Body Mass Index and All-cause Mortality in a large Chinese Cohort

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Abstract

Background: Obesity, defined by the body mass index (BMI), is related to the increased risk of death in Caucasians. However, the prospective association between BMI and the risk of death in adult Taiwanese remains unclear.

Methods: We examined the association between BMI and all-cause mortality prospectively among 58,738 men and 65,718 women, aged 20 years and older at enrollment in 1998-1999, from four nationwide health screening centers in Taiwan. Cox proportional hazards regression analyses were used to estimate the relative risks of all-cause death for different BMI categories during a maximum follow-up of 10 years.

Results: 3,947 participants died during the follow-up period. The lowest risks of death were observed at a BMI between 24.0 to 25.9 for both men and women (mean BMI= 24.9 in both genders). After adjustment for age, smoking status, alcohol intake, betel nut chewing, physical activity, income status, and education level, a U-shaped association between BMI and all-cause death was observed. Similar U-shaped relationship existed on different age groups, smoking status, having preexisting chronic diseases, or if excluding deaths during the first 3 years of follow up.

Interpretation: The association between BMI and all-cause death was represented as a U-shape relationship in adult Taiwanese. The lowest risk for all-cause death among adult men and women was observed to relate to a BMI of 24.9.

Keywords: body mass index, mortality, obesity, underweight, Chinese

Introduction

The prevalence of obesity has dramatically increased in past decades in both developed and developing countries. The World Health Organization (WHO) reported that 1.6 billion adults are overweight and at least 400 million adults are obese; they further predicted that by year 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese [1]. In Taiwan, according to the National Health and Nutrition Survey performed between 1993-1996 and 2005-2008, the prevalence of overweight or obesity (defined as body mass index (BMI) ≥ 24 kg/m^2) in men and women had also dramatically increased from 33.4 % and 31.7 % to 50.8 % and 36.9 % [2]. Overweight and obesity have been recognized as important and independent risk factors for many chronic diseases, such as diabetes, hypertension, stroke, cardiovascular diseases, and cancers [3-7]. Substantial epidemiological evidences indicated that obesity is associated with increased cardiovascular and all-cause mortality [8,9]. Therefore, obesity has become a major public health problem around the world. Current definitions for obesity and overweight in adults were based on Caucasian populations. The WHO has proposed another definition of obesity and overweight for Asians, but most of these data were based on the cross-sectional studies [10]. Previous study also found that, for a given BMI, Asians had higher body fat than Caucasians [11]. Furthermore, the association between BMI and all-cause mortality had been found to be a J-shaped or U-shaped relationship. Most studies were done in Caucasians, with only a few conducted amongst Asians. For example, Gu et al reported that a U-shaped association existed between BMI and all-cause mortality in Chinese [12]. However, the participants in Gu's study were middle-aged adults with age over 40 years, not general adults (age over 20 years). Therefore, we designed a large prospective cohort study to assess the relationship between BMI and all-cause mortality in a nationwide representative sample of Taiwanese adult (age over 20 years). We also intended to find the optimal BMI cut-off values for overweight or obesity in Taiwanese adults.

Methods

Study subjects

The data were collected from four private nationwide MJ Health Screening Centers in Taiwan from 1998 to 1999. Membership was required for attending the programme. The registered health practitioners in these centers provide a multidisciplinary team approach of health assessment programme for their members. Most of them undergo health examination every 3-4 years and approximately 30 % of them will receive the same health check-up every year. A total of 58,738 male and 65,718 female adults, aged 20 years and above, were recruited into the study. The population structure in our study was similar to the national data of adult published by the Taiwanese government. The population structure in our study was similar to the national data of adult published by the Taiwanese government [13]. Deaths were ascertained by computer linkage to the national death registry using ID number. All deaths that occurred between study entry and December 2008 were included.

Anthropometric indices

Anthropometric characteristics were described in our previous report [14,15]. In brief, trained staff measured height (measured to the nearest 0.1 cm) and weight (measured to the nearest 0.1 kg) of each participant using an auto-anthropometer (KN-5000A, Nakamura, Tokyo, Japan). Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Study participants were grouped into 9 categories according to BMI at baseline (<18.5, 18.5-19.9, 20-21.9, 22-23.9, 24-25.9, 26-27.9, 28-29.9, 30-34.9,and ≥35 kg/m^2). Approval for patient recruitment and data analyses was obtained from the MJ Research Foundation Review Committee in Taiwan. Informed consent was obtained from every subject. The reported investigations were carried out in accordance with the principles of the Declaration of Helsinki as revised in 2000.

Questionnaire

Cigarette smoking, alcohol intake, betel nut chewing, and physical activity histories were recorded for each subject using questionnaires. Current, former, or never users for smoking, alcohol intake, and betel nut chewing were defined as those who reported the current use, any prior use, or never use of these substances, respectively, at baseline survey. The cumulative exposure to smoking was assessed by recording the duration (years) and quantity (number of cigarettes/day). Former users were also asked for their age at quitting. Cumulative pack-years of smoking were calculated as smoking-years multiplied by average daily cigarette use divided by 20. Cumulative pack-years for smokers were categorized into two groups (Low: <10 pack-years; High: ≥ 10 pack-years), so smoking status was categorized as none (0 pack-years), low (0~9.9 pack-years), and high (≥ 10 pack-years). Physical activity was classified into three levels: none to mild (exercise less than one hour per week), moderate (exercise one to four hours per week), and vigorous (exercise more than five hours per week) physical activity. Income status was sub-divided into three levels: low (< USD 12,500/year), middle (12,500-37,500/year), and high (>37,500/year). Education was also sub-divided into three levels: low (elementary school and below), middle (junior and senior high school), and high (college/university and above). Participants who reported a history of stroke, cardiovascular disease, liver cirrhosis, asthma, chronic renal disease, and cancer were defined as with preexisting chronic diseases (n=15,180). Others were defined as health participants (n=109,276).

Statistical analysis

The data are presented as the means and standard deviation for continuous variables. Analysis of variance (ANOVA) test was used to compare the continuous variables (such as age, height, weight) across BMI groups in Table 1. Proportions and categorical variables (such as smoking, alcohol drinking, and betel nut chewing status) were tested by the χ^2 test and by the two-tailed Fisher's exact method when appropriate in Table 1. Cox proportional hazards regression analyses adjusted for possible confounders were used to estimate the relative risks (RRs) for all-cause death in relation to BMI categories in Table 2 and Figure 1-2. Survival curves adjusted for other covariates were drawn for different BMI categories in Figure 1-2. These statistical analyses were performed using the PC version of SPSS statistical software (13th version, SPSS Inc., Chicago, IL, USA).

Results

During a maximum follow-up of 10 years (1,109,273 person-years), 2,398 men and 1,549 women died. In **Table 1**, we showed the baseline characteristics of study participants across 9 BMI categories. Participants with a higher BMI, as compared with those who had a lower BMI, were characterized by older age, more likely to consume alcohol and betel nut chewing currently, less physical activity, with higher income status in men and a lower income status and lower educations level in women,.

In **Table 2**, we showed the RRs for the risk of all-cause death among men and women. It poses a nonlinear association between BMI and the risk of all-cause death. The lowest risk in relation to all-cause death among both male and female participants was found at a BMI between 24.0 to 25.9 kg/m^2. There was a statistically significant U-shaped association between BMI and all-cause death. Using participants with a BMI between 24.0 to 25.9 as the reference group, and with the Cox proportional hazards regression analyses with adjustment for age, smoking status, alcohol intake, betel nut chewing, physical activity, income status, and education level, the RRs for all-cause death across BMI categories among men and women were showed in **Table 2** and **Figure 1**.

There were significant interactions ($P < 0.05$) between BMI categories and preexisting chronic disease status/age group/smoking status for predicting the risk of all-cause mortality. We therefore stratified these groups and presented the results in **Figure 2. Figure 2** showed the adjusted RRs in relation to all-cause death according to smoking status (never smoker, low-dose smokers, and high-dose smokers; Figure 2a), different age groups (participants aged 20 to 64 years old and aged 65 years or more; Figure 2b), and with or without preexisting chronic diseases (Figure 2c). The U-shaped association between BMI and all-cause death persisted within these three smoking groups and within the two age groups. High-dose and low-dose smokers seem to have higher RRs for all-cause mortality in relation to BMI than the never smokers with increased risks in the lower BMI categories. In comparison to the high-dose smokers, for those participants in the higher BMI categories, the RRs for all-cause mortality were higher among never and low-dose smokers. In comparison to participants less than 65 years, the RRs for all-cause mortality in lower and higher BMI categories were higher among those with age over 65 years. The lowest all-cause mortality was also found in BMI between 24.0 to 25.9 in both age groups. Participants with or without preexisting chronic diseases also exhibited the U-shaped relationship between BMI and all-cause death. Participants with preexisting chronic diseases in the lower BMI categories had higher risks of death than healthy participants. In contrast, participants with preexisting chronic diseases in the higher BMI categories had lower risks of death than healthy participants.

After excluding study participants who died during the first 3 years of follow-up and using BMI between 24.0 to 25.9 for comparison, the adjusted RRs for all-cause death across BMI categories were also showed in **Table 2**. The U-shaped association between BMI and all-cause death still existed among both men and women.

Interpretation

In this population-based prospective study, we demonstrated that the higher risks of death were observed in the lower and upper BMI categories compared to the middle categories, showing a U-shaped relationship between BMI and all-cause mortality in adult Taiwanese. The same U-shaped association existed on those who were either aged over 65 or less than 65 years old, or who were never smokers, low-dose smokers, or high-dose smokers, or who were with or without preexisting chronic diseases, or who did not die during the first 3 years of follow-up. In addition, we also found that the lowest death in relation to BMI was observed at a BMI of 24.9 for both men and women.

The WHO has proposed a lower BMI cut-off values for defining overweight and obesity in Asians. However, most of this evidence was based on cross-sectional studies. Some prospective studies done in Chinese have reported the U-shaped relationship between BMI and all-cause mortality and found subjects with BMI between 24.0 to 28.0 have the lowest risks of all-cause death [12,16,17]. For example, Gu et al reported that subjects with BMI between 24.0 to 24.9 in both men and women had the lowest risk of all-cause death in 169,871 Chinese aged 40 years and older. Studies done in Caucasians have also identified a J- or U-shaped association between BMI and all-cause mortality. They also reported that subjects with a BMI between

23.0 to 28.0 had lowest risk in relation to all-cause mortality and the minimum mortality close to a BMI of 25.0 [8,18-20]. Our findings are consistent with these studies and do not support the use of a lower BMI cut-off value for obesity in Taiwanese general adults. We also conducted the sensitivity analyses to demonstrate the optimal cut-off values of BMI for all-cause mortality by dividing BMI into 15 groups according to BMI- <18.5, 18.5-19.9, 20-20.9, 21-21.9, 22-22.9, 23-23.9, 24-24.9, 25-25.9, 26-26.9, 27-27.9, 28-28.9, 29-29.9, 30-34.9, ≥35 kg/m^2. The lowest risk of death was observed at a BMI of 24.0 to 24.9 for men and 25.0 to 25.9 for women (mean BMI= 24.5 in men and 25.5 in women) which were also consistent with our results (BMI: 24.0-25.9). These findings demonstrated the robustness of our results.

Previous studies had found that age was an effect modifier for the relationship between BMI and the risk of death [18,20]. For example, Weiss et al reported that BMI is inversely related to mortality in the elderly [21]. Our study, however, found that the similar U-shaped association between BMI and all-cause death was presented among participants aged 20 to 64 years and among those 65 years and above. This finding did not support the theory of “obesity paradox” in the elderly.

Smoking is associated with lower body weight and an increased risk of death [22-24]. Compared to previous studies [12,23], our findings are consistent with the findings that among current smokers, subjects in lower BMI categories had higher risk of death.

However, among never smokers we did not find subjects in the higher BMI categories had higher risk of death. Similar U-shaped relationships between BMI and all-cause mortality were found among never smokers, low-dose smokers, and high-dose smokers.

Preexisting chronic diseases were linked to an increase in all-cause death and decrease in body weight. Two criteria were used to avoid possible bias caused by preexisting chronic diseases: 1) limited the analysis to healthy participants and 2) excluded those who died during the first 3 years of follow-up. In this study, similar U-shaped association between BMI categories and all-cause death remained existed after making these adjustments. In the lower BMI categories, the risk of death was higher for those participants with preexisting chronic diseases, compared to healthy participants. This confirmed that preexisting chronic diseases were associated with the increase of all-cause death. In contrary, in the higher BMI categories, the risk of death among participants with preexisting chronic diseases was lower compared to the healthy participants. This suggested that obesity may be a protective factor among subjects with preexisting chronic diseases. However this finding was consistent with the reports from other populations i.e. see Adams et al. in the United States [25].

Limitations

Although we have shown that a U-shaped relationship existed between BMI and all-cause mortality in adult Taiwanese, there are some limitations in this study. Firstly, we didn't measure the weight at the end of follow-up, so we could not get information about weight changes over time. Hence, we could not find the relationship between weight change and mortality. Secondly, our study population mainly came from generally healthy volunteers who attended health screening centers rather than nationally representative subjects. However, the population structure in our study was similar to the national data of adult published by the Taiwanese government. External validation will be necessary in future studies. Finally, we have adjusted several variables, including smoking status, alcohol intake, betel nut chewing, physical activity, level of education, and level of income, which allowed us to minimize the potential confounders. However, we still could not exclude the possibility of the residual confounding.

Conclusion

We have demonstrated that both obesity and underweight are related to increase all-cause mortality in adult Taiwanese population. This relation was found in persons who were above or less than 65 years old, were heavy, mild, or never smokers, were with or without preexisting chronic diseases, and who did not die during the first 3 years of follow-up. The consistency of our findings in both men and women and across all ages (younger to middle-aged adults and in the elderly) also argues for the use of a single recommended range of body weight throughout life.

Competing interests: None declared

Contributions: Dr. WY Lin and KC Huang had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design*: Dr. WY Lin, CCLin, and KC Huang. *Acquisition of data*: Dr. PK Song, SL Tsai, and TC Li. *Analysis and interpretation of data*: Dr. WY Lin, JB Albu, FX Pi-Sunyer, and TC Li. *Drafting of the manuscript*: Dr. WY Lin and KC Huang. *Critical revision of the manuscript for important intellectual content*: Dr. JB Albu, FX Pi-Sunyer, CC Lin, TC Li, and KC Huang. *Statistical analysis*: Dr. WY Lin, SL Tsai, and TC Li. *Obtained funding*: Dr. WY Lin, CC Lin, TC Li, and FX Pi-Sunyer. *Administrative, technical, and material support*: Dr. PK Song and CC Lin. S*tudy supervision*: Dr. CC Lin, KC Huang, JB Albu, and FX Pi-Sunyer. All of the authors approved the final version of the manuscript submitted for publication.

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Table 1. Baseline Characteristics of Participants according to BMI among Men and Women[1]

	Body mass index (BMI, kg/m^2)								
	<18.5	**18.5-19.9**	**20-21.9**	**22-23.9**	**24-25.9**	**26-27.9**	**28-29.9**	**30-34.9**	**≥35**
Men (N)	2448	4300	10473	14983	13368	7738	3374	1819	235
Age (years)[2,4,5]	39.3(15.6)	39.7(14.8)	41.1(14.5)	43.3(13.8)	44.6(13.4)	45.1(13.3)	44.4(13.4)	41.7(12.9)	37.5(11.9)
Height (cm)[2,4,5]	169.1(6.6)	169.0(6.5)	168.8(6.2)	168.5(6.3)	168.2(6.2)	168.1(6.1)	168.4(6.3)	169.0(6.4)	170.2(7.1)
Weight (kg)[2,4,5]	50.3(4.6)	55.3(4.4)	60.1(4.7)	65.4(5.1)	70.4(5.4)	76.1(5.8)	81.9(6.4)	90.3(8.0)	109(11.4)
BMI (kg/m^2)[2,4,5]	17.5(0.8)	19.3(0.4)	21.1(0.6)	23.0(0.6)	24.9(0.6)	26.9(0.6)	28.8(0.6)	31.6(1.3)	37.7(3.9)
Smoking (%)[3,5]									
Current	46.2	43.6	40.7	38.7	39.4	40.5	42.5	44.7	56.5
Former	9.7	9.7	10.6	12.1	13.3	13.5	14.3	13.0	8.1
Never	44.1	46.7	48.7	49.2	47.3	46.0	43.2	42.3	35.4
Alcohol intake (%)[3,5]									
Current	24.3	25.0	27.7	30.2	33.0	33.9	34.4	35.1	22.8
Former	5.8	5.0	5.2	5.0	5.4	6.3	7.0	6.7	7.8
Never	69.9	70.0	67.1	64.8	61.6	59.8	58.6	58.2	69.4
Betel nut chewing (%)[3,5]									
Current	9.6	10.1	9.5	9.7	10.6	12.2	13.8	15.6	18.8
Former	10.9	9.5	9.3	8.5	9.8	11.0	12.6	14.8	18.4
Never	79.5	80.4	81.2	81.8	79.6	76.8	73.7	69.6	62.8

Physical activity (%)[3,5]									
None/mild	52.1	48.6	45.5	42.6	42.8	44.7	46.4	51.0	55.6
Moderate	34.9	37.5	38.4	39.4	38.5	37.2	36.5	34.5	34.7
Vigorous	13.1	13.8	16.1	18.0	18.7	18.1	17.1	14.5	9.7
Income (%)[3,5]									
Low	39.7	37.2	32.2	27.8	27.0	28.3	29.3	29.0	34.6
Moderate	55.1	57.1	59.5	61.5	60.6	59.2	58.5	60.3	55.1
High	5.2	5.7	8.3	10.7	12.4	12.5	12.2	10.7	10.3
Education (%)[3,5]									
Low	13.5	13.7	13.5	15.5	16.9	18.3	18.9	15.8	12.6
Moderate	38.2	36.1	34.6	33.2	34.8	36.1	37.5	39.0	41.7
High	48.3	50.2	51.8	51.3	48.4	45.6	43.6	45.2	45.7
Women (N)	6850	10171	16054	13253	9224	5322	2633	1908	303
Age (years)[2,4,5]	32.7(10.6)	35.5(11.1)	40.1(12.2)	45.5(13.1)	49.5(12.8)	51.6(12.5)	51.8(12.4)	51.2(13.0)	47.6(13.5)
Height (cm)[2,4,5]	158.6(5.6)	158.0(5.5)	157.0(5.6)	155.7(5.6)	155.0(5.5)	154.4(5.5)	154.3(5.6)	154.3(5.6)	154.4(6.3)
Weight (kg)[2,4,5]	44.0(3.7)	48.3(3.5)	51.8(3.8)	55.7(4.1)	59.9(4.4)	64.2(4.7)	68.9(5.1)	75.6(6.3)	89.7(9.5)
BMI (kg/m^2)[2,4,5]	17.5(0.8)	19.3(0.4)	21.0(0.6)	23.0(0.6)	24.9(0.6)	26.9(0.6)	28.9(0.6)	31.7(1.3)	37.6(2.4)
Smoking (%)[3,5]									
Current	9.0	7.3	5.6	4.7	3.9	4.2	4.3	5.0	6.7
Former	2.2	2.0	1.6	1.3	1.1	1.0	1.5	1.5	2.1

Never	88.8	90.7	92.8	94.0	95.0	94.8	94.2	93.5	91.2
Alcohol intake (%)[3,5]									
Current	5.6	4.9	5.9	5.7	5.7	5.6	4.6	5.3	6.2
Former	1.5	1.3	1.4	1.6	1.5	1.4	1.3	2.3	6.2
Never	92.9	93.8	92.7	92.8	92.8	92.9	94.1	92.4	87.6
Betel nut chewing (%)[3,5]									
Current	0.2	0.3	0.3	0.3	0.5	0.9	1.3	1.6	2.9
Former	0.2	0.1	0.2	0.4	0.3	0.5	0.5	0.9	0.4
Never	99.6	99.6	99.5	99.3	99.2	98.6	98.2	98.5	96.7
Physical activity (%)[3,5]									
None/mild	67.2	60.2	54.7	50.2	49.0	48.9	52.7	54.6	59.2
Moderate	28.1	32.9	35.1	34.3	32.8	31.6	30.0	29.0	29.6
Vigorous	4.7	7.0	10.2	15.5	18.2	19.5	17.2	16.5	11.2
Income (%)[3,5]									
Low	57.8	54.3	57.0	65.6	73.4	78.5	79.4	82.8	80.1
Moderate	39.8	42.7	39.6	31.6	24.4	19.5	17.9	15.7	18.1
High	2.4	3.0	3.4	2.8	2.2	2.1	2.7	1.5	1.8
Education (%)[3,5]									
Low	7.0	9.9	18.6	34.7	48.5	58.5	61.6	62.0	56.7
Moderate	38.6	39.7	40.5	37.0	32.8	28.5	26.6	26.1	28.9

High	54.4	50.5	40.9	28.3	18.7	13.0	11.8	11.9	14.4

[1] BMI, body mass index;

[2] ANOVA test was used for comparing mean values of continuous variables between groups

[3] Pearson chi-square test was used for categorical data

[4] mean (SD) (all such values).

[5] p values < 0.001

Table 2. Mortality Rate and Relative Risks of Death in relation to BMI among Men and Women.

	Body Mass Index (BMI, kg/m^2)								
	<18.5	**18.5-19.9**	**20-21.9**	**22-23.9**	**24-25.9**	**26-27.9**	**28-29.9**	**30-34.9**	**≥35**
Men									
Deaths (no.)	145	196	425	586	506	310	148	71	11
Person-years	21507	38092	92829	133037	118723	68759	29954	16083	2080
Relative risk (95%CI)									
Crude[1]	1.80(1.50-2.17)	1.47(1.24-1.73)	1.26(1.11-1.44)	1.11(0.98-1.25)	1.00	1.03(0.90-1.19)	1.18(0.98-1.42)	1.40(1.09-1.80)	2.48(1.36-4.50)
Adjusted[2]	1.65(1.34-2.04)	1.32(1.09-1.60)	1.15(0.99-1.33)	1.14(0.99-1.30)	1.00	1.01(0.86-1.18)	1.12(0.91-1.38)	1.27(0.95-1.70)	2.37(1.22-4.60)
Follow-up period (1990-2007)[3]									
Adjusted[2]	1.65(1.29-2.10)	1.36(1.10-1.69)	1.10(0.92-1.30)	1.09(0.94-1.27)	1.00	1.00(0.84-1.20)	1.19(0.95-1.50)	1.09(0.76-1.55)	2.08(0.92-4.67)
Women									
Deaths (no.)	90	128	265	332	306	202	117	95	14
Person-years	61448	91146	143926	118733	82357	47488	23422	16989	2698
Relative risk (95%CI)									
Crude[1]	1.50(1.19-1.90)	1.22(0.99-1.50)	1.05(0.89-1.24)	0.99(0.85-1.16)	1.00	1.00(0.84-1.20)	1.16(0.94-1.44)	1.34(1.07-1.69)	1.63(0.96-2.79)
Adjusted[2]	1.52(1.17-1.99)	1.34(1.06-1.70)	1.18(0.97-1.42)	1.05(0.88-1.26)	1.00	1.03(0.84-1.26)	1.08(0.83-1.39)	1.39(1.07-1.80)	1.65(0.92-2.95)
Follow-up period (1990-2007)[3]									
Adjusted[2]	1.60(1.19-2.15)	1.22(0.93-1.61)	1.22(0.99-1.51)	1.03(0.84-1.26)	1.00	1.07(0.85-1.34)	1.03(0.77-1.38)	1.44(1.08-1.93)	1.76(0.93-3.34)

[1]Crude: adjusted for age.

[2] Adjusted 1: adjusted for age, smoking status (current, former, never), alcohol intake, betel nut chewing, physical activity, income, and education level.

[3]Excluded those who died during first 3 years follow-up (only deaths that occurred after more than 3 years of follow-up were included).

Legend to Figure 1

Adjusted relative risks of all-cause mortality according to BMI categories among men and women. Relative risks adjusted for age, smoking status, alcohol intake, betel nut chewing, physical activity, income, and education level (a) in men; (b) in women. Error bars indicate 95 % confidence interval.

Figure 1(a)

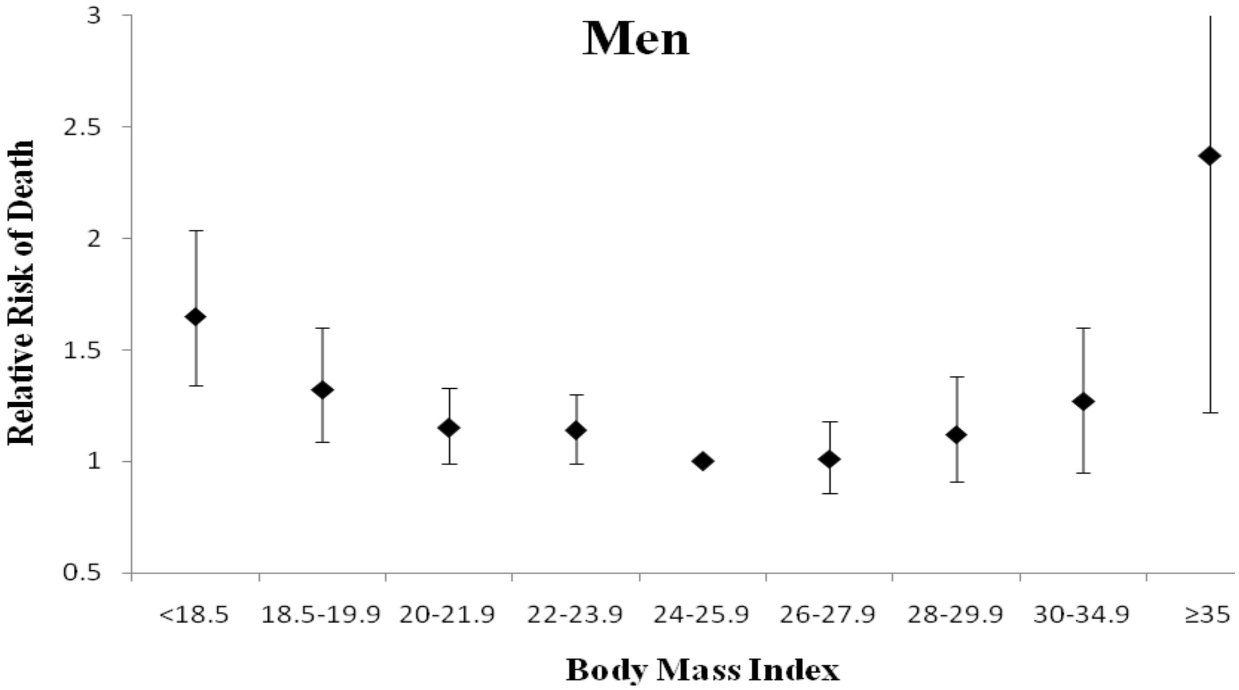
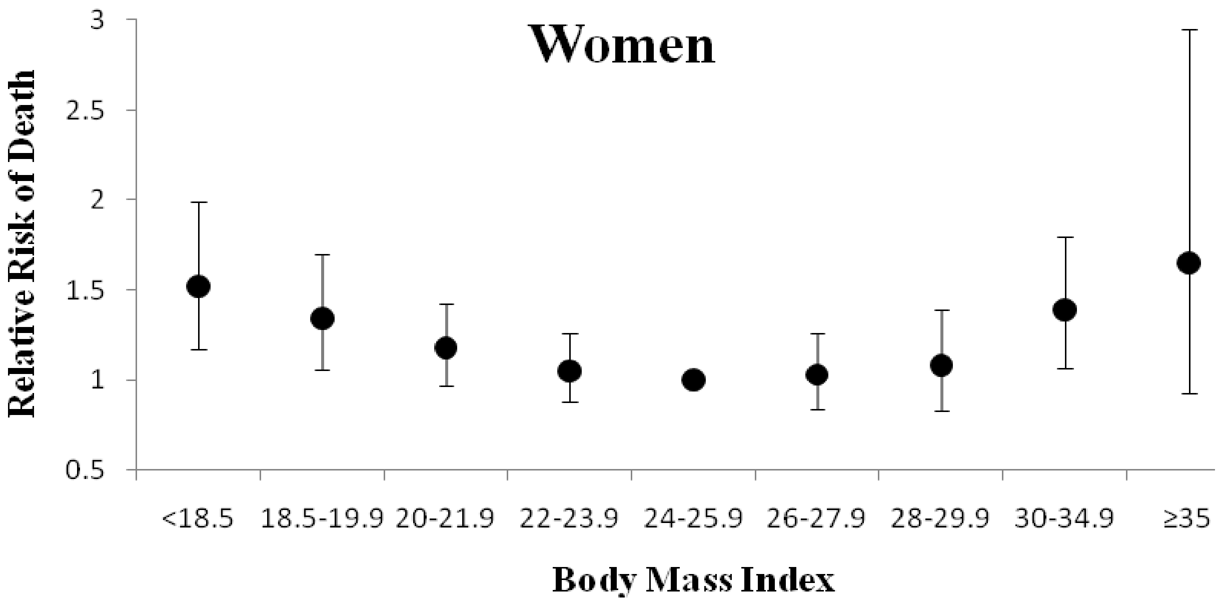


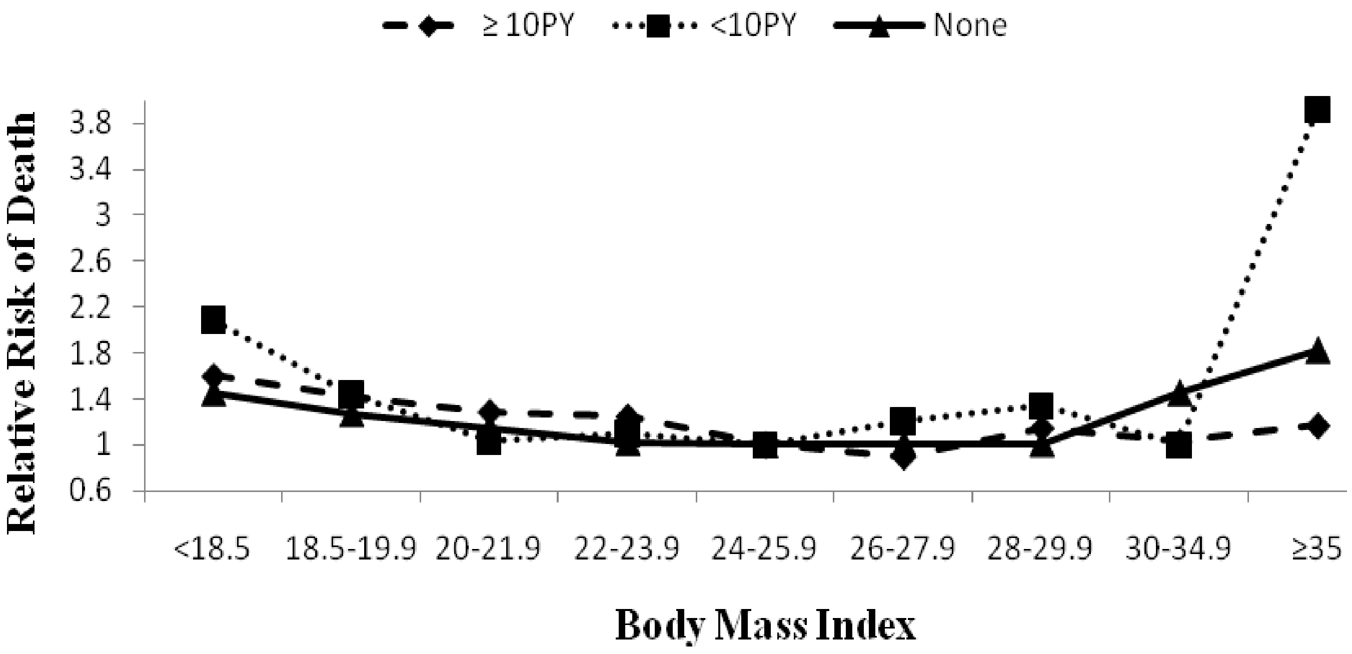
Figure 1 (b).



Legend to Figure 2

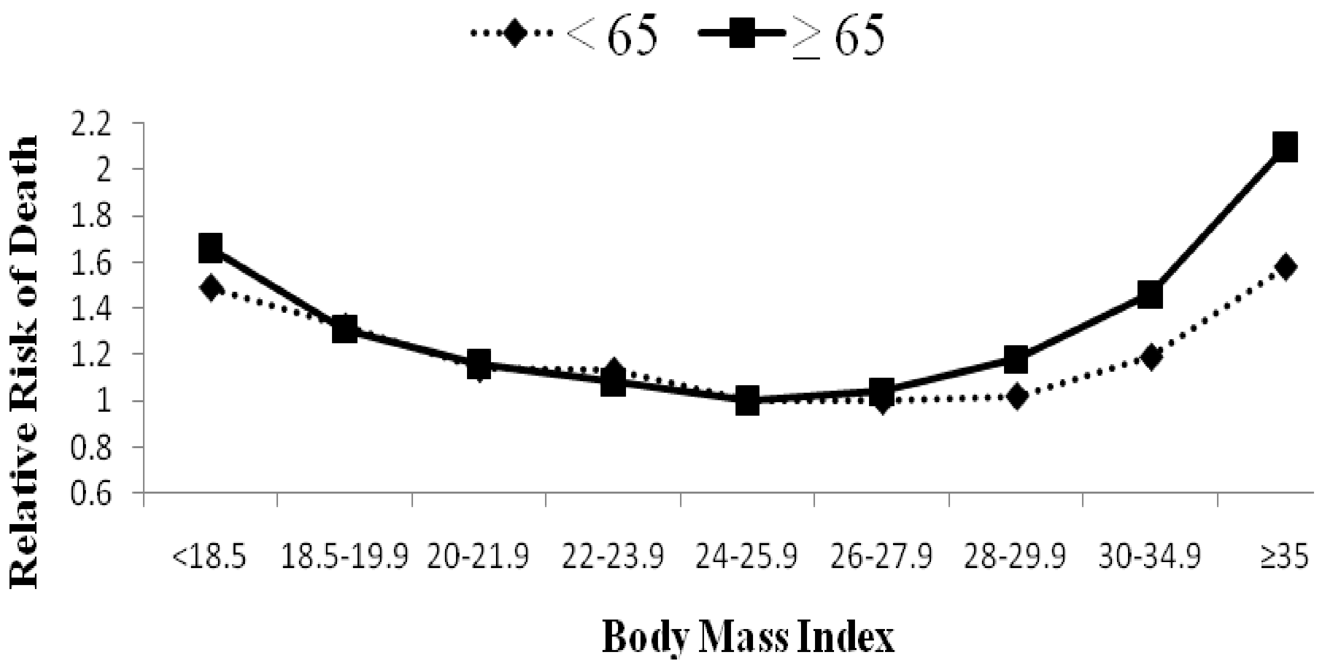
Adjusted relative risks of all-cause mortality according to BMI categories by smoking status, age group, and presence of preexisting chronic diseases. (a) Smoking status was divided into three categories by the consumption and smoking duration: none, <10 PY, and ≥ 10 PY (PY: pack per day x smoking duration (year)). The relative risks were adjusted for age, gender, cumulative smoking amount, alcohol intake, betel nut chewing, income, and education level; (b) age was divided into two categories: <65 years old and ≥ 65 years old; (c) participants with and without preexisting chronic diseases (previous history of stroke, cardiovascular disease, liver cirrhosis, chronic renal disease, asthma, or cancers). The relative risks were adjusted for age, gender, smoking status, alcohol intake, betel nut chewing, physical activity, income, and education level.

Figure (2a).



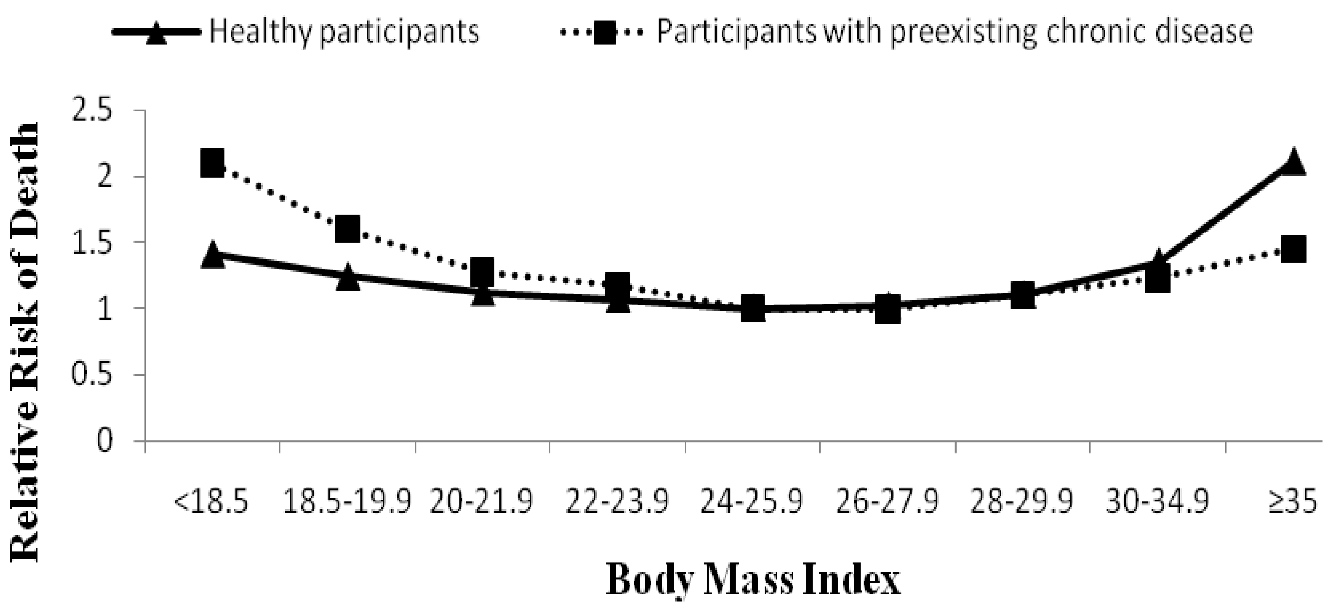
≥10PY
<10PY
None
Relative Risk of Death
3.8
3.4
3
2.6
2.2
1.8
1.4
1
0.6
<18.5
18.5-19.9
20-21.9
22-23.9
24-25.9
26-27.9
28-29.9
30-34.9
≥35
Body Mass Index

Figure (2b).



< 65
≥ 65
Relative Risk of Death
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
<18.5
18.5-19.9
20-21.9
22-23.9
24-25.9
26-27.9
28-29.9
30-34.9
≥35
Body Mass Index

Figure (2c).


Healthy participants
Participants with preexisting chronic disease
Relative Risk of Death
2.5
2
1.5
1
0.5
0
<18.5
18.5-19.9
20-21.9
22-23.9
24-25.9
26-27.9
28-29.9
30-34.9
≥35
Body Mass Index