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Original Research Article

Relations of body weight status in early adulthood and weight changes until middle age with metabolic syndrome in the Chinese population

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ABSTRACT

Background: The evidences for the relationship between long-term weight gain and metabolic syndrome (MetS) in Chinese population were limited. Therefore, this study aims to explore the association of body weight status in early adulthood and weight changes with MetS.
Methods: Data from China Multicenter Collaborative Study of Cardiovascular Epidemiology including 12808 participants aged 35–59 were used. Participants were surveyed for cardiovascular risk factors and a self-reported weight at age 25, which was defined as early adulthood. Weight change was calculated as the difference between baseline weight and early adulthood weight. MetS was defined according to AHA/NHLBI definition in 2009. Multivariate logistic regression model was used to examine the association between early adulthood weight status, weight change and MetS.
Results: Mean age of participants was 46.7 years, including 6134 men and 6674 women. The overall prevalence of MetS was 21.8%. After adjusted for age, sex and other confounding factors, both BMI at 25 age and weight gain were positively associated with the risk of MetS. Being overweight (BMI, 24–27.9 kg m^{-2}) or obese (BMI ≥28 kg m^{-2}) at early adulthood was related to an increased risk of MetS, the odds ratio (OR) and 95%confidence interval (CI) was 3.24 (2.82–3.72) and 13.31 (8.72–20.31). In addition, weight gain was also associated with higher risk of MetS (P for trend<0.01).
Conclusions: Overweight and obesity in early adulthood and weight gain were both independently related to an increased risk of MetS in the middle-aged Chinese men and women.

Keywords: Body mass index, Weight change, Metabolic syndrome

INTRODUCTION

Metabolic syndrome (MetS) is a cluster of cardiovascular disease risk factors associated with overweight and obesity, including central adiposity, dyslipidemia, elevated blood pressure, and impaired glucose metabolism.[1-3] Numerous studies have shown that MetS is strongly associated with increased risk of cardiovascular disease (CVD).[4,5] And it is well known that being overweight and obese have been widely confirmed had a strong positive association with MetS.[6,7] In recent decades, the prevalence of overweight and obesity has continued to rise. According to the 2011 China Health and Nutrition Survey, the age-adjusted overall prevalence of obesity approximately tripled from 3.75% in 1991 to 11.3% in 2011.[8] Previous studies have shown a strong relationship between long-term weight gain and risk of MetS, the person who gained weight since early adulthood was at an increased risk of MetS, as compared to those who maintained a stable weight. But these findings were based on Western or Japanese populations.[9-11] To our knowledge, no study has explored the long-term effects of body weight status in early adulthood and weight changes in adult on the risk of MetS in Chinese general population. Therefore, this study evaluated cross-sectional survey data from the China Multicenter Collaborative Study of Cardiovascular Epidemiology to assess whether the body weight status in early adulthood and subsequent weight changes are related to metabolic syndrome in middle age.

METHODS

Study populations

Participants included in the analysis were from the China Multicenter Collaborative Study of Cardiovascular Epidemiology, which was originally designed as a cross-sectional multicenter comparison of cardiovascular disease risk factors and later evolved into a comprehensive epidemiological study. The cross-sectional survey conducted from August 1998 to December 1998 included 15 population samples, of which 9 were from rural residential areas and 6 from urban areas. These populations were selected on the basis of the main population characteristics, such as socioeconomic status and geographical location. Approximately one thousand participants with an age range of 35–59 years, of whom half were men and half women, were included as a random cluster sample (all eligible participants in randomly selected rural or urban areas, the latter including city blocks and factories) from each of the populations and were surveyed for risk factors of cardiovascular disease. Further details about the study populations have been reported elsewhere.[12,13] All participants signed consent forms.

Data collection

The demographic information, lifestyle risk factors and personal medical history were collected through a standardized questionnaire which also asked participants to recall their body weight at age 25. All staff involved in administering the survey were trained and certified in advance of the survey according to a uniform protocol and operation manual. In addition to the survey items, body weight, height, blood pressure (BP), waist and hip circumferences were measured. All the items surveyed were carried out according to internationally standardized methods stipulated in a uniform working manual. Height was measured to the nearest centimeter using a vertical ruler, and weight was measured to the nearest kilogram with a spring balance. Each participant was measured wearing their usual indoor clothing and no shoes. Waist circumference (WC) was measured in the standing position with a measuring tape at the middle point between the lowest point of the costal arch and the crest of the iliac bone on both sides of the body, and through the mid-point between umbilicus and xyphoid process on the abdominal side of the body. Blood pressure was performed while participants seated in a quiet room and measured manually in the participant's right arm by trained medical personnel with a standard sphygmo-manometer. Subjects did not eat, smoke, drink alcohol or perform strenuous exercise for half an hour before the BP measurement. The mean BP of the three measurements was used for the analysis.

Fasting blood specimens after an overnight fast were obtained from each participant for measurement of serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) and glucose. Serum were separated within 3 hours, and measured by local laboratories. Serum TC and TG was measured with enzymatic methods ; Serum HDL-C was measured with the same enzymatic method with cholesterol after precipitation of other lipoprotein fractions using DS (dextran sulfate) -Mg^{++} under the quality control of the Central Laboratory of the Coordinating centre in the Department of Epidemiology, Cardiovascular Institute and Fuwai Hospital, Chinese Academy of Medical Sciences, which participated in the lipid standardization programme of the Centers for Disease Control and Prevention (Atlanta, Georgia, USA).

The body mass index (BMI) at age 25 was calculated as the recalled weight at age 25 (in kilograms) divided by the square of the height (in meters). MetS was defined according to the AHA/NHLBI joint interim statement in 2009, as having any 3 of the following 5 criteria: central obesity, WC ≥85 cm in males or ≥80 cm in females; elevated blood pressure, systolic BP/diastolic BP ≥130/85 mmHg or taking anti-hypertensive drugs; low HDL-C, HDL-C <40 mg/dL in males or <50 mg/dL in females; high triglycerides, TG ≥150 mg/dL; high fasting glucose, fasting glucose ≥100 mg/dL.[3]

Statistical analysis

All data were entered twice into the computers by trained staff at local centers and were then sent to the coordinating center of the Department of Epidemiology, Fuwai Hospital for final processing and analysis. During the analysis, the BMI at age 25 was categorized as underweight (<18.5 kg m^{-2}), normal weight (18.5–23.9 kg m^{-2}), overweight (24–27.9 kg m^{-2}) and obesity (≥28 kg m^{-2}) based on the Working Group on Obesity in China guidelines.[14] Weight change was calculated as the difference between the measured weight in 1998 and the recalled weight at age 25 and was grouped into six categories (< -7.5 kg; -7.5 to -2.6 kg; -2.5–2.5 kg; 2.6–7.5 kg; 7.6–12.5 kg and >12.5 kg); the -2.5–2.5kg group was defined as stable weight. The baseline characteristics among study participants were presented as the mean ± SD or median (interquartile range) for continuous variables and assessed by one-way analysis of variance or Kruskal-Wallis rank test. Categorical variables was presented as percentages and assessed by χ^2–test. In addition, multivariate non-conditional logistic regression models were used to assess the associations between BMI and weight change categories and the risk of metabolic syndrome in middle-aged adults. To test for trends, we calculated the median values of BMI at 25 years of age and weight change within each category and then modeled these median values as a continuous variable in all models. Potential covariates, such as age, sex, urbanization, education level, cigarette use and alcohol consumption, were included in the multivariate models. In a separate analysis, we mutually adjusted for BMI at age 25 and adult weight change as a continuous variable to examine their independent contributions. A two-tailed p value <0.05 was considered statistically significant. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA).

RESULTS

There were 15573 participants attended to this study, 2765 participants were excluded in the current analysis, including 935 who could not provide the recalled body weight data at age 25, 3 whose body weight had not been measured in 1998, 1075 whose glucose test results did not reach the quality control requirement, and 752 participants lack of serum lipid detection data. In total, 12808 participants remained in the present analysis, include 6134 males and 6674 females. Participants had a mean age of 46.7 years, a mean BMI at age 25 of 21.5 kg m^{-2} and a mean subsequent weight change of +6.2 kg. The overall prevalence of MetS was 21.8% (2787/12808), baseline characteristics of the study population (in 1998) according to BMI at age 25 are shown in Table 1. Significant differences were found between the BMI at age 25 groups in terms of age, sex, urbanization, education level, cigarette use, alcohol consumption (all p values <0.01). From the underweight group to obese group systolic BP (SBP), diastolic BP (DBP), TG and glucose level were significantly raised in middle-aged participants. In addition, the prevalence of MetS for the four BMI categories was 18.1%, 20.6%, 29.1% and 45.3%, respectively, significantly increased with the BMI status at age 25 (p for trend <0.01).

Table 2 shows the baseline characteristics of the study population (in 1998) according to the weight change categories. Participants who had greater weight gain were more likely to be urban residents, have higher education levels and have a high level of SBP, DBP, TG and glucose, but they were less likely to be smokers than those who had moderate weight gain or weight loss. More importantly, the prevalence of MetS for the six weight change categories was 5.6%, 5.8%, 9.0%, 14.9%, 27.1% and 46.4%, significantly increased with weight gain from age 25 years to middle age (p for trend <0.01).

Table 1: Baseline characteristics of participants categorize by BMI at 25 years of age.

	BMI at 25 years (kg m^{-2})				P value
	＜18.5	18.5~23.9	24~27.9	≥28	
	(n=1268)	(n=9640)	(n=1783)	(n=117)	
Age (years)	45.5±7.1	46.6±7.1	47.9±6.9	48.6±7.9	<0.01
Men (%)	415 (32.7)	4955 (51.4)	713 (40.0)	51 (43.6)	<0.01
Urban (%)	801 (63.2)	4473 (46.4)	619 (34.7)	43 (36.8)	<0.01
Education (%)					<0.01
Primary school or below	301 (23.7)	3082 (32.0)	768 (43.1)	44 (37.6)	
Junior high school	423 (33.4)	3281 (34.0)	629 (35.3)	45 (38.5)	
High school or equivalent	404 (31.9)	2332 (24.2)	298 (16.7)	21 (18.0)	
At least some college	140 (11.0)	945 (9.8)	88 (4.9)	7 (6.0)	
Current smokers (%)	245 (19.3)	3131 (32.5)	496 (27.8)	43 (36.8)	<0.01
Current drinkers (%)	229 (18.1)	2655 (27.5)	408 (22.9)	33 (28.2)	<0.01
BMI at 25 years (kg/ m^2)	17.6±0.9	21.2±1.4	25.3±1.0	29.3±1.3	<0.01
BMI (kg/ m^2)	22.0±3.1	23.6±3.3	25.7±3.7	28.2±3.5	<0.01
Weight change (kg)	11.7±8.5	6.5±8.8	1.1±9.5	-2.7±9.0	<0.01
Waist circumference (cm)	75.1±9.2	78.6±9.7	82.1±10.6	88.6±10.2	<0.01
SBP (mmHg)	118.9±18.5	122.4±19.3	125.8±21.0	133.5±22.5	<0.01
DBP (mmHg)	76.2±11.1	78.5±11.7	80.1±12.7	83.1±13.1	<0.01
TG (mmol/L)*	1.13 (0.82,1.59)	1.20 (0.86,1.72)	1.22 (0.87,1.77)	1.22 (0.91,1.85)	<0.01
HDL-C (mmol/L)	1.43±0.34	1.37±0.35	1.35±0.34	1.27±0.34	<0.01
Blood glucose (mmol/L)	5.00±0.94	5.01±1.26	5.17±1.69	5.68±2.27	<0.01
Metabolic syndrome (%)	230 (18.1)	1986 (20.6)	518 (29.1)	53 (45.3)	<0.01

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol. *Median (P_{25}, P_{75})

Table 3 shows the odds ratios (ORs) of MetS according to BMI at age 25. In an age and sex-adjusted analysis (Model 1), BMI at age 25 was significantly associated with the risk of MetS in middle age. The ORs and 95% confidence interval (CI) for the underweight group, the overweight group and the obesity group relative to the normal weight group were 0.89 (0.76–1.04), 1.50 (1.34–1.68) and 2.97 (2.05–4.32), respectively (P for trend <0.01). This association did not change after adjusting for urbanization, education, cigarette use, alcohol consumption (Model 2). When we further adjusted for weight change as a continuous variable in model 3, this association also remained unchanged, and the risk in underweight group even became significant.

Table 2: Baseline characteristics of participants categorize by weight change since 25 years of age.

	Weight change since 25 years of age (kg)						P value
	<-7.5 (n=721)	-7.5~-2.6 (n=1647)	-2.5~2.5 (n=2347)	2.6~7.5 (n=2611)	7.6~12.5 (n=2539)	>12.5 (n=2943)	
Age (years)	48.3±7.0	47.1±7.3	46.0±7.3	45.9±7.1	46.5±6.9	47.4±6.8	0.75
Men (%)	384 (53.3)	840 (51.0)	1140 (48.6)	1144 (43.8)	1168 (46.0)	1458 (49.5)	<0.01
Urban (%)	166 (23.0)	403 (24.5)	914 (38.9)	1319 (50.5)	1409 (55.5)	1725 (58.6)	<0.01
Education (%)							<0.01
Primary school or below	371 (51.5)	802 (48.7)	868 (37.0)	774 (29.6)	643 (25.3)	737 (25.0)	
Junior high school	232 (32.2)	511 (31.0)	791 (33.7)	889 (34.1)	889 (35.0)	1066 (36.2)	
High school or equivalent	93 (12.9)	257 (15.6)	508 (21.6)	705 (27.0)	700 (27.6)	792 (26.9)	
At least some college	25 (3.5)	77 (4.7)	180 (7.7)	243 (9.3)	307 (12.1)	348 (11.8)	
Current smokers (%)	304 (42.2)	628 (38.1)	764 (32.6)	697 (26.7)	714 (28.1)	808 (27.5)	<0.01
Current drinkers (%)	204 (28.3)	441 (26.8)	580 (24.7)	635 (24.3)	658 (25.9)	807 (27.4)	0.04
BMI at 25 years (kg/ m^2)	24.2±2.3	22.8±2.1	21.7±2.3	21.2±2.2	20.9±2.2	20.6±2.3	<0.01
BMI (kg/ m^2)	20.2±2.2	20.9±2.1	21.8±2.3	23.2±2.3	24.8±2.3	27.6±2.9	<0.01
Weight change (kg)	-10.3±2.2	-4.8±1.4	0.0±1.5	5.2±1.4	10.0±1.4	18.8±5.4	<0.01
Waist circumference (cm)	70.1±6.8	71.1±6.6	73.3±7.5	77.4±7.5	81.6±7.5	88.7±8.4	<0.01
SBP (mmHg)	118.0±20.1	118.2±18.3	118.8±18.4	120.9±18.3	124.1±19.0	129.5±20.5	<0.01
DBP (mmHg)	74.2±11.8	74.1±11.0	75.4±10.8	77.4±10.8	80.1±11.3	84.2±12.0	<0.01
TG (mmol/L)*	1.00 (0.77,1.31)	1.01 (0.76,1.37)	1.02 (0.77,1.46)	1.16 (0.85,1.65)	1.33 (0.94,1.88)	1.48 (1.05,2.18)	<0.01
HDL-C (mmol/L)	1.49±0.36	1.48±0.34	1.44±0.35	1.39±0.33	1.33±0.33	1.26±0.32	<0.01
Blood glucose (mmol/L)	4.98±1.82	4.88±1.18	4.92±1.42	5.00±1.21	5.10±1.23	5.22±1.30	<0.01
Metabolic syndrome (%)	40 (5.6)	96 (5.8)	210 (9.0)	390 (14.9)	687 (27.1)	1364 (46.4)	<0.01

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol. *Median (P_{25}, P_{75})

Table 3: The odds ratios associated with BMI at 25 years of age and metabolic syndrome.

	Model 1		Model 2		Model 3	
BMI at 25 years (kg m^{-2})	OR	95%CI	OR	95%CI	OR	95%CI
<18.5	0.89	0.76-1.04	0.86	0.74-1.00	0.44	0.37-0.53
18.5~23.9	1.00	reference	1.00	reference	1.00	reference
24~27.9	1.50	1.34-1.68	1.53	1.37-1.72	3.24	2.82-3.72
≥28	2.97	2.05-4.32	3.02	2.08-4.39	13.31	8.72-20.31
P for trend	<0.01		<0.01		<0.01	

Abbreviations: BMI, body mass index; OR, odds ratio; CI, confidence interval; Model 1: adjusted for age and sex; Model 2: further adjusted for urbanization (urban or rural), educational level (primary school or below, junior high school, high school or equivalent or at least some college), smoking status (current smoker or not), drinking status (current drinker or not); Model 3: additionally adjusted for weight change between the age of 25 and the study baseline (1998) as a continuous variable.

Table 4 shows the ORs of MetS based on the weight change categories. In an age- and sex adjusted analysis (Model 1) and multivariate-adjusted analysis (Model 2), weight gain of 2.6 kg or more during adulthood was associated with a higher risk of MetS than that of the stable weight group. And our results also found that weight loss was significantly associated with lower risk of MetS in Model 1 and Model 2. In addition, we adjusted for BMI at age 25 as a continuous variable in Model 3, and the trend was consistent with the previous two Models. In addition, the ORs (95% CI) for the two weight loss groups (-7.5 to -2.6 kg and <-7.5 kg) were 0.45 (0.35–0.58) and 0.26 (0.18–0.37), respectively.

Table 4: The odds ratios associated with weight change since 25 years of age and metabolic syndrome.

	Model 1		Model 2		Model 3	
Weight change (kg)	OR	95%CI	OR	95%CI	OR	95%CI
<-7.5	0.54	0.38-0.76	0.50	0.35-0.71	0.26	0.18-0.37
-7.5~-2.6	0.59	0.46-0.76	0.56	0.44-0.73	0.45	0.35-0.58
-2.5~2.5	1.00	reference	1.00	reference	1.00	reference
2.6~7.5	1.81	1.52-2.17	1.91	1.59-2.28	2.28	1.90-2.75
7.6~12.5	3.77	3.19-4.46	4.06	3.42-4.81	5.50	4.61-6.57
>12.5	8.63	7.35-10.13	9.46	8.04-11.14	15.20	12.76-18.10
P for trend	<0.01		<0.01		<0.01	

Abbreviations: OR, odds ratio; CI, confidence interval; Model 1: adjusted for age and sex; Model 2: further adjusted for urbanization (urban or rural), educational level (primary school or below, junior high school, high school or equivalent or at least some college), smoking status (current smoker or not), drinking status (current drinker or not); Model 3: additionally adjusted for BMI at 25 years of age as a continuous variable.

We also explored the association between BMI at age 25 and adult weight change with MetS stratified by 5-year age groups, and the results showed that the risk of MetS was consistent across the age groups (Table 5).

For each age group, overweight or obese in early adulthood was associated with MetS, and this association was also found in weight gain in middle age (p for trend<0.01).

Table 5: The ORs and 95% CI associated with metabolic syndrome and BMI at 25 years of age, weight change since 25 age stratified by baseline age.

	Baseline age groups (years)				
	35-39	40-44	45-49	50-54	55-59
BMI at 25 (kg m $^{-2}$)[a]					
<18.5	0.27 (0.15-0.47)	0.29 (0.18-0.46)	0.46 (0.33-0.65)	0.49 (0.33-0.73)	0.72 (0.51-1.02)
18.5~23.9	1.00	1.00	1.00	1.00	1.00
24~27.9	4.81 (3.17-7.28)	5.47 (3.91-7.67)	2.87 (2.16-3.82)	2.64 (1.99-3.51)	2.61 (1.99-3.44)
≥28	9.36 (3.05-28.72)	8.96 (2.48-32.40)	16.65 (6.25-44.40)	39.44 (15.42-100.83)	5.68 (2.64-12.22)
P for trend	<0.01	<0.01	<0.01	<0.01	<0.01
Weight changes (kg)[b]					
<-7.5	0.30 (0.08-1.13)	0.20 (0.07-0.60)	0.30 (0.13-0.69)	0.26 (0.13-0.51)	0.26 (0.14-0.49)
-7.5~-2.6	0.50 (0.22-1.13)	0.49 (0.25-0.95)	0.57 (0.31-1.04)	0.31 (0.18-0.54)	0.46 (0.30-0.72)
-2.5~2.5	1.00	1.00	1.00	1.00	1.00
2.6~7.5	2.61(1.48-4.61)	3.12 (1.94-5.02)	3.08 (2.01-4.73)	1.53 (1.03-2.26)	2.06 (1.46-2.89)
7.6~12.5	8.15 (4.75-14.00)	7.85 (5.00-12.32)	7.50 (4.98-11.30)	4.33 (2.99-6.26)	3.43 (2.46-4.78)
>12.5	23.87 (13.97-40.78)	31.16 (19.98-48.62)	18.01 (11.97-27.10)	11.44 (7.96-16.45)	7.79 (5.62-10.79)
P for trend	<0.01	<0.01	<0.01	<0.01	<0.01

Abbreviations: BMI, body mass index; ORs, odds ratios; CI, confidence interval. [a]: adjusted for age, sex, urbanization (urban or rural), educational level (primary school or below, junior high school, high school or equivalent or at least some college), smoking status (current smoker or not), drinking status (current drinker or not) and weight change as a continuous variable. [b]: adjusted for age, sex, urbanization (urban or rural), educational level (primary school or below, junior high school, high school or equivalent or at least some college), smoking status (current smoker or not), drinking status (current drinker or not) and BMI at age 25 as a continuous variable.

DISCUSSION

In this large-scale population study, we examined relationships between BMI at age 25 and weight changes from early adulthood to middle age with metabolic syndrome. As compared with the normal BMI at age 25 and stable weight (-2.5–2.5 kg), being overweight or obese at early adulthood and long-term weight gain (>2.5 kg) was related to an increased risk of MetS in the middle-age Chinese men and women. These findings were consistent with the results of the National Health and Nutrition Examination Survey (NHANES) conducted between 1999 and 2006, which shown that those who reported weight gain of more than 10 kg in 10 years, independent of current BMI, were more likely to have a diagnosis of MetS, as compared to a person who had maintained the same weight over approximately 25 years (OR, 1.89; 95% CI, 1.19–3.01).[15] Similarly, Suzuki et al reported that long-term weight gain is related to the risk of MetS in Japanese, the obese/gain group showed the highest risk of MetS in men and women.[11] Furthermore, even the non-obese/gain group had an increased risk of MetS in men (OR, 4.98; 95% CI, 3.47–7.15) and women (OR, 6.28; 95% CI, 1.53–25.83).

In the present study, even moderate weight gain (2.6 to 7.5 kg) was associated with a higher risk of MetS in middle age (OR, 2.28; 95% CI, 1.90–2.75). This result was consistent with the findings of the Doetinchem cohort study, participants aged in 20-59 years, the result showed that compared to stable weight (-2.5–2.5 kg), weight gain (>2.5 kg) was associated with an increased number of components of MetS.[10] When the study stratified for 10-year age group, these independent associations of weight changes with the number of MetS components were more pronounced in younger people (OR, 1.31; 95% CI, 1.21–1.41). In addition, in the Coronary Artery Risk Development in Young Adults (CARDIA) study, a prospective study in persons aged 18–30 years at baseline, a stable BMI group (2.2%) over 15 years time was associated with a smaller incidence of the MetS compared to a rise in BMI over time (18.8%; $p<0.001$), regardless of the baseline BMI. However, this study was limited to the young adults only, it differed from our present study.[16] Furthermore, in our study, weight loss (even moderate weight loss) could reduce the risk of MetS, independent of age, sex, BMI at age 25 and other risk factors (Table 4).

Given the wide range of participants' ages (35–59 years), the time between age 25 and the baseline survey varied greatly. And in the view of weight gain tends to be larger in younger individuals compared to older people.[17] Therefore, we stratified participants by 5-year of age group (Table 5) to study the relationship between weight change and MetS. Notably, a positive association between BMI at age 25 and the risk of MetS was found in all age groups (all p values for trend <0.01). Similar associations were reported by Bot et al, participants were stratified by every 10-year age group with a follow-up of 16 years.[10] For each age group, 1 kg weight gain was positively associated with the number of components of the MetS. And in our study, when further adjusted for BMI at 25 in the model, the weight gain in each age group was also significantly associated with MetS, indicating that the association weight gain during adulthood increased the risk of MetS in middle age regardless of the time between age 25 and the BMI at age 25.

Our study has two strengths. First, in this retrospective cohort design, we enrolled a large population-based sample, including male and female participants from China. Second, to our knowledge, the present study is the first report from a retrospective cohort study simultaneously examining the body weight status in early adulthood and long-term weight changes until middle age and the subsequent risk for metabolic syndrome in the Chinese general population.

The present study also has several potential limitations. First, our analyses relied on self-reported and recalled weight at 25 years of age instead of measured values. Although the validity of self-reported weights and measured weights has been examined, and the accuracy has been established, a previous study suggested that there is a systematic tendency for heavy persons to underestimate their weight and, conversely, for thin persons to overestimate their weight.[18-20] The weight at age 25 and BMI at the time of the survey results in our study could be affected by the 'regression to the mean' phenomenon. Thus, the relationship between overweight or obesity in early adulthood and the risk of MetS could be underestimated. However, the relationship between weight gain and risk of MetS may be overestimated. Second, because the study had a cross-sectional design, we did not collect reasons for weight change during adulthood; as a result, the cause-and-effect relationships among long-term weight gain, and weight loss in particular, and MetS cannot be further explained.

In conclusion, we have shown in this large-scale retrospective cohort study that overweight and obesity in early adulthood and adult weight gain were both independently related to a marked increase in the risk of metabolic syndrome in the middle-aged Chinese men and women. Long-term weight loss (even moderate weight loss) could reduce the risk of metabolic syndrome.

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