

BODY MASS INDEX AS A PREDICTOR OF MORTALITY IN OLDER PEOPLE IN TAIWAN

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SUMMARY

Background: Obesity is associated with diverse health risks, but its role as a risk factor for death remains controversial in the elderly. This study estimated the association of body mass index (BMI) with the risk of death from any cause and from specific diseases in elderly Taiwanese.

Methods: The Six-Community Hypertension Intervention Project Study, a nationwide population-based cohort, was conducted in 1982 and followed up for 23 years. Cause of death was ascertained by review of death certificate files. Proportional hazards models were used to evaluate the association between the baseline BMI and risk of death.

Results: Of 1,568 participants aged 65 years (range, 60–75 years) at study entry, 1,085 (69%) died during follow-up. The relationship between death from any cause and BMI follows a J-shaped pattern. Increasing BMI categories were associated with increased risk of all-cause mortality (BMI, 25–26.9: hazard ratio, HR, 1.36; 95% confidence interval, CI, 1.11–1.67; BMI \geq 27: HR, 1.46; 95% CI, 1.15–1.85). Death from diabetes, cardiovascular diseases or cancer increased progressively with increasing categories of BMI, and HRs were significantly increased at BMI levels $>$ 23.0 kg/m² (BMI, 23–24.9: HR, 1.29; 95% CI, 1.05–1.60; BMI, 25–26.9: HR, 1.58; 95% CI, 1.21–2.05; BMI \geq 27: HR, 1.74; 95% CI, 1.29–2.35). These associations were more obvious in men than in women.

Conclusion: This study found that BMI $>$ 25 kg/m² was a significant independent predictor of all-cause mortality, especially among older men. BMI $>$ 23 kg/m² also increased risk of mortality from cancer, cardiovascular diseases and diabetes. The relationship was J-shaped in older Taiwanese. [International Journal of Gerontology 2009; 3(1): 39–46]

Key Words: body mass index, elderly, mortality, obesity, Taiwan

Introduction

Obesity is an epidemic problem in most industrialized countries and is also a growing public health problem in Taiwan with nearly one quarter of the adult population currently overweight or obese¹. The prevalence of overweight and obese individuals is particularly high

in the elderly. In Taiwan, 48.3% of men and 57.2% of women aged 60–69 years are either overweight or obese (defined as body mass index [BMI] \geq 24 kg/m²)². Obesity is associated with diverse health risks, such as increased incidence of diabetes mellitus and coronary heart disease, and mortality of cardiovascular diseases (CVD)^{3,4}. However, the role of body weight as a risk factor for death remains controversial.

Being overweight or obese was positively associated with an increased risk of all-cause mortality in the Cancer Prevention Study II⁵. The rate of death was lowest among men with a BMI of 23.5–24.9 and among women with a BMI of 22.0–23.4. However, in the



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Accepted: January 11, 2009

National Health and Nutrition Examination Survey I, II or III, being overweight was not related to increased mortality⁶.

The effects of an increasing BMI on mortality risk are less pronounced in the elderly than in young and middle-aged adults^{7–13}. Some studies found a greater BMI to be a risk factor for mortality, while others found different results. Of the 13 studies of individuals aged 65 years or older reviewed by Heiat et al.¹⁴ in 2001, most showed a non-significant or even a negative association between BMI and all-cause mortality. In 2006, Janssen et al.¹⁵ published a literature review of 26 studies examining the BMI–mortality relationship in the elderly. The findings of this meta-analysis showed that a BMI in the overweight range is not associated with a significantly increased risk of mortality, while a BMI in the obese range is only associated with a modest increase (about 10%) in mortality risk¹⁵.

Data are limited on the relationship between obesity and survival in the Taiwanese population. The aim of the present study was to examine the association of BMI with the risk of death from any cause and from specific diseases in the elderly in Taiwan.

Materials and Methods

Details of the Six-Community Hypertension Intervention Project (SCHIP) Study baseline cohort have been described previously¹⁶. This nationwide study was conducted in 1982 and followed up for 23 years. The initiated SCHIP data were collected in six communities in Taiwan from October 1982 to September 1983. A total of 7,763 subjects, representative of the general adult population in Taiwan through stratified systematic clustering sampling, participated in a nationwide population-based survey. All subjects gave written informed consent for participation. Subjects were excluded if they were aged less than 60 years or older than 75 years, and if they had suffered stroke and were bedridden. To minimize the effect of existing medical conditions on the baseline BMI, we excluded subjects who died during the first 3 years of follow-up. The remaining 1,568 subjects were included in the analyses.

Data collection

Data on sociodemographic characteristics including sex, age, exercise habits, smoking habits, alcohol consumption, family history of cardiovascular-related diseases,

physician-diagnosed diseases and medication history were collected by trained public health workers during a home visit. During the visit, sitting blood pressure (BP), weight and height measurements were taken. BMI was calculated as: body weight (kg)/height (m)².

Survival status and cause of death through December 31, 2006, was ascertained by review of death certificate files (documented underlying cause of death by the International Classification of Diseases, Ninth Revision [ICD-9], from the Department of Health in Taiwan) by a unique subject's national identification number. A death was ascribed to CVD if the primary cause of death was CVD (ICD-9 codes 390–459). Cancer is defined as ICD-9 codes 140–239. Diabetes is defined as ICD-9 code 250. Death from bronchial or lung diseases is defined as ICD-9 codes 460–519.

Statistical analysis

Data were analyzed using SAS version 9 (SAS Institute Inc., Cary, NC, USA). These cutoffs of BMI values corresponded to the definition of overweight and obesity suggested by the 2000 World Health Organization Asian Pacific Guideline¹⁷. Subjects were classified into underweight (BMI < 18.5 kg/m²), normal weight (BMI, 18.5–22.9), overweight (BMI, 23–24.9), and obese (BMI ≥ 25) at baseline. We divided the obesity group into two groups (BMI, 25–26.9, and BMI ≥ 27) to match the definition of obesity (BMI ≥ 27) suggested by the Department of Health in Taiwan.

Cox's proportional hazards models were used to evaluate the association between the baseline BMI and risk of death by adjusting for age, exercise habits, education level, alcohol drinking, and smoking status. Study subjects with normal BMI scores served as controls. The criteria for statistical significance were $p < 0.05$ and a 95% confidence interval (CI) of hazard ratios (HRs) that excluded 1.

Results

Sample characteristics

The mean age of the study cohort participants was 65.7 ± 4.0 years; 55.3% were men, 36.3% had a history of hypertension, and 17.5% had a history of diabetes. The characteristics of the study sample are summarized in Table 1. Overall mean BMI was 22.2 ± 3.3 kg/m² (21.8 ± 3.0 kg/m² in men and 22.7 ± 3.6 kg/m² in women). The distribution of the study population categorized

Table 1. Baseline characteristics of this study's population*

| Characteristics | Total subjects | Men | Women | <i>p</i> |
|--------------------------------------|---------------------|-------------------|-------------------|----------|
| | (<i>n</i> = 1,568) | (<i>n</i> = 868) | (<i>n</i> = 700) | |
| Age (yr) | 65.7 ± 4.0 | 65.7 ± 4.0 | 65.6 ± 4.0 | 0.421 |
| Educational level (yr) | | | | |
| None | 903 (57.6) | 337 (38.8) | 566 (80.9) | < 0.0001 |
| 1–6 | 500 (31.9) | 389 (44.8) | 111 (15.9) | |
| > 6 | 165 (10.5) | 142 (16.4) | 23 (3.3) | |
| Smoking status | 561 (35.8) | 523 (60.3) | 38 (5.4) | < 0.0001 |
| Alcohol consumption | 244 (15.6) | 211 (24.3) | 33 (4.7) | < 0.0001 |
| Exercise [†] | 986 (70.6) | 584 (74.4) | 402 (65.8) | 0.0005 |
| | (<i>n</i> = 1,396) | (<i>n</i> = 785) | (<i>n</i> = 611) | |
| Hypertension history | 569 (36.3) | 325 (37.4) | 243 (34.7) | 0.2868 |
| Diabetes history | 17.5 | 13.5 | 22.7 | 0.0011 |
| Body mass index (kg/m ²) | 22.2 ± 3.3 | 21.8 ± 3.0 | 22.7 ± 3.6 | < 0.0001 |
| Systolic blood pressure (mmHg) | 131.7 ± 22.8 | 131 ± 22.5 | 132.5 ± 23.1 | 0.2127 |
| Diastolic blood pressure (mmHg) | 79.5 ± 12.7 | 80.2 ± 12.8 | 78.7 ± 12.5 | 0.0275 |
| Fasting plasma glucose (mg/dL) | 100.9 ± 48.3 | 94.4 ± 35.6 | 109.3 ± 60.1 | < 0.0001 |
| Total cholesterol (mg/dL) | 242.4 ± 62.0 | 239.3 ± 61.0 | 246.5 ± 63.1 | 0.1105 |
| Triglyceride (mg/dL) | 173.1 ± 70.4 | 168.2 ± 63.4 | 179.6 ± 78.2 | 0.0302 |

*Data presented as mean ± standard deviation or *n* (%); [†]for subjects with complete exercise information.

according to the 2000 World Health Organization Asian Pacific Guideline is as follows: 11.6% were underweight (BMI < 18.5 kg/m²), 54.3% were normal weight (BMI, 18.5–22.9 kg/m²), 17.5% were overweight (BMI, 23–24.9 kg/m²), and 16.5% were obese (BMI > 25.0 kg/m²). Based on the categories of classification of the Department of Health in Taiwan, 6.6% of the cohort were obese.

Men had significantly higher rates of smoking and alcohol consumption than women. Men also had significantly higher levels of diastolic blood pressure than women, but lower BMI, fasting blood glucose and triglyceride levels.

BMI and mortality

Of the 1,568 participants aged 65 years (on average) at study entry (1982–83), 1,085 (69%) died during the 23 years of follow-up (Table 2). The rates of death from cancer in men were greater than in women (24.1% vs. 16.6%), but the rates of death from CVD in men were lower than in women (25.3% vs. 33.3%).

There were more deaths from all causes, cancer, diabetes and CVD in the higher BMI categories compared with the normal BMI classification. Excessive risk of death from cancer or lung diseases also was present

in the underweight group. The all-cause mortality (48.1 per 1,000 person-years) was significantly increased at BMI levels > 25.0 kg/m² (Figure). Elevated BMI scores were associated with increased risks of all-cause mortality in adjusted analyses (BMI, 25–26.9: HR, 1.36; 95% CI, 1.11–1.67; BMI ≥ 27: HR, 1.46; 95% CI, 1.15–1.85). Deaths from diabetes, CVD or cancer increased progressively with increasing categories of baseline BMI, and HRs were significantly increased at BMI levels > 23.0 kg/m² (BMI, 23–24.9: HR, 1.29; 95% CI, 1.05–1.60; BMI, 25–26.9: HR, 1.58; 95% CI, 1.21–2.05; BMI ≥ 27: HR, 1.74; 95% CI, 1.29–2.35).

Sex differences

The risk for all causes of death was not significantly different between women with BMI of 18.5–22.9 and those with BMI of 23–24.9 or > 25 (Table 3). There was also no difference in risk of cancer mortality in the overweight and obese groups compared with the normal-weight group in women.

However, the multivariate-adjusted HRs of all causes of death for the overweight group and obesity group in men were 1.49 (95% CI, 1.14–1.96) and 1.59 (95% CI, 1.13–2.23), respectively (Table 4). The risk of death from diabetes, CVD or cancer in men increased progressively

Table 2. Relationship of body mass index categories to all-cause and specific disease mortality in overall subjects

| | Body mass index categories (kg/m ²) | | | | |
|--|---|------------------------|----------------------|----------------------|-------------------|
| | < 18.5 (n = 182) | 18.5–22.9 (n = 852) | 23–24.9 (n = 275) | 25–26.9 (n = 155) | ≥ 27 (n = 104) |
| Death, n (%) | 132 (72.5) | 574 (67.4) | 188 (68.4) | 112 (72.3) | 79 (76.0) |
| Follow-up time (person-years) | 2,745.9 | 13,858.9 | 4,450.6 | 2,327.2 | 1,563.2 |
| Cumulative mortality rate (per 1,000 person-years) | 48.1 | 41.4 | 42.2 | 48.1 | 50.5 |
| HR (95% CI)* | | | | | |
| All-cause mortality | 1.18 (0.98–1.43) | 1 [Reference] | 1.09 (0.92–1.28) | 1.36 (1.11–1.67) | 1.46 (1.15–1.85) |
| Coronary heart disease mortality (codes 410–414) [†] | 1.87 (0.91–3.86) | 1 [Reference] | 1.44 (0.73–2.84) | 0.73 (0.22–2.41) | 0.41 (0.05–2.96) |
| Stroke mortality (codes 430–438) [†] | 0.40 (0.17–0.93) | 1 [Reference] | 1.41 (0.94–2.11) | 1.52 (0.91–2.55) | 1.50 (0.81–2.77) |
| Diabetes mortality (code 250) [†] | 0.59 (0.18–1.93) | 1 [Reference] | 1.53 (0.79–2.98) | 2.90 (1.45–5.77) | 3.26 (1.52–6.99) |
| Cancer mortality (codes 140–208) [†] | 1.86 (1.29–2.67) | 1 [Reference] | 1.11 (0.76–1.61) | 1.61 (1.04–2.50) | 1.89 (1.15–3.13) |
| Respiratory mortality (codes 460–519) [†] | 2.04 (1.40–2.98) | 1 [Reference] | 0.60 (0.36–1.01) | 0.76 (0.40–1.46) | 0.71 (0.31–1.62) |
| Heart diseases (codes 401–429) [†] | 0.77 (0.42–1.39) | 1 [Reference] | 0.81 (0.54–1.21) | 0.88 (0.47–1.64) | 1.05 (0.53–2.08) |
| CVD mortality (codes 390–459) [†] | 0.69 (0.44–1.08) | 1 [Reference] | 1.37 (1.04–1.82) | 1.33 (0.91–1.94) | 1.39 (0.90–2.16) |
| Diabetes and CVD mortality | 0.58 (0.45–1.03) | 1 [Reference] | 1.39 (1.08–1.91) | 1.55 (1.12–2.15) | 1.66 (1.14–2.43) |
| Diabetes, CVD and cancer mortality | 1.11 (0.85–1.45) | 1 [Reference] | 1.29 (1.05–1.60) | 1.58 (1.21–2.05) | 1.74 (1.29–2.35) |

*Cox regression model: adjusted for age, sex, alcohol intake status, smoking status, education levels and exercise; [†]death certificates using the National Death Files (International Classification of Diseases, Ninth Revision). HR = hazard ratio; CI = confidence interval; CVD = cardiovascular disease.

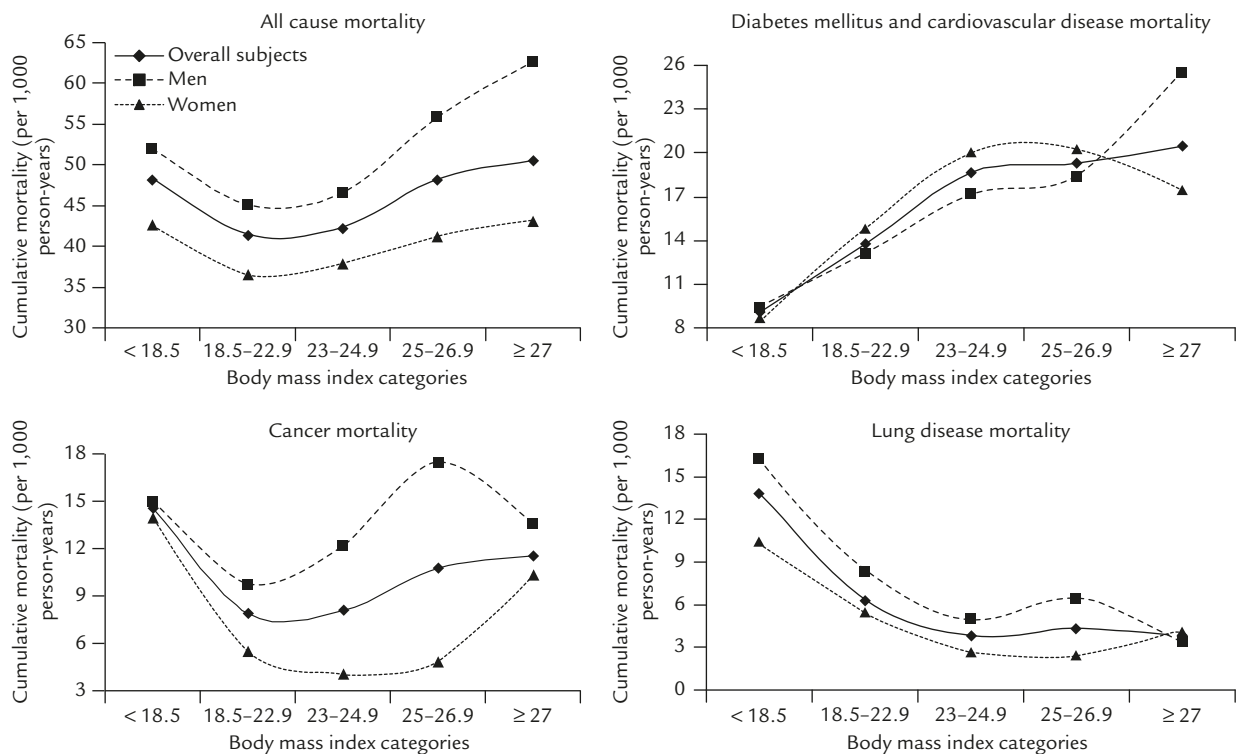


Figure. Relationship of categories of body mass index to cumulative all-cause mortality and specific cause mortality in men and women.

Table 3. Relationship of categories of body mass index to all-cause and specific disease mortality in women

| | Body mass index categories (kg/m ²) | | | | |
|--|---|------------------------|----------------------|---------------------|------------------|
| | < 18.5 (n = 72) | 18.5–22.9 (n = 360) | 23–24.9 (n = 131) | 25–26.9 (n = 77) | ≥ 27 (n = 60) |
| Death, n (%) | 49 (68.1) | 220 (61.1) | 85 (64.9) | 51 (66.2) | 42 (70.0) |
| Follow-up time (person-years) | 1,147.2 | 6,012.9 | 2,241.3 | 1,237.4 | 973.4 |
| Cumulative mortality rate (per 1,000 person-years) | 42.7 | 36.6 | 37.9 | 41.2 | 43.1 |
| HR (95% CI)* | | | | | |
| All-cause mortality | 1.23 (0.89–1.67) | 1 [Reference] | 1.04 (0.81–1.24) | 1.21 (0.89–1.64) | 1.34 (0.96–1.87) |
| Coronary heart disease mortality (codes 410–414) [†] | 2.43 (0.71–8.34) | 1 [Reference] | 3.10 (1.19–8.06) | 0.68 (0.08–5.49) | – |
| Stroke mortality (codes 430–438) [†] | 0.66 (0.23–1.88) | 1 [Reference] | 1.30 (0.72–2.37) | 1.39 (0.67–2.92) | 1.78 (0.85–3.73) |
| Diabetes mortality (code 250) [†] | 0.36 (0.05–2.71) | 1 [Reference] | 1.70 (0.77–3.75) | 2.54 (1.07–6.02) | 0.90 (0.21–3.93) |
| Cancer mortality (codes 140–208) [†] | 2.33 (1.27–4.28) | 1 [Reference] | 0.72 (0.34–1.50) | 0.91 (0.38–2.18) | 1.93 (0.95–3.94) |
| Respiratory mortality (codes 460–519) [†] | 2.22 (1.24–4.33) | 1 [Reference] | 0.49 (0.21–1.17) | 0.48 (0.15–1.57) | 0.98 (0.34–2.78) |
| Heart diseases (codes 401–429) [†] | 0.55 (0.20–1.52) | 1 [Reference] | 0.87 (0.49–1.53) | 0.90 (0.39–2.08) | 0.89 (0.35–2.28) |
| CVD mortality (codes 390–459) [†] | 0.67 (0.33–1.35) | 1 [Reference] | 1.33 (0.89–1.99) | 1.23 (0.72–2.09) | 1.42 (0.81–2.50) |
| Diabetes and CVD mortality | 0.61 (0.32–1.18) | 1 [Reference] | 1.36 (0.95–1.95) | 1.44 (0.92–2.25) | 1.31 (0.78–2.21) |
| Diabetes, CVD and cancer mortality | 1.13 (0.74–1.73) | 1 [Reference] | 1.18 (0.86–1.63) | 1.30 (0.87–1.93) | 1.48 (0.98–2.26) |

*Cox regression model: adjusted for age, sex, alcohol intake status, smoking status, education levels and exercise; [†]death certificates using the National Death Files (International Classification of Diseases, Ninth Revision). HR = hazard ratio; CI = confidence interval; CVD = cardiovascular disease.

with scores of baseline BMI > 23.0 kg/m², and HRs were significantly increased (BMI, 23–24.9: HR, 1.39; 95% CI, 1.05–1.85; BMI ≥ 27: HR, 1.83; 95% CI, 1.29–2.60; BMI, 25–26.9: HR, 2.02; 95% CI, 1.30–3.12).

Discussion

In this nationwide cohort of the elderly, the average baseline BMI was 22.2 kg/m² and BMI was a significant independent predictor of all-cause, cancer, CVD and diabetes mortality. A BMI > 25 kg/m² was associated with an increased risk of all-cause mortality, and a BMI > 23 kg/m² also increased the risk of mortality from cancer, CVD and diabetes. However, these associations were more obvious in men than in women. Our study showed that the relationship between death from any cause and BMI follows a J-shaped pattern in elderly men and women.

Obesity and overweight combined is the second leading cause of preventable death¹⁸. Previous studies

have demonstrated a strong association between obesity and decreased survival in the general population, primarily because of the increased risk of CVD^{3,19}. A BMI > 30 kg/m² was associated with an increased risk of all-cause mortality in a cohort study of 7,735 middle aged men¹⁹ and with a significantly increased risk of death from CVD in the Nurses' Health Study³.

In contrast to the general population, the role of increased BMI as a risk factor for death remains controversial in elderly subjects. Kulminski et al.²⁰ reported in their 9-year follow-up study of older Americans that the mortality risk pattern was higher for lower BMI (< 22.0) and flat for higher BMI. Overweight or obesity scores (BMI, 25.0–34.9) were not risk factors for all-cause mortality. The relationship between BMI and mortality exhibited an inverse J shape. Corrada et al.²¹ also showed similar relationships in a California cohort study. Being overweight (relative risk, 1.01) was not associated with excess mortality, but obese participants (relative risk, 1.25) had significantly increased mortality.

Table 4. Relationship of categories of body mass index to all-cause and specific disease mortality in men

| | Body mass index categories (kg/m ²) | | | | |
|--|---|------------------------|----------------------|---------------------|--------------------|
| | < 18.5 (n = 110) | 18.5–22.9 (n = 492) | 23–24.9 (n = 144) | 25–26.9 (n = 78) | ≥ 27 (n = 44) |
| Death, n (%) | 83 (75.5) | 354 (72.0) | 103 (71.5) | 61 (78.2) | 37 (84.1) |
| Follow-up time (person-years) | 1,598.8 | 7,845.9 | 2,209.4 | 1,089.7 | 589.8 |
| Cumulative mortality rate (per 1,000 person-years) | 51.9 | 45.1 | 46.6 | 55.9 | 62.7 |
| HR (95% CI)* | | | | | |
| All-cause mortality | 1.14 (0.90–1.45) | 1 [Reference] | 1.13 (0.91–1.41) | 1.49 (1.14–1.96) | 1.59 (1.13–2.23) |
| Coronary heart disease mortality (codes 410–414) [†] | 1.51 (0.61–3.77) | 1 [Reference] | 0.57 (0.17–1.95) | 0.87 (0.20–3.76) | 0.73 (0.10–5.47) |
| Stroke mortality (codes 430–438) [†] | 0.22 (0.05–0.92) | 1 [Reference] | 1.54 (0.89–2.69) | 1.65 (0.80–3.42) | 1.03 (0.32–3.33) |
| Diabetes mortality (code 250) [†] | 0.96 (0.21–4.34) | 1 [Reference] | 1.18 (0.31–4.04) | 3.34 (1.04–10.68) | 12.15 (4.59–32.16) |
| Cancer mortality (codes 140–208) [†] | 1.60 (1.01–2.54) | 1 [Reference] | 1.31 (0.84–2.05) | 2.81 (1.26–3.47) | 1.68 (0.81–3.49) |
| Respiratory mortality (codes 460–519) [†] | 2.00 (1.27–3.16) | 1 [Reference] | 0.70 (0.37–1.33) | 1.00 (0.45–2.18) | 0.48 (0.12–1.97) |
| Heart diseases (codes 401–429) [†] | 0.86 (0.40–1.86) | 1 [Reference] | 0.77 (0.44–1.36) | 0.83 (0.33–2.12) | 1.18 (0.43–3.23) |
| CVD mortality (codes 390–459) [†] | 0.72 (0.40–1.28) | 1 [Reference] | 1.45 (0.98–2.14) | 1.33 (0.78–2.31) | 1.28 (0.62–2.65) |
| Diabetes and CVD mortality | 0.72 (0.42–1.25) | 1 [Reference] | 1.43 (0.98–2.08) | 1.64 (1.01–2.67) | 2.24 (1.30–3.87) |
| Diabetes, CVD and cancer mortality | 1.86 (0.77–1.54) | 1 [Reference] | 1.39 (1.05–1.85) | 1.83 (1.29–2.60) | 2.02 (1.30–3.12) |

*Cox regression model: adjusted for age, sex, alcohol intake status, smoking status, education levels and exercise; [†]death certificates using the National Death Files (International Classification of Diseases, Ninth Revision). HR = hazard ratio; CI = confidence interval; CVD = cardiovascular disease.

The literature review in an elderly population survey by Janssen et al.¹⁵ showed that the summary relative risk of all-cause mortality for a BMI of 25–29.9 was 1.00 and that for a BMI within the obese range was 1.10 (95% CI, 1.06–1.13). According to selective survival hypothesis, individuals susceptible to the risky effects of an elevated BMI may have already died before getting old. With increasing age, subjects are progressively more strongly selected survivors. Thus, if we select an elderly group to evaluate BMI effect, the results tend to be neutral because they are resistant to the effects of a high BMI. Our findings did not support this contention as the HRs of all-cause mortality were significant for a BMI > 25. This study showed that the relationship between BMI and mortality in the elderly was not different from that in the general population. The difference in results between our study and the study of Janssen et al.¹⁵ may be explained by differences in average BMI scores between cohorts. Asians obviously have lower BMI values and lower CVD mortality than Western populations. The adverse effects of high BMI

on mortality might be postponed and last into the geriatric phase of life.

In previous studies of older Chinese and Japanese people^{22,23}, BMI was apparently inversely related to all-cause mortality after a short-term follow-up (e.g., 4 years). In those with multiple comorbidities, obesity was associated with better outcomes, whereas in those with initially good health status, obesity was associated with worsened outcomes. To minimize the effect of existing medical comorbidities on the BMI in our study, subjects who died during the first 3 years of follow-up were excluded. Therefore, long-term effects of a high BMI were positively associated with all-cause mortality.

Our study confirms the findings of previous studies demonstrating that the relationship between all-cause mortality and BMI categories follows a J-shaped pattern^{24,25}. In the Korean Cancer Prevention Study, the J-shaped risk relationship has been documented; however, the relative risk associated with BMI declined in the elderly. Loss of J-shaped pattern was noticed in

the group above the age of 64 years. In our study, those with a low BMI had higher risk from respiratory death, whereas those with a high BMI had higher risk from cancer, diabetes and CVD. The J-shaped risk relationship has still remained in this older Taiwanese population.

Higher BMIs are most likely to contribute to the risk associated with CVD in Western countries. Since the distribution of major causes of death may differ between Taiwanese and inhabitants of Western countries, obesity is likely to contribute to the risk of death from cancer and diabetes in this 23-year prospective study.

Progressive increases in risks associated with BMI were seen in both sexes; however, HRs for all-cause mortality were significant only among men. Low BMI (<18.5) was associated with higher mortality of cancer and respiratory disease in both sexes. Some studies have also found differences in the BMI–mortality association for men and women^{26,27}.

Limitation

When interpreting our results regarding baseline BMI scores, it is important to note that we were unable to evaluate weight changes, body fat or fat distribution during the follow-up period. We assumed that the influence of being overweight or obese defined by BMI on the risk of death is, in part, reflected by the increased body fat mass in those with an elevated BMI. However, the relationship between BMI with body fatness is weaker in the elderly compared with younger adults²⁸. Furthermore, in a study by Heitmann et al.²⁹, greater body fat quintile was a risk for mortality in a group of 60-year-old Swedish men. The effect of a high BMI on mortality might be underestimated in older men and women. Limitations include a single baseline measurement of BMI to predict events several years in the future.

Conclusion

The purpose of this study was to determine the effect of an elevated BMI on mortality risk from any cause and major causes in men and women aged 60 years and older. The result showed that BMI is an independent risk factor for all causes, cancer, diabetes or CVD mortality in this cohort. It is clear that a BMI in the obesity range is associated with a significantly increased risk of all-cause mortality in the elderly, and a BMI in

the overweight range is associated with a significantly increased risk of mortality from cancer, diabetes and CVD in elderly Taiwanese. These findings need to be confirmed by additional studies.

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