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The association of body mass index (BMI) with all-cause mortality in older Taiwanese: Results of a national cohort study

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ABSTRACT

In older adults, underweight has been shown to be associated with increased all-cause mortality, but the association with excessive weight is inconclusive. The study aimed to determine the association of weight status with subsequent all-cause mortality risk in older Taiwanese. The study analyzed the dataset of the "Survey of Health and Living Status of the Elderly in Taiwan", a nationally representative longitudinal cohort study. Baseline BMI calculated from self-reported weight and height (kg/m^2) was used to predict all-cause mortality risk during subsequent four years in 2462 $\geq$ 53 years old Taiwanese. Cox-regression analysis was performed to determine the significance of the association of weight status with all-cause mortality during follow-up four-years controlled for demographic, lifestyle and health-related variables. Results showed that underweight was associated with increased risk of mortality risk in all age ranges examined, but excessive weight was not significantly associated with increased risk of mortality. Results suggest that the association between BMI status and all-cause mortality is "L-shaped" and "obesity paradox" may indeed exist in these specific age groups in Taiwanese over 65 years old. However, some uncertainty remains because confounding factors could not be totally controlled. Large scale prospective studies with better control of confounding factors are needed to resolve this important public health issue.

1. Introduction

Obesity is becoming a pandemic in many parts of the world. Globally, more than 1 billion adults are overweight and at least 300 million of them are obese (World Health Organization, 2004). In United States, approximately 30% of 50 to 70-year old persons are obese (BMI $\geq$ 30 kg/m^2) (Center for Disease Control and Prevention, 2009). In Taiwan, approximately 4% of adults over 53 years old are obese based on $\geq$30 kg/m^2. The proportion is 15% based on the WHO definition (BMI $\geq$ 27 kg/m^2) for Eastern Asian populations (Tsai et al., 2007a). The WHO definition takes the population-related differences in percent body fat to BMI relationship into consideration (Deurenberg et al., 2002; Pan et al., 2004).

Extreme body weight or BMI is associated with certain comorbidities. Underweight is associated with respiratory and non-cancer, non-circulatory and non-respiratory diseases whereas excessive-weight is associated with hypertension, hyperlipidemia, heart disease, diabetes or chronic kidney disease (Flegal et al., 2007; Pischon et al., 2008). Body weight status is also associated with all-cause mortality risk and the relationship has been observed to be either U- (or J-) (Zhu et al., 2003; Adams et al., 2006; Klenk et al., 2009; Orpana et al., 2009; Prospective Studies Collaboration, 2009) or L- (or reverse J-) shaped (Grabowski and Ellis, 2001; Jee et al., 2006; Locher et al., 2007; Kuk and Ardern, 2009; Oreopoulos et al., 2009; Tamakoshi et al., 2009; Auyeung et al., 2010), or a simple positive association (Freedman et al., 2006). The U-shaped relationship suggests that both under-weight and excessive weight are associated with increased all-cause mortality risk, whereas the L-shaped relationship suggests that low but not high (excessive) body weight is associated with increased all-cause mortality risk, and overweight or even obesity may confer some protection. This phenomenon is often referred to as the obesity paradox (Oreopoulos et al., 2009). Ethnicity, age, gender, study setting and analytical methods have been shown to contribute to the differences in the observed associations (Mazza et al., 2007; Kuk and Ardern, 2009; Tamakoshi et al., 2009; Thinggaard et al., 2010).

The association between weight status and all-cause mortality has been examined and debated rather extensively. However, most of these studies examined the association in Western countries. Relatively few studies have been conducted in Eastern Asian populations (Nanri et al., 2010), especially with a population-representative longitudinal design. Since the Taiwanese, one of the Eastern Asian populations, have a different body weight to BMI

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relationship from that of the Western populations (Deurenberg et al., 2002; Pan et al., 2004), it is imperative to examine the association. Hence, this study was aimed to examine the relationship of body weight status with all-cause mortality risk in older Taiwanese by analyzing the dataset of a nationally representative prospective cohort study.

2. Subjects and methods

2.1. Source of data

This study analyzed dataset of the "Survey of Health and Living Status of the Elderly in Taiwan" (SHLSET), a nationally representative longitudinal study. This on-going cohort study was initiated in 1989 for the purpose of determining the impact of socio-environmental changes on health, healthcare use and quality of life of older Taiwanese (Bureau of Health Promotion, 1989). The detail of the design, method and procedure of the survey has been described in a recent publication (Tsai and Chang, 2010). Briefly, the study was initiated with a multi-stage national probability sample of 4049 elderly men and women 60 years or older in 1989. In 1996, a second sample of 2462 50-66-year subjects, selected with the same procedure was added to the cohort to maintain and extend the age range of the sample. Subjects in the study cohort were interviewed every 3–4 years and a total of 6 major rounds of interviews (in 1989, 1993, 1996, 1999, 2003 and 2007) have been completed. The original SHLSET survey from which information used in the current study was obtained had ethical approval from a review board composed of government-appointed representatives and the study was conducted according to the ethical standards set forth in the Helsinki Declaration.

2.2. Weight status

In each survey, trained interviewers conducted in-home in-person interviews using structured questionnaire. The 1999 survey included more anthropometric indicators and thus served as the baseline of the present study. The 2003 survey served as the endpoint. The completion rates were over 90% in both years.

Weight and height were obtained by self-report or from participant's most recent health check-up or clinical records. BMI was calculated according to kg/m^2. Mortality data were taken from records maintained by the survey and confirmed with records of the National Health Insurance Program and the National Household Registration. Follow-up mortality rates were analyzed according to BMI status at baseline.

2.3. Statistical analysis

The mortality risk was analyzed according to age range and BMI status (<18.5, 18.5–21, 21–24, 24–27, 27–30 and >30 kg/m^2). Cox regression analysis was performed to evaluate the relative mortality risks of subjects with low or high BMI by gender adjusted for age, lifestyle variables (smoking, alcohol drinking and exercise activity) and major comorbidities (hypertension, diabetes, heart disease, stroke, cancer and kidney disease). The lower range (BMI 21) was based on the population-specific cut-off point for low BMI in the Mini-Nutritional Assessment for older Taiwanese (Tsai et al., 2007b), whereas the upper range (BMI 27) was based on the cut-off point for obesity defined by the World Health Organization (WHO). Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS version 15.0. Chicago, IL). Statistical significance for all analyses was evaluated at $\alpha = 0.05$. All values are weighting-adjusted according to study design.

3. Results

Table 1 shows the characteristics of subjects. The sample included slightly more men (53%) than women which reflected the composition of the specific age group. Thirty-five percent of subjects were 53–64 years old, 37% were 65–75 years old, 24% were 75–84 years old and 4.4% were 85 years old or older. Roughly 24% of subjects were current smokers; 24% drank alcohol ≥1 time/week; and 41% exercised ≥3 days/week. Roughly 60% of subjects were desirable weight (21–27 kg/m^2), 24% were underweight (<21 kg/m^2) and 13% were overweight/obese (>27 kg/m^2).

Table 2 shows the Cox regression analysis of the association of BMI status with follow-up 4-year all-cause mortality risk stratified by age and gender. Underweight (<21 kg/m^2) was significantly associated with increased follow-up 4-year mortality risk in both men and women in all three age-ranges whereas overweight–obesity showed no association. Mortality rates increased with advancing age regardless of weight status (Fig. 1). In younger (53–64 years) subjects, the lowest death rate was in subjects with BMI 21–27 kg/m^2. For older age groups, the lowest death rate were around BMI 27–30 kg/m^2 or higher.

4. Discussion

4.1. The major finding

In a regression model that controlled for age, gender, lifestyle variables (smoking, alcohol drinking and physical activity) and chronic co-morbidities, underweight (defined as BMI < 21 kg/m^2) is associated with an increase in all-cause mortality in both men and women. Overweight–obesity (>27 kg/m^2) is not associated with a significant change in all-cause mortality in all age ranges examined. Thus, the over-all relationship between body weight status and all-cause mortality risk is L-shaped in Taiwanese over 53 years of age. This finding is similar to that observed in other Eastern populations such as the Japanese (Tamakoshi et al., 2009), Chinese in Hong Kong (Auyeung et al., 2010) and the Koreans (Jee et al., 2006).

Table 1
Characteristics of 4440 subjects.

Variables	*n* (%)
Sex	
Men	2357 (53.1)
Women	2083 (46.9)
Age, years	
53–64	1550 (34.9)
65–74	1629 (36.7)
75–84	1069 (24.0)
≥85	194 (4.4)
Formal education, years	
<6	3164 (71.3)
7–12	741 (16.7)
>12	255 (5.7)
Current smoker	1072 (24.1)
Alcohol drinking ≥1 time/week	1072 (24.1)
Exercise ≥3 days/week	1821 (41.0)
BMI distribution	
<18.5	291 (6.6)
18.5–21	742 (16.7)
21–24	1524 (34.3)
24–27	1149 (25.9)
27–30	429 (9.7)
30–33	118 (2.7)
>33	37 (0.8)
Weight loss ≥3 kg	
No	3779 (85.1)
Yes	636 (14.3)

Table 2
Cox regression analysis of the association of BMI status with 4-year total mortality risk stratified by gender and age, and controlled for age, smoking, drinking, exercise, hypertension, diabetes, heart disease, stroke, cancer and kidney disease in ≥53 year-old Taiwanese.

Grouping	Men (n = 2357)		Women (n = 2083)	
	% died[a]	HR (95% CI)[b]	% died	HR (95% CI)
53–64 years old				
BMI < 21	10.74	2.29 (1.11–4.75)*	6.34	4.05 (1.59–10.34)**
BMI 21–27	4.05	1	2.16	1
BMI > 27	4.76	1.01 (0.37–2.74)	3.60	1.53 (0.50–4.64)
65–74 years old				
BMI < 21	20.95	2.06 (1.39–3.04)***	12.50	1.76 (1/00–3.13)*
BMI 21–27	11.73	1	8.59	1
BMI > 27	7.37	0.60 (0.27–1.31)	5.31	0.62 (0.26–1.49)
≥75 years old				
BMI < 21	41.26	1.54 (1.15–2.06)**	35.89	2.05 (1.44–2.91)***
BMI 21–27	31.65	1	19.57	1
BMI > 27	20.45	0.57 (0.29–1.12)	17.72	0.83 (0.46–1.52)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a] 4-year total mortality rate.
[b] Hazardous ratio and (95% confidence interval).

4.2. The association in Western populations

The association of underweight with increased all-cause mortality appears fairly consistent among studies, but the association of overweight/obesity with increased all-cause mortality is controversial. The majority of studies conducted in Western populations showed a U- or J-shaped relationship between BMI and all-cause mortality (Zhu et al., 2003; Adams et al., 2006; Klenk et al., 2009; Orpana et al., 2009; Prospective Studies Collaboration, 2009). The collaborative analysis of 57 studies conducted in Western Europe and North America involving approximately 900,000 adults (mean recruitment age 46 ± 11 years) showed that mortality was lowest at about 22.5–25 kg/m^2 in both sexes; above this range, positive associations were observed for several specific causes (especially cardiovascular disease) and inverse associations for none (Prospective Studies Collaboration, 2009). The association of excessive weight with mortality appears to be age and gender dependent. Mazza et al. (2007) observed that the relationship between BMI and mortality was significant only in men aged 76 years or less and no prediction based on BMI is possible in women in an Italian general population aged 65-95 years. Similarly, Kuk and Ardern (2009) found that the adverse effects of obesity on mortality risk are apparent only in adults younger than 65 years of age.

4.3. The association in Eastern populations

In Eastern Asian populations, obesity characterized with several different measures such as waist circumference, waist-to-hip ratio, and bioelectrical impedance was generally observed to be not associated with greater mortality risk in older adults (Jee et al., 2006; Tamakoshi et al., 2009; Auyeung et al., 2010). The overall relationship between all-cause mortality and extreme body weight is mostly L- or reverse J-shaped, meaning a strong association with low body weight (BMI) but little or no association with excessive body weight. Tamakoshi et al. (2009) observed that among Japanese 65–79 years old, a low BMI (<20 kg/m^2) was associated with increased risk of all-cause mortality and a wide range of BMI (between 20.0 and 29.9 kg/m^2) with low all-cause mortality risk in both older men and women. The study observed a slight increase in mortality risk only in women BMI ≥ 30 kg/m^2 but no such association in men. Auyeung et al. (2010) observed that older Chinese men were resistive to hazards of overweight and obesity and a mild-grade of overweight or central obesity might even be protective in a convenience sample of 2000 Chinese aged over 65 years of age in Hong Kong. The relationship in women was inconclusive because of low number of death recorded in the sample. Jee et al. (2006) observed a U- or J-shaped relationship between all-cause mortality and BMI in both Korean men and women under 65 years of age. However, in men and women over 65 years old, an L-shaped relationship was observed. Taking together, the majority of studies conducted in East Asian populations suggest an L-shaped association between body weight status and all-cause mortality in older (≥65 years) individuals.

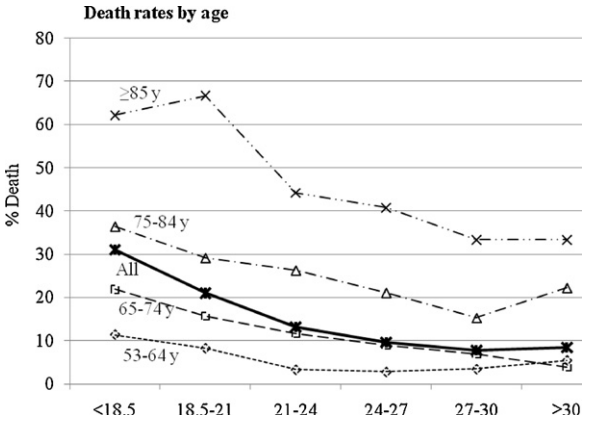

Fig. 1. All-cause mortality rates according to BMI status stratified by age ranges during a 4-year period (1999–2003).

4.4. Possible reason for the difference

Clearly, ethnicity, gender and age can influence the association of body weight with all-cause mortality risk. However, it appears that the distribution of body weight status and the leading causes of death of a population are also factors that can influence the relationship. In populations where obese (obesity class I or higher) is prevalent and cardiovascular disease is the leading cause of death such as US (Center for Disease Control and Prevention, 2009), the association is more likely to be U- or J-shaped because obesity is an independent long-term risk factor of cardiovascular mortality (Prospective Studies Collaboration, 2009). On the other hand, in populations where morbid obesity is not prevalent and underweight-related morbidities (such as chronic obstructive pulmonary disease, later stage cancer, diabetes, kidney disease and dementia) are the major causes of death, it is more likely to see an L-shaped relationship because underweight is associated more with increased long term risk of non-cardiovascular mortalities such as cancer, respiratory disease, diabetes, liver cirrhosis and renal failure (Flegal et al., 2007; Pischon et al., 2008; Thinggaard et

al., 2010). These diseases are often among the major causes of death in the Eastern Asian populations. For example, these diseases account for 49.5% of the total death of people over 65 years of age in Taiwan (Department of Health, 2009).

A weak or non-association between overweight/obesity and all-cause mortality in Eastern Asian populations probably should not be interpreted as that these populations are resistive to obesity-related chronic diseases especially cardio-vascular disease. It is probable that the lack of a strong association is mainly due to the low prevalence of extremely obese individuals in the current generation of elderly in these populations. If the prevalence and severity of obesity continue to increase, a clear U- or J-shaped relationship would probably be observed.

The prevalence of overweight and obesity in the elderly has become a growing global concern. It is commonly presumed that obesity is associated with higher risk of death. However, result of the present and many other studies suggest that obesity is not associated with a higher risk of mortality in older adults and in some cases may confer a protection (Jee et al., 2006; Orpana et al., 2009; Tamakoshi et al., 2009; Auyeung et al., 2010). This paradox deserves a careful examination and should be resolved quickly because the message has great practical implication and far-reaching consequences in health promotion and public health policy making.

4.5. Strengths and limitations

This study has some strengths and limitations. A major strength is that the data are from a nationally representative longitudinal cohort study and the survey has high completion rates (over 90%). However, the study also has some limitations. Weight and height data were mainly self-reports. Self-reported heights and weights are generally considered acceptable although some bias or errors are unavoidable. In the current study relatively few elderly were >35 kg/m^2, thus the impact of obesity could not be adequately assessed.

5. Conclusion

Results of the present study suggest that the association between BMI status and all-cause mortality in Taiwanese over 65 years of age is "L-shaped" and "obesity paradox" may indeed exist in this specific age group. However, some uncertainty remains because confounding factors could not be totally controlled. Large scale prospective studies with better control of confounding factors are urgently needed to resolve this important public health issue.

Conflict of interest

None.

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