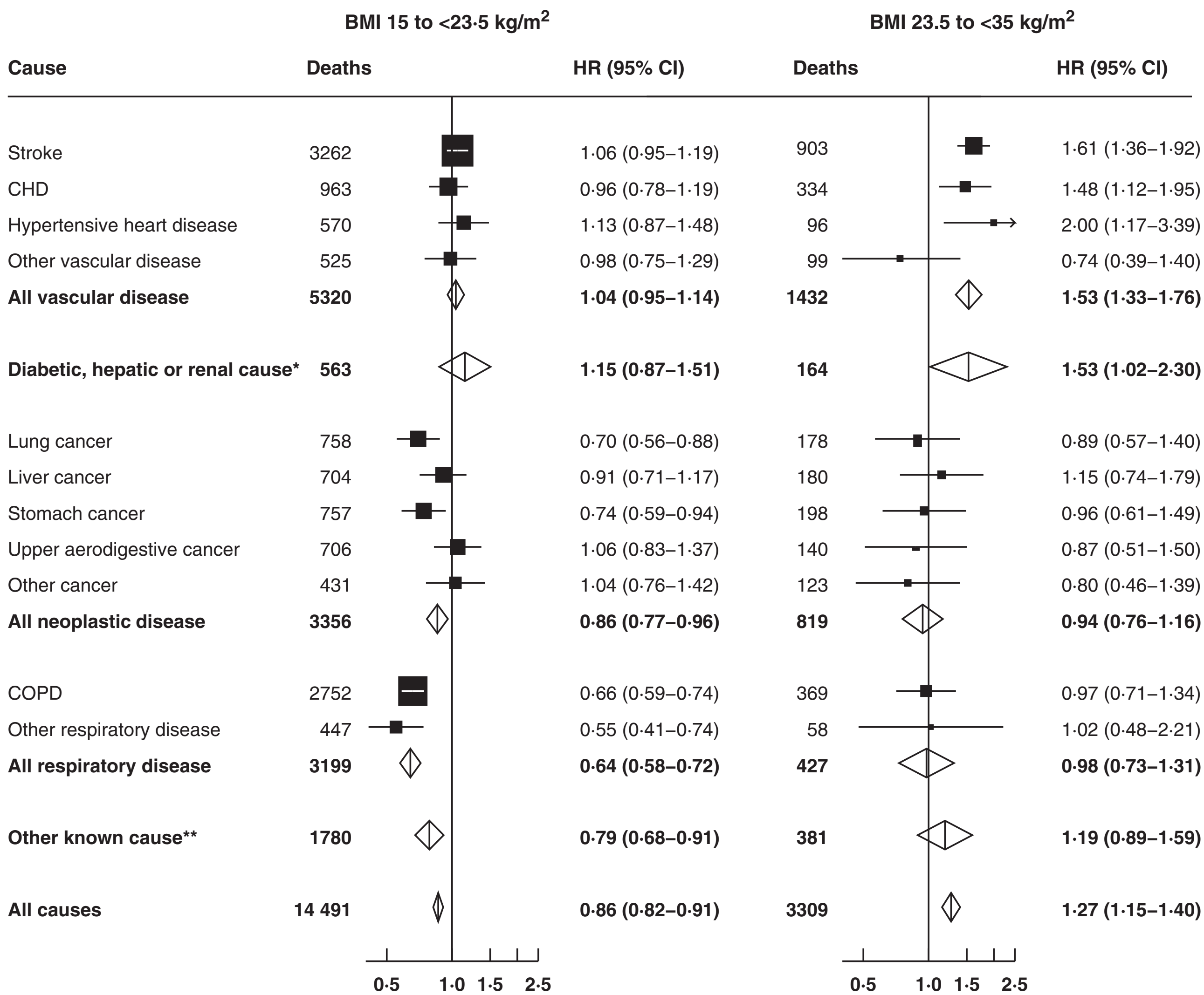
[a]Excludes 4017 men with baseline age ⩾80 years, or with baseline BMI that was missing, <15 kg/m^2 or ⩾35 kg/m^2.
[b]HR and 95% CI for 5 kg/m^2 higher BMI within the BMI range, adjusting for smoking, alcohol, education, area of residence and age at risk. HR < 1 indicates an inverse association.
[c]History at survey in 1990–91 of diagnosed COPD, asthma, heart disease, stroke, cancer, peptic ulcer, cirrhosis, kidney disease, hepatitis or tuberculosis.

the inverse association was stronger during the first 5 years than subsequently (Table 2).

Cause-specific mortality

Of the 17 800 deaths among men with at least 5 years of follow-up and no disease history, 38% were vascular (6752), 23% neoplastic (4175) and 20% respiratory (3626). About 2% had an ill-defined cause (359). The most common specific causes of death (Figure 2) were stroke (23% of the 17 800), COPD (18%), coronary heart disease (CHD, 7%) and cancers of the stomach, lung, liver and upper aerodigestive tract (5% each). For most specific causes of death, the associations with BMI were reasonably log linear above or below 23.5 kg/m^2 (Supplementary Figures S1 and S2 available as Supplementary Data at *IJE* online).

In the lower range (15 to <23.5 kg/m^2), mortality from COPD, other respiratory diseases, lung cancer and stomach cancer were each associated inversely with BMI (Figure 2). For COPD, mortality was 34% lower for 5 kg/m^2 higher BMI (HR 0.66, 95% CI 0.59–0.74), the inverse association was little affected by adjustment for cigarettes per day and age started, and a strong inverse association was present even after excluding the first 10 years of follow-up and among never-smokers (Supplementary Table S2 available as Supplementary Data at *IJE* online). For cancers of the lung and stomach, there was no evidence of an association among never-smokers; the CIs were,



*For components, see Supplementary Table S2 available as Supplementary Data at *IJE* online
**Excludes ill-defined causes (273 deaths at low BMI, 86 at high BMI)

Figure 2 Cause-specific mortality HR for 5 kg/m^2 higher baseline BMI, by BMI range, in 142 214 men with at least 5 years of follow-up and no history of serious disease. HR per 5 kg/m^2, adjusted for age at risk (45–79 years), area, smoking, alcohol and education. First 5 years of follow-up excluded. Area of square inversely proportional to variance of log HR. Diamond indicates summary result. Error bar and diamond width indicate 95% CI. HR < 1 indicates an inverse association however, wide (Supplementary Table S2 available as Supplementary Data at *IJE* online). Although blood pressure continued to decrease with BMI throughout the full BMI range (Table 1), mortality from stroke, CHD, hypertensive heart disease and other vascular disease was hardly related to BMI in the lower BMI range (Figure 2); nor was there any evidence of an association for vascular mortality in this range among never-smokers (Supplementary Table S2 available as Supplementary Data at *IJE* online). Mortality from other known causes was somewhat greater at low BMI, chiefly because of an excess of deaths from external causes, which in part was due to an excess of fatal traffic-related injuries (HR 0.67, 95% CI 0.44–0.96) (Supplementary Table S2 available as Supplementary Data at *IJE* online).

In the upper range (23.5 to <35 kg/m^2), mortality from stroke, CHD, hypertensive heart disease and the composite of diabetic, renal and hepatic disease,[7] were each associated positively with BMI (Figure 2, and Supplementary Table S2 available as Supplementary Data at *IJE* online). There was no evidence that the association for stroke differed by pathological subtype (Supplementary Table S2 available as Supplementary Data at *IJE* online), though only a small proportion of the subtypes would have been confirmed by imaging or autopsy. For vascular disease overall, mortality was ~50% higher for 5 kg/m^2 higher BMI (HR 1.53, 95% CI 1.33–1.76). This association appeared to be much the same for never- as for ever-smokers, and for men living in urban areas as for men living in rural areas (Supplementary Table S2 available as Supplementary Data at *IJE* online), although the CIs do not rule out the possibility of moderate differences. In the upper BMI range, there was no evidence of an association for any other specific cause of death, for the neoplastic category, or for the respiratory category.

Absolute mortality rates

Using the study's own mortality rates (mean age at death: 67 years), over half of the absolute excess mortality (54%) in the lower BMI range was accounted for by excess COPD, and most of the remainder was due to excess mortality from other respiratory disease (12%), lung cancer (13%), stomach cancer (11%) and external causes (13%). In the upper range, more than half of the absolute excess mortality was accounted for by excess stroke (55%), with the remainder due chiefly to excess CHD (16%), hypertensive heart disease (8%) and diabetic, renal and hepatic diseases (9%). In the upper range, none of the excess was attributable to neoplastic disease.

Using China's estimated mortality rates for men aged 50–69 years in 2000,[14] a BMI of 30 kg/m^2 compared with 25 kg/m^2 could, assuming that the relevant associations were causal, have been associated with a stroke mortality rate of about 5.2/1000 compared with 3.2/1000—i.e. with an excess of 2.0 stroke

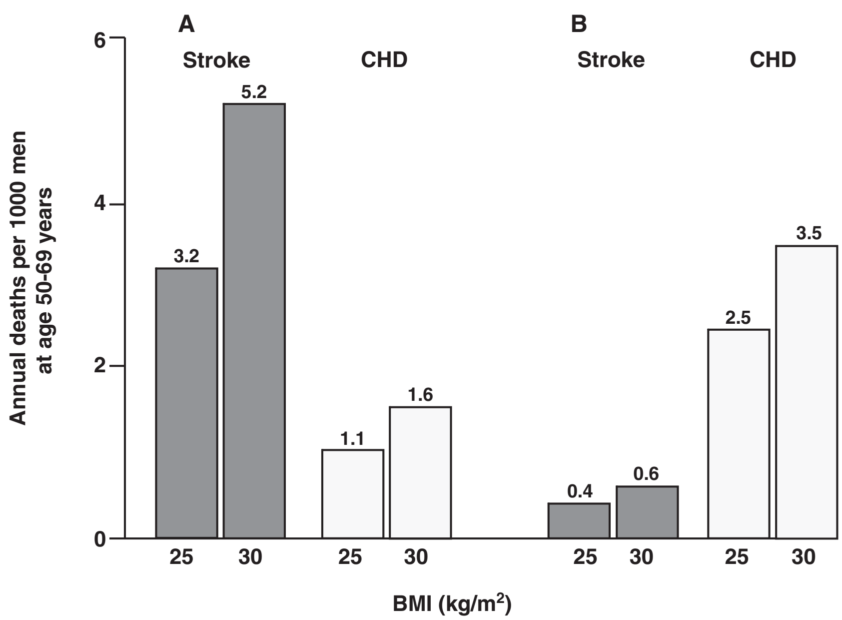


Figure 3 Male stroke and CHD mortality at 30 kg/m^2 compared with 25 kg/m^2 in China and the USA, estimated using year 2000 mortality rates at age 50–69 years. Number at top of the bar is mortality rate (annual deaths per 1000 men). (A) For China, the mortality rate at 25 kg/m^2 was taken as the average rate (mean of rates at age 50–54, 55–59, 60–64 and 65–69 years) for the whole Chinese population (calculated as a 30:70 weighted average of the rates for selected urban areas and selected rural areas provided by China to the WHO), and the mortality rate at 30 was calculated as that at 25 kg/m^2 multiplied by the relevant HR from this study. (B) For USA, the average WHO mortality rate (same age categories as for China) was assumed to be that at 28.5 kg/m^2, and the mortality rates at 30 and 25 kg/m^2 were calculated by multiplying this rate by male HRs derived from the Prospective Studies Collaboration[7]

deaths for every 1000 men in this age range (Figure 3). For CHD, there would have been an excess of just 0.5 CHD deaths per 1000.

Discussion

In this large, nationally representative prospective study of men in China, the lowest all-cause mortality was among those with a BMI of ~22.5–25 kg/m^2. The excess mortality below that apparent optimum was accounted for chiefly by a strong inverse association for COPD, and that above it by a strong positive association for stroke.

Strengths, limitations and past studies

This may be the first large-scale prospective study in China to describe the association of a BMI measurement during middle or old age with subsequent all-cause mortality after—in its main analyses—simultaneously controlling for the biases that can be caused by pre-existing disease and smoking.[15–23] A 2006 report[15] from the largest previous study included people with pre-existing disease in its main analyses, and the main relative risks from that study imply that the inverse association below the apparent optimum (~25 kg/m^2) was more than twice as steep as in the present study, but that the positive association above this BMI was nearly a third shallower. (Subsidiary analyses in that study for participants with pre-existing disease mixed that important group with those in the study who drank alcohol heavily or smoked cigarettes, thus obscuring any effects of previous disease.) In many previous studies,[7,8,18,24] people with pre-existing disease had unusually large risks at low BMI but relatively small risks at high BMI, probably because of disease-induced weight loss (reverse causation)[6–8] and, for a few diseases, possible beneficial effects of adiposity on prognosis once the disease has become established.[25] The 2006 report may, therefore, have substantially overstated the mortality hazards at low BMI but underestimated them at high BMI.

Our study did not collect blood (or, therefore, any information on blood lipids), nor any data on non-fatal morbidity, central adiposity or extreme adiposity. Moreover, BMI was measured for each participant at just one point in time, and although BMI may tend to be fairly stable once people reach middle age[7] (including in China[26]), recent evidence suggests that prolonged obesity may have larger effects on disease risks than recently acquired obesity,[27] which could have important implications for the current generation of younger Chinese adults since average BMI has risen rapidly in this group.

Causation for specific disease associations

Randomized, observational and laboratory evidence taken together now shows unequivocally that greater adiposity can cause CHD and stroke.[5,7,8,28–31] Observational evidence implies that most of the effects on CHD can be accounted for by the associations of adiposity with blood pressure, blood lipids and diabetes.[7,31] The strength of the positive associations for stroke, CHD and other vascular mortality in the upper BMI range of this study were generally consistent with results from prospective studies of other Asian[32,33] or chiefly Western[7,31] populations, although the study's confidence intervals exclude only big differences. The study suggests that, by far, the main way obesity kills in China is stroke; in the USA (Figure 3) and other Western countries, in contrast, it is CHD.[7] However, the lack of a positive association for vascular diseases in the lower BMI range,[11,34] despite blood pressure continuing to decrease with BMI throughout that range, is surprising and hard to explain. The same phenomenon has been reported previously in other populations for stroke in general,[7,35] and for haemorrhagic stroke in particular.[32,33,35,36]

At baseline, 5 kg/m^2 higher BMI was associated with ~5 mmHg (rural) to 7 mmHg (urban) higher SBP. In this China study, a sustained increase in SBP of 5 or 7 mmHg would, assuming SBP had similar levels of random measurement error to those in Western populations,[37] be expected to increase vascular mortality by ~16–24%.[11,34] The actual observed increase for 5 kg/m^2 higher BMI was ~50% (Figure 2), suggesting that blood pressure accounted for one-third to one-half of the association of high BMI with vascular mortality. Some of the excess vascular mortality at high BMI will also have been accounted for by diabetes, but diabetes was uncommon in this population.

Obesity is considered a cause of some specific types of cancer,[7,38,39] but in China it may still be only a negligible cause of cancer overall.

As in Western populations, the higher overall mortality at lower BMI in China was due mostly to smoking-related diseases (COPD, lung cancer and, for China, stomach cancer). The reasons for this have not been fully explained.[7] The associations might have been residually confounded by some aspects of smoking,[7] though for COPD there was a strong inverse association even among never-smokers. These smoking-related diseases can each cause weight loss, but there were inverse associations even after excluding the first 5 years of follow-up (and 10 years, for COPD). Whether the inverse associations for these diseases are wholly the result of confounding, or partly causal, is not known.[7,40]

Interpretation of all-cause mortality

If the higher mortality at low BMI levels is largely or wholly a consequence of bias, then the real optimum BMI for mortality could be substantially lower than 22.5–25 kg/m^2. Above 22.5–25 kg/m^2, the greater adiposity associated with 5 kg/m^2 may increase overall mortality in China by ~30% (but plausibly in the range 15–40%). This central estimate is similar to the ~30% increase generally observed in equivalent analyses of large Western populations;[7,8,30] it is stronger, however, than in a recent analysis of East Asian populations[41] (that analysis, though, adjusted for vascular intermediate factors and it did not adjust for smoking). Given the substantially different mix of causes of death in China (Figure 2) compared with any Western country,[42] numerical consistency of relative risks for all-cause mortality need not be expected.

Implications for BMI guidelines in China

Several proposals have been made for BMI cut-points defining overweight and obesity in Chinese[43,44] and other Asian populations,[44–47] with the proposed cut-points generally differing from the commonly used international values[12] (i.e. 25 and 30 kg/m^2). But, these proposals have been based mostly on laboratory studies and cross-sectional surveys,[44,48] rather than on prospective studies. This large prospective study suggests that the optimum BMI for mortality is not very different in China from that in many other studied populations,[7,24,30,49] and that the relative increases in overall mortality above that level may not be so different either. Future guidelines will need, however, to also reflect associations with incidence of serious non-fatal diseases and injuries, for which there is still little large-scale prospective evidence from China.[26,50]

Supplementary Data

Supplementary Data are available at *IJE* online.

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Conflict of interest: None declared.

KEY MESSAGES

- After simultaneously controlling for biases that can be caused by pre-existing disease and smoking, the lowest all-cause mortality in this prospective study of 220 000 men in China was observed for those with a BMI of ~22.5–25 kg/m^2.
- Below that apparent optimum, more than half of the excess mortality was due to excess COPD.
- Above the apparent optimum, more than half of the excess mortality was due to excess stroke.
- Previous studies in China may have overestimated the possible hazards at low BMI, but underestimated the well-established hazards at high BMI.
- There is little evidence that the optimum BMI for overall mortality in China differs much from that in most other studied countries.

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Commentary: Obesity and mortality in China: The shape of things to come

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The prevalence of obesity in Western countries has escalated to alarming proportions in recent years. In 2009, the prevalence of obesity reached 36% among US adults, and is estimated to reach 50% by 2030 if current rates do not subside.[1,2] This epidemic is not limited to Western countries. Countries such as China, with large populations undergoing rapid transitions to an urbanized and Western diet and lifestyle, are particularly susceptible to the public health burden of obesity, given their high absolute number at risk, despite lower overall prevalence of obesity.[3]

Overweight and obesity are major risk factors for type 2 diabetes and cardiovascular disease, likely through the metabolic consequences of excess adipose accumulation (insulin resistance, dyslipidaemia, inflammation). Additionally, hormone-secreting adipose tissue may also increase risk of some cancers. Asians tend to be particularly susceptible to many of these consequences, as they tend to develop type 2 diabetes, hypertension and other metabolic diseases at lower body mass index (BMI) levels than Caucasians. This is likely due to differences in body composition.[4] For this reason, lower BMI cut-off points for classifying overweight and obesity have been proposed for Asian populations. In China, for example, BMI cut-off points of 24 and 28 are widely used to define overweight and obesity, respectively.[5]

Despite overwhelming evidence associating excess body weight with several chronic disease end points, its relationship with mortality has been widely debated. In particular, there is controversy surrounding the shape of association curve between BMI and mortality. Various J-shaped, U-shaped and linear relationships have been identified in epidemiological literature, with some suggesting overweight BMI status is associated with increased mortality, and others showing no or even slightly decreased mortality, compared with normal weight individuals.[6] The estimated number of deaths attributable to overweight and