### RESEARCH



# Associations of obesity with chronic inflammatory airway diseases and mortality in adults: a population-based investigation



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#### Abstract

**Background** The association between obesity and respiratory diseases has been confirmed. However, few studies have reported the relationship between obesity and the risk and mortality of chronic inflammatory airway disease (CIAD). The aim of this study was to reveal the association between obesity and the risk of CIAD, and mortality in patients with CIAD.

**Methods** The study was conducted using data from the National Health and Nutrition Examination Survey (NHANES) 2013 to 2018 among adults aged 20 years and above. All participants were grouped according to body mass index (BMI) and waist circumference (WC) levels to study the relationship between obesity and CIAD. Multivariate logistic regression analysis was utilized to examine the connection between CIAD and obesity in a cross-sectional study. The association between obesity and all-cause mortality in individuals with CIAD was examined using multiple cox regression models and smooth curve fitting in a prospective cohort study.

**Results** When stratified based on BMI in comparison to the normal weight group, the ORs with 95%CIs of CIAD for underweight and obesity were 1.39 (1.01–1.93) and 1.42 (1.27–1.58), respectively. The OR with 95%CI of CIAD for obesity was 1.20 (1.09–1.31) when stratified according to WC. Additionally, underweight was associated with a higher mortality (HR = 2.44, 95% CI = 1.31–4.55), whereas overweight (HR = 0.58,95% CI = 0.39–0.87) and obesity (HR = 0.59,95% CI = 0.4–0.87) were associated with a lower mortality (*P* for trend < 0.05). There was a non-linear association between BMI and all-cause mortality (P for non-linear = 0.001). An analysis of a segmentation regression model between BMI and all-cause mortality revealed a BMI turning point value of 32.4 kg/m<sup>2</sup>. The mortality of CIAD patients was lowest when BMI was 32.4 kg/m<sup>2</sup>. When BMI < 32.4 kg/m<sup>2</sup>, BMI was inversely associated with all-cause mortality in patients with CIAD (HR: 0.92, 95%CI:0.88–0.97). However, when BMI > 32.4 kg/m<sup>2</sup>, there was no association between BMI and all-cause mortality (HR: 1.02, 95%CI:0.97–1.06).

**Conclusion** Compared to normal weight, underweight and obesity were associated with the increased risk of CIAD. Underweight was associated with increased all-cause mortality, while overweight was associated with reduced all-cause mortality. There was a non-linear association between BMI and all-cause mortality in patients with CIAD. The all-cause mortality was lowest when BMI was 32.4 kg/m<sup>2</sup>.

Keywords Obesity, Chronic inflammatory airway diseases, COPD, Asthma, Chronic bronchitis, NHANES, Mortality

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#### Introduction

Chronic obstructive pulmonary disease (COPD), asthma and chronic bronchitis are collectively referred to as chronic inflammatory airway diseases(CIAD) and have become an important cause of the increasing global disease burden [1, 2]. According to the Global Burden of Disease 2017 data reported, smoking, household air pollution from solid fuels and ambient particulate matter were the leading risk factors for chronic respiratory disease-related disability [2]. In 2017, an estimated 3.91 million fatalities were attributed to chronic respiratory diseases, marking an increase of 18% compared to 1990 data. Chronic respiratory diseases have become the third leading cause of mortality globally, following cardiovascular diseases and cancer [3]. COPD and asthma are two primary types of chronic respiratory diseases. Both conditions are intricately associated with chronic airway inflammation. In 2019, 212.3 million people worldwide had COPD, resulting in 3.3million deaths and 74.4 million disability adjusted life years [4]. Furthermore, asthma represents a diverse clinical syndrome impacting over 300 million individuals globally, with 25 million affected in the United States alone [5].

Obesity is a pressing global public health concern, and the persistently rising burden is expected to intensify even further [6]. In 2017, there were 4 million people died as a result of being overweight or obese according to global burden of disease statistics [7]. An investigation shown that a total of 124,076 deaths were attributed to obesity-related causes from 1999 to 2020 in the United States [8]. It is well known that obesity is a risk factor for many chronic diseases. Studies have confirmed that obesity affects lung function and outcomes in COPD patients. Another study proposed that body mass index(BMI) and abdominal obesity were associated with the risk of airflow obstruction [9]. Specifically speaking, abdominal obesity increases risk of airway obstruction compared with normal weight population. Additionally, overweight are associated with increased risk of asthma attacks, and population with obesity are at increased risk of asthma exacerbations and hospitalizations [10]. However, despite numerous studies on the relationship between obesity and respiratory diseases, there is no consistent conclusion. Moreover, few studies have reported the relationship between obesity and the risk and mortality of CIAD. Thus we analyzed the data from the National Health and Nutrition Examination Survey (NHANES) 2013-2018 to contribute more scientific evidence and opinions for the prevention and treatment of CIAD.

## Materials and methods

#### Data source and participants

NHANES is a national study investigating the nutrition and health status of Americans with a 2-year survey cycle, which is a free and open database that researchers around the world can download for free for academic research analysis. The entire research study passed the ethical review of the National Center for Health Statistics (NCHS) in the United States, and informed consent was obtained from all participants.

Adults over 20 who answered the chronic inflammatory airway disease questionnaire between 2013 and 2018 were included in our study. Initially, a total of 29,400 patients were collected. Participants with missing data on BMI (n=3584), waist circumference (WC)(n=4825) and CIAD (n=7674) and pregnancy (n=167) were excluded. Finally, 15,124 eligible participants were included in the analysis. The specific inclusion and exclusion flow chart is shown in Fig. 1.

#### **Exposure variables**

The values of BMI and WC were obtained from NHANES examination data (Body Measures section). BMI is calculated using the formula of weight (kg) divided by height (m) squared. Based on guidance from the National Heart, Lung, and Blood Institute (NHLBI) of the USA and the WHO, we divide BMI into four categories: underweight (<18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight (25–29.9 kg/m<sup>2</sup>), and obesity ( $\geq$  30 kg/m<sup>2</sup>) [11, 12]. WC is an obesity indicator that measures visceral fat. Males > 102 cm and females > 88 cm are defined as obese, and other participants are defined as normal.

#### **Outcome variables**

The outcome variables of this study are whether the participant had any self-reported CIAD, including COPD, asthma, and chronic bronchitis. These variables were obtained from NHANES questionnaire data in which participants had been told by a doctor or other health professional that they have or have had chronic bronchitis, asthma, or COPD. Participants who provided a clear answer of "yes" for any of CIAD were defined as participants having this disease.

#### Mortality

To assess the impact of obesity on all-cause mortality in participants with CIAD, we conducted a prospective cohort analysis. In NHANES, study participants who had died were identified from the death certificate records from the National Death Index (NDI) in December 31st, 2019. All-cause mortality records for



Fig. 1 Flowchart of participants' selection. BMI: body mass index; WC: waist circumference; CIAD: chronic inflammatory airway disease

participants were obtained via the 2019 Linked Mortality File (LMF). Follow-up time was counted from the date of interview to the date of death or the end of the mortality period.

#### Covariates

Information regarding covariates for analysis was collected from demographics, questionnaires, dietary, examination and laboratory data in NHANES. This study divided the covariates into four categories, including baseline demographic data (age, gender, BMI, WC, ethnicity, education level and poverty-income ratio), lifestyle (physical activity, energy intake, drinking status and smoking status), laboratory data (blood eosinophil counts), and comorbidities (hypertension and cardiovascular disease). And measurement details for all covariates are described on the NHANES website. Regarding the classification and definition of covariates, the study refers to other related studies [1, 13]. Education level was categorized as below high school, high school and above high school. Information on comorbidities, including hypertension and cardiovascular disease was self-reported. Cardiovascular diseases (CVD) included coronary heart disease, angina, heart failure, heart attack, and stroke.

#### Statistical analysis

Continuous variables were presented as mean with standard deviation (mean  $\pm$  SD) or as the median (interquartile range), while categorical variables were shown as absolute values and/or frequency (%). Missing data for covariates were filled using the imputation approach. According to the presence or absence of CIAD, all participants are divided into two groups. One-way analyses of variance (ANOVA) (normal distribution), Kruskal– Wallis test (skewed distribution), and  $\chi^2$  test (categorical variables) were conducted to compare the baseline characteristics between the two groups.

In order to evaluate the relationship between BMI, WC, and CIAD, univariate and multivariate logistic regression analyses were conducted after adjusting for correlated covariates in the three models. Covariates were identified based on previous CIAD-related studies and clinical relevance. Model 1 was adjusted for age. Model 2 was adjusted for age, sex, race, poverty-income ratio (PIR), education level, energy intake and physical activity. Model 3 was adjusted for Model 2 plus smoking status, drink status, blood eosinophil counts, hypertension and CVD. Furthermore, all participants were divided into four groups based on BMI:<18.5 kg/m<sup>2</sup> (underweight), 18.5–24.9 kg/m<sup>2</sup> (normal weight), 25–29.9 kg/

 $m^2$  (overweight), and  $\geq 30 \text{ kg/m}^2$  (obesity), and normal weight was used as a reference for comparison. And according to WC, all participants were divided into obese group and normal group. To explore the possible non-linear dose–response association between BMI, WC and CIAD, we further conducted restricted cubic spline to develop smooth curves. In addition, we performed stratified analyzes among different subgroups.

In prospective cohort analysis, cox proportionalhazards regression models were employed to estimate the association between obesity and all-cause mortality. Additionally, we utilized restricted cubic spline models to generate smooth curves to assess potential nonlinear dose-response relationship between BMI, WC and all-cause mortality in patients with CIAD. In the models, BMI and WC were treated as a continuous variable with four knots (at the 5th, 35th, 65th, and 95th percentiles), as recommended by Harrell [14]. Nonlinearity was assessed using a likelihood ratio test, comparing the model with only a linear term against the model with both linear and cubic spline terms. If a nonlinear association was detected, a two-piecewise regression model was conducted to calculate the threshold effect of BMI and WC on all-cause mortality, as depicted in the smoothing plot.

All analyses were performed with R Statistical Software (https://www.R-project.org, The R Foundation) and Free Statistics software versions 1.9. A two-tailed P < 0.05 was considered to be significant for all analyses.

#### Results

#### **Baseline characteristics**

As shown in Fig. 1, a total of 15,124 participants were included in the final analysis, including 2932 individuals with CIAD and 12,192 non-CIAD participants. In the prospective cohort study, 5 CIAD participants with missing mortality follow-up data were excluded from survival analysis. Finally, a total of 2927 participants were included in survival analysis. The baseline characteristics of all participants were shown in Table 1. The average age of the study population was  $49.8 \pm 17.4$  years and 7398 (48.9%) were male. The prevalence rates of CIAD, asthma, chronic bronchitis, and COPD were 19.4%, 14.9%, 5.9% and 3.7%. The mean BMI was 29.4±7.0 kg/  $m^2$ , and the mean WC was  $100.0 \pm 16.7$  cm. Compared to the non-CIAD participants, the participants with CIAD were more likely to be older, to be female and to have higher BMI and WC. Participants in the CIAD group were more likely to smoke.

#### Associations between BMI, WC and CIAD

The associations between BMI, WC and CIAD are presented in Table 2. We found that BMI and WC have a significant association with the risk of CIAD (including asthma, chronic bronchitis and COPD). After adjusting for potential covariates, it was found that for each unit increase in BMI, the incidence of CIAD increased to 2.7%. And for each unit increase in WC, the incidence of CIAD increased to 1.2%. Stratifying according to BMI, and using normal weight group as a reference, we found that the risk of CIAD in underweight and obese groups increased by 39% and 42%, respectively (p for trend < 0.001). The incidence of CIAD is not increased in overweight group (OR=1.06, 95% CI: 0.94-1.19; P=0.32). Stratifying according to WC, we found that the risk of CIAD in obese population increased by 20% (OR=1.20, 95% CI: 1.09–1.31; P<0.001). Furthermore, the dose-response relationship between BMI, WC and incidence of CIAD is presented in Fig. 2. There were nonlinear associations between BMI, WC and CIAD (P for nonlinearity < 0.05).

#### Subgroup analysis

In order to further assess the potential association between BMI,WC and CIAD, we conducted the subgroup analysis (Figs. 3 and 4), with stratification factors including sex (male, female), age (<40, 40–59,  $\geq$ 60), PIR (<1.0, 1.0-2.99,  $\geq 3.0$ ), educational attainment (below high school, high school, above high school), physical activity (inactive, insufficiently active, active), smoking status (never smokers, former smokers, current smokers), hypertension (yes, no), CVD (yes, no). In the stratified analysis of BMI, all subgroups had no significant interactions. The result revealed that the relationship between obesity and CIAD is consistent in all subgroups (all *P* for interactions > 0.05). In the stratified analysis of WC, the result found that there was a significant association between obesity with CIAD in female population (OR=1.31, 95%CI:1.14-1.5, P<0.001) but not in male population (OR=1.1, 95%CI:0.97-1.26, P=0.15) (P for interactions < 0.05). There were no interactions in other subgroups.

# Associations between obesity and mortality among adults with CIAD

In prospective cohort study, the median follow-up time is 47 months (mean  $\pm$  SD, 48.1  $\pm$  21.1 months). There are 186 (6.4%) all-cause deaths among 2,927 participants with CIAD. After cox regression analysis, we found that compared with normal weight group, underweight was associated with a higher mortality (HR = 2.44, 95% CI:1.28–4.44, *P*=0.005), whereas overweight (HR = 0.58, 95% CI:0.39–0.87, *P*=0.009) and obesity (HR = 0.59, 95% CI:0.4–0.87, *P*=0.008) were associated with a lower mortality (*P* for trend < 0.05). And the results were the same when stratified by

#### Table 1 Baseline characteristics of adult participants in NHANES 2013–2018

Variables	Total (n = 15,124)	Non CIAD(n = 12,192)	CIAD (n=2932)	P-value
BMI, kg/m <sup>2</sup>	29.4±7.0	29.0±6.7	30.9±8.1	< 0.001
WC, cm	$100.0 \pm 16.7$	99.1±16.2	103.6±18.5	< 0.001
Age, years	49.8±17.4	49.5±17.3	50.6±17.8	0.002
Sex, n (%)				< 0.001
Male	7398 (48.9)	6116 (50.2)	1282 (43.7)	
Female	7726 (51.1)	6076 (49.8)	1650 (56.3)	
Race/ethnicity, n (%)				< 0.001
Mexican American	2227 (14.7)	1954 (16)	273 (9.3)	
Other Hispanic	1602 (10.6)	1319 (10.8)	283 (9.7)	
Non-Hispanic White	5589 (37.0)	4236 (34.7)	1353 (46.1)	
Non-Hispanic Black	3248 (21.5)	2571 (21.1)	677 (23.1)	
Other race	2458 (16.3)	2112 (17.3)	346 (11.8)	
poverty-income ratio, <i>n</i> (%)				< 0.001
< 1.0	2823 (20.7)	2161 (19.8)	662 (24.6)	
1.0–2.99	5824 (42.7)	4648 (42.5)	1176 (43.7)	
≥3.0	4981 (36.5)	4126 (37.7)	855 (31.7)	
Education level, n (%)				0.026
Below high school	3217 (21.3)	2635 (21.6)	582 (19.9)	
High school	3428 (22.7)	2718 (22.3)	710 (24.2)	
Above high school	8467 (56.0)	6831 (56.1)	1636 (55.9)	
Energy intake, kcal/day	2110.2±1003.2	2114.7±993.0	2092.0±1044.2	0.288
Smoking status, <i>n</i> (%)				< 0.001
Never smoker	8655 (57.3)	7326 (60.1)	1329 (45.4)	
Former smoker	2936 (19.4)	2150 (17.6)	786 (26.8)	
Current smoker	3524 (23.3)	2709 (22.2)	815 (27.8)	
Drinking status, <i>n</i> (%)				< 0.001
Never drinker	1964 (13.9)	1664 (14.7)	300 (10.8)	
Former drinker	2523 (17.9)	1932 (17)	591 (21.2)	
Mild drinker	4876 (34.5)	3941 (34.7)	935 (33.6)	
Moderate drinker	3240 (22.9)	2580 (22.7)	660 (23.7)	
Heavier drinker	1523 (10.8)	1226 (10.8)	297 (10.7)	
Physical activity, n (%)			, , , , , , , , , , , , , , , , , , ,	< 0.001
Inactive	8651 (57.5)	7074 (58.3)	1577 (54.1)	
Insufficiently active	3793 (25.2)	2975 (24.5)	818 (28.1)	
Active	2599 (17.3)	2081 (17.2)	518 (17.8)	
hypertension, n (%)				< 0.001
No	10.624 (70.3)	8813 (72.4)	1811 (61.8)	
Yes	4478 (29.7)	3359 (27.6)	1119 (38.2)	
CVD. n (%)				< 0.001
No	13,464 (89,4)	11,107 (91,5)	2357 (80.9)	
Yes	1589 (10.6)	1033 (8.5)	556 (19.1)	
Asthma. n (%)	,			< 0.001
No	12.873 (85.1)	12.192 (100)	681 (23.2)	
Yes	2251 (14.9)	0 (0)	2251 (76.8)	
Chronic bronchitis, $n$ (%)				< 0.001
No	14,230 (94.1)	12.192 (100)	2038 (69.5)	(0.001
Yes	894 (5.9)	0 (0)	894 (30.5)	
COPD. n (%)	0		00. (00.0)	< 0.001
No	14 559 (96 3)	12 192 (100)	2367 (80 7)	×0.001
Yes	565 (3 7)	0 (0)	565 (193)	
Blood eosinophil counts 10 <sup>9</sup> /	0.2 (0.1 0.3)		0.2 (0.1 0.3)	~ 0.001
blood cosinophil counts, 10 /L	0.2 (0.1, 0.5)	0.2 (0.1, 0.2)	0.2 (0.1, 0.3)	< 0.001

Data are presented as the mean ± SD or median (interquartile range) for skewed variables or as numbers (%) for categorical variables

CIAD chronic inflammatory airway disease, BMI body mass index, WC waist circumference, CVD Cardiovascular diseases, COPD chronic obstructive pulmonary disease

	Model 1		Model 2		Model 3	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
BMI (kg/m <sup>2</sup> )						
Continuous	1.04 (1.03-1.04)	< 0.001	1.03 (1.03-1.04)	< 0.001	1.03 (1.02-1.03)	< 0.001
Clinical cutoffs						
< 18.5	1.64 (1.20-2.25)	0.0018	1.50 (1.09–2.06)	0.0118	1.39 (1.01–1.93)	0.045
18.5–24.9	1(Ref)		1(Ref)		1(Ref)	
25-29.9	1.04 (0.93-1.17)	0.4871	1.08 (0.97-1.22)	0.1686	1.06 (0.94-1.19)	0.316
≥30	1.56 (1.41–1.73)	< 0.001	1.57 (1.41–1.75)	< 0.001	1.42 (1.27–1.58)	< 0.001
Trend test	1.16 (1.12–1.20)	< 0.001	1.16 (1.12–1.20)	< 0.001	1.12 (1.08–1.16)	< 0.001
WC (cm)						
Continuous	1.02 (1.01-1.02)	< 0.001	1.02 (1.01-1.02)	< 0.001	1.01 (1.01-1.01)	< 0.001
Clinical cutoffs						
Normal	1(Ref)		1(Ref)		1(Ref)	
Obese	1.43 (1.31–1.56)	< 0.001	1.32 (1.20–1.45)	< 0.001	1.20 (1.09–1.31)	< 0.001

Table 2 Multivariate logistic regression analyses of obesity and CIAD

Model 1 was adjusted for age; Model 2 was adjusted for age, sex, race, PIR, education level, energy intake and physical activity; Model 3 was adjusted for Model 2 plus smoking status, drink status, blood eosinophil counts, hypertension and CVD. Normal weight group is the reference group

CIAD chronic inflammatory airway disease, BMI body mass index, WC waist circumference, PIR poverty-income ratio, CVD Cardiovascular disease



**Fig. 2** Restricted cubic spline analyses the association of BMI (**a**), WC (**b**) and the risk of chronic inflammatory airway diseases (CIAD). Adjusted for age, sex, race, PIR, education level, energy intake, physical activity, smoking status, drinking status, blood eosinophil counts, hypertension and CVD. Abbreviations: BMI: body mass index; PIR: poverty-income ratio; CVD: Cardiovascular diseases

waist circumference (HR = 0.68, 95% CI = 0.49–0.95, P = 0.023). The results are presented in Table 3.

By restricted cubic spline model and smooth curve fitting (after adjusting for age, gender, race, PIR,

education level, energy intake, physical activity, smoking status, drinking status, blood eosinophil counts, hypertension and CVD), we found that there was a non-linear association between BMI and all-cause mortality (*P* for non-linear = 0.001, Fig. 5). A turning point value of BMI (32.4 kg/m<sup>2</sup>) was found by a segmentation regression model between BMI and all-cause mortality. The mortality of CIAD patients was lowest when BMI was 32.4 kg/m<sup>2</sup>. When BMI  $\leq$  32.4 kg/m<sup>2</sup>, BMI was inversely associated with all-cause mortality in patients with CIAD (HR: 0.92, 95%CI:0.88-0.97, P<0.001). However, when BMI > 32.4 kg/m<sup>2</sup>, there was no association between BMI and all-cause mortality (HR:1.02, 95%CI:0.97–1.06, P = 0.52). P value for likelihood ratio test (LRT) was 0.001. The results indicated that model II (two-segment non-linear model) was more suitable to describe the relationship between BMI and the risk of all-cause mortality in CIAD patients, as presented in Table 4.

#### Discussion

We conducted a cross-sectional study to analyze the relationship between obesity and the incidence of CIAD using NHANES 2013–2018 data. The results found that a positive association between BMI, WC and the risk of CIAD, which were non-linear associations. When grouped by BMI and WC, we found that underweight and obesity were positively associated with a higher prevalence of CIAD compared with normal weight. Grouped according to BMI, this positive association

Pipe         Outward         Pipe	Subgroup	Variable	Total	Event (%)	OR (95%CI)		P for interaction
column consigned con	Age						0.093
No.50         No.50 <th< td=""><td>everyears.</td><td>under weight</td><td>120</td><td>20 (16 7)</td><td>0.93(0.56~1.56)</td><td></td><td></td></th<>	everyears.	under weight	120	20 (16 7)	0.93(0.56~1.56)		
Ac-Styperal         Normal         Edit         Part of the sector         Part of the sector         Part of the sector           Ac-Styperal         Sector         Part of the sector         Paro		normal weight	1607	261 (16.2)	1/Befi	1	
eventy         eventy<		over weight	1384	244 (17.6)	1.21 (0.99~1.47)	L_	
43-36-japaria         Under weight over weight		obesity	1812	399 (22)	1.47 (1.23~1.77)		
Number         Under weight         64         17 (20.20) (20.20)         17 (20.20.20) (20.20)         17 (20.20) (20.20)         17	40-59vears	000010	1012	000 (aa)	in the may	· · · · · · · · · · · · · · · · · · ·	
Note         Note <th< td=""><td>· · · ·</td><td>under weight</td><td>54</td><td>16 (29.6)</td><td>1.7 (0.89~3.26)</td><td></td><td></td></th<>	· · · ·	under weight	54	16 (29.6)	1.7 (0.89~3.26)		
Adversion solution solution operation <		normal weight	1211	184 (15.2)	1(Ref)	🔶 👘 🐪	
Story in the image in		over weight	1636	230 (14.1)	0.95 (0.76~1.19)	<b>_</b> _	
Addyunder weightiii<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<i<<i<<i<<i<<i<<i< <td></td> <td>obesity</td> <td>2214</td> <td>501 (22.6)</td> <td>1.43 (1.17~1.76)</td> <td>· · · · · · · · · · · · · · · · · · ·</td> <td></td>		obesity	2214	501 (22.6)	1.43 (1.17~1.76)	· · · · · · · · · · · · · · · · · · ·	
Image weight is 10         00 (20.8) 20 (20.8) 20 (20.8) (20.	≥60yesrs						
Nome weight         100         200 (7.7)         1847         124 (2.8.2.)         124 (2.8.2.)         124 (2.8.2.)         124 (2.8.2.)         124 (2.8.2.)         0.135           Sor make         Image weight         100         120 (2.8.1)         124 (2.8.2.1)         124 (2.8.1)         124 (2.9.1)		under weight	61	20 (32.8)	2.1 (1.17~3.79)	<b>_</b>	
Note of the set of th		normal weight	1190	203 (17.1)	1(Ref)	<b>•</b>	
Body1000.26 2.301.27 (2-1.70)0.35main1005000100010000.110correntation (1)10001000100010000.111correntation (1)12001000101010100.111correntation (1)12001000101010100.111correntation (1)1200100010000.1110.111correntation (1)1200100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1000100010000.1110.111correntation (1)1100100010000.1110.111correntation (1)1100100010000.1110.111correntation (1)1100100010000.1110.111correntation (1)1100100010000.1110.111correntation (1)11001000100010000.111correntation (1)11001000		over weight	1846	350 (19)	1.12 (0.92~1.37)		
Sec mail		obesity	1989	504 (25.3)	1.47 (1.2~1.79)		
mail         under weight over wei	Sex						0.135
under weight orenwiget         100         26 (2)         1.6 (1-2-6)         1.0 (1-2-6)           over weight over weight o	male						
normal weight         187         29         11         177         177		under weight	100	25 (25)	1.62 (1~2.64)	<b>_</b>	
over weight over weight 202 202 (12,7) 104 (053-143) veer weight 202 202 (12,7) 104 (10,72-29) veer weight 202 202 (12,7) 104 (053-143) 104 (053-143) 104 (053-143) 104 (053-143) 104 (053-143) 104 (053-143) veer weight 202 202 (12,7) 104 (10,12) 047 (04-143) veer weight 044 veelght 202 044 veelght 202 044 veelght 202 044 veelght 044 veelght 044 veelght 044 veelght 044 veelght 044 veelght 044 veelght 101 (13,1) 104 (13,1) 104 (13,1) 104 (13,1) 104 (13,1) 104 (13,1) 104 (14,1) 104 (14,1)		normal weight	1887	291 (15.4)	1(Ref)	•	
tension         open weight per weight below high school         constraines (12) (22) (22) (22) (22) (22) (22) (22)		over weight	2743	436 (15.9)	1.07 (0.9~1.26)	- <b>+</b>	
terms         open wight is about one weight one weight is about below high school         15         12         12         15         16         16         16         16         16         16         16		obesity	2668	530 (19.9)	1.3 (1.1~1.54)		
Biology Worth 135         31 (25)         1 (20)	temale						
normal ways         212         357 (18.3)         11.02 (19.12.2)           Educational statiument below high school         2371         257 (25.1)         1.02 (0.25-2.27)         0.319                mermal ways         2371         257 (25.1)         1.02 (0.25-2.27)         0.000 (0		under weight	135	31 (23)	1.26 (0.82~1.95)		
Book Waght 1         12/12         380 (12.3)         1.50 (12.9-1.2)         0.919           Sciencifical station         Income waght 1         10 (12.9-2.2)         0.919         0.919           Inder weight 1         10 (12.9-2.2)         10 (12.9-2.2)         0.919         0.919           Inder weight 1         10 (12.9-2.2)         10 (12.9-2.2)         0.919         0.919           Inder weight 2010         10 (12.9-2.2)         10 (12.9-2.2)         0.919         0.919           Inder weight 30 (10 (11.9)         10 (12.9-2.2)         10 (12.9-2.2)         0.919         0.919           Inder weight 31 (12.9)         0.91 (12.1)         1.10 (12.9-2.2)         0.919         0.919           Income weight 10 (12.9)         0.91 (12.1)         1.10 (12.9-2.2)         0.919         0.919           Income weight 10 (12.9)         0.91 (23.1)         1.10 (12.9-2.2)         0.919         0.9119         0.919         0.919		normal weight	2121	357 (16.8)	1(Hel)	T	
Educational statisment below high school mere weight high school under weight below high school below high school under weight below high school under weight below high school under weight below high school below high school below high school under weight below high school under weight below high school under weight below high school below high school under weight below high school below high		over weight	2123	388 (18.3)	1.05 (0.89~1.23)		
Characterization at Mainment Note Note Night action 1         Under weight 1         00         11         120         10.90 (55-2-27)         10.90 (55-2-27)           high action 1         120         20         202 (21.5)         15.60 (1.5-2.20)         1.90 (1.5-2.20)	Educational attainment	obesity	3347	6/4 (20.1)	1.5 (1.29~1.74)		0.010
under weight over weight thigh school         under weight ites is weight deesity         51 11 (2) 120 (22, 21) (22) (22, 21) (2) 220 (22, 21) (2) 20 (22, 21) (2) 20 (22, 21) (2) 20 (2)	below high school						0.919
moningenerative         res          res<         res<         res<         res<         res<         res<         res<         res< <thres< th="">         res&lt; <thres< th=""></thres<></thres<>	outow mgn aut001	under weight	50	11 (22)	1.09 (0.52-2.27)		
Image: Note of the first of the fi		normal weight	766	122 (15.9)	1/Ref)		
Line Line Line Line Line Line Line Line		over weight	1116	170 (15.2)	1.09 (0.8%-1./9)	_ <b>_</b>	
high school       under weight oor weight debug high school       10       12 <th12< th="">       12       12<td></td><td>obesity</td><td>1290</td><td>282 (21.9)</td><td>1.56 (1.2~2.02)</td><td>T</td><td></td></th12<>		obesity	1290	282 (21.9)	1.56 (1.2~2.02)	T	
udde weight         51         51         72         73         74 <th74< th="">         74         74</th74<>	hiah school					· · ·	
nerrow light school		under weight	51	15 (29.4)	1.49 (0.77~2.91)		
over weight obeen high school         107         200 (18.7)         1.10 (10.8-1.6)           above high school         under weight oor weight 288         200 (18.7)         1.13 (10.8-1.67)           smoking statue mere smokes         288         377 (15.8)         1.44 (0.82-222)         1.44 (0.82-222)           smoking statue mere smokes         0.267         454 (16.9)         1.36 (10.8-1.65)         0.267           over weight over weight over weight over weight over weight over weight over weight 288         201 (18.7)         1.52 (0.94-1.65)         0.46-1.65)           under weight over weight over weight 278         200 (23.2)         1.64 (0.89-1.58)         0.46-1.65)           over weight 278         200 (23.2)         1.60 (20.8-1.28)         0.46           over weight 278         200 (23.2)         1.60 (20.8-1.8)         0.435           over weight 278         120 (18.2)         1.60 (20.8-1.8)         0.435           over weight 278         120 (18.2)         120 (18.2)         140 (70.8-2.61)         0.435           102.59         under weight 000 over weight 278         120 (18.2)         120 (18.2)         120 (18.2)         120 (18.2)         120 (18.2)           102.59         under weight 000 over weight 278         201 (18.7)         138 (0.8-1.8)         0.435         0.435 <td></td> <td>normal weight</td> <td>853</td> <td>150 (17.6)</td> <td>1(Ref)</td> <td>🖕 T</td> <td></td>		normal weight	853	150 (17.6)	1(Ref)	🖕 T	
doew high school         doed wight under weight 2000         1458         946 (p2.7)         133 (10.0-167)           under weight over weight 2000         128         930 (12.2)         114 (10.9-22.2)         114 (10.9-22.2)           smoking status noer stockers         2007         424 (15.9)         126 (10.9-22.2)         114 (10.9-22.2)           under weight 2007         2007         2007         123 (10.0-167)         104 (10.9-22.2)           tormer stockers         under weight 2007         2017         123 (10.2-167)         104 (10.9-22.2)           tormer stockers         under weight 2007         2017 (20.8-1.56)         106 (10.2-167)         104 (10.9-22.2)           tormer stockers         under weight 2007         2017 (20.8-1.65)         104 (10.2-167)         104 (10.9-127)           tormer stockers         under weight 200 (20.1)         116 (20.8-1.35)         116 (20.8-1.35)         104 (10.9-127)           tormer stockers         under weight 200 (20.1)         139 (10.3-1.71)         104 (10.9-2.51)         004 (20.1)         139 (10.2-1.67)           tormer weight 100 - 200 (20.1)         120 (20.2)         139 (10.1-1.75)         004 (20.1)         004 (20.1)         004 (20.1)         004 (20.1)         004 (20.1)         004 (20.1)         004 (20.1)         004 (20.1)         004 (20.1)		over weight	1071	200 (18.7)	1.1(0.86-1.4)	_ <b>_</b>	
above high school         In y         In y <thin th="" y<="">         In y         In y<td></td><td>obesity</td><td>1456</td><td>345 (23.7)</td><td>1.33 (1.06~1.67)</td><td></td><td></td></thin>		obesity	1456	345 (23.7)	1.33 (1.06~1.67)		
under weight over weight deeling         134 280         30 (25.4) 282         14 (40.58-22) (16.09-1.24) 282         154 (16.09-1.24) 282         154 (16.09-1.24) 292         154 (16.09-1.24) 292         154 (16.09-1.24) 292         154 (16.09-1.24) 292         154 (16.09-1.24) 292         154 (16.09-1.24) 292         154 (16.09-1.24) 292         154 (16	above high school			,		•	
neronal weigh over weight meent smokers         220 220         277 (15.3) (15.6) (10.1-12) (15.6) (10.1-12) (15.6) (10.1-12) (15.6) (10.1-12) (15.6) (10.1-12) (15.6) (15.1-12) (15.6)		under weight	134	30 (22.4)	1.44 (0.93~2.22)		
over weight besits besits smoking status neres smokes         over weight increal weight incre		normal weight	2389	376 (15.7)	1(Ref)	🔶 - T	
observing study memor smokings theore smokings         cosesity (2000)         2828         777 (23.8)         1.43 (1 (23-165)         0.257           normal weight conserved cosesity         128         201 (25.1)         1.93 (1 (25-167)         1.93 (1 (25-167)         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.97 (0 (45-135))         0.98 (1 (45-135))		over weight	2679	454 (16.9)	1.06 (0.91~1.24)	_ <b></b>	
amaking statue neeres anokers         0.267           transmissioners         under weight 273         114         119.0         0.87         0.48-1.55           transmissioners         under weight 273         277         12.6         0.87         0.48-1.55           transmissioners         under weight 273         277         12.6         0.87         0.48-1.55           transmissioners         under weight cover weight 272         216         12.4         12.4         1.41         1.2.1         0.435           courrent anokers         under weight cover weight 272         22         22         1.14         0.287         0.435           remail weight 272         130 (13.3)         1.145 (1.17-1.4)         0.436         0.435           ourrent anokers         under weight 100         28         114(4)         28         1.2.4.6.69           normal weight 110         130 (13.3)         139 (13.4)         138 (0.85-1.34)         0.435           courrent anokers         under weight 1215         28 (22.4)         1.38 (0.85-2.24)         0.435           under weight 1212         29 (23.4)         1.38 (0.85-2.24)         0.443         0.435           cosery         272         21 (15.4)         1499         0.435         0.4		obesity	3269	777 (23.8)	1.43 (1.23~1.65)	· · · · · · · · · · · · · · · · · · ·	
never smokers under weight 240 340 421 340 421 340 42 340 42 340 42 340 42 340 4 4 1 1	smoking status						0.267
under weight normal weight over weight 273         372 (13, 6)         0.48-1.65           former smokers         274         39 (12, 7)         1.26 (28-1.65)           oder weight obersity         620         39 (12, 7)         1.26 (28-1.65)           over weight over weight obersity         620         39 (12, 7)         1.26 (28-1.26)           over weight obersity         620         216 (24.2)         168 (08-1.35)         0.49 (16, 16, 16, 16, 16, 16, 16, 16, 16, 16,	never smokers						
Image: Non-Warding Variable         200 (12.5)         1 (Her)           over weight         240         600 (18.8)         1.63 (25.2-167)           image: Non-Warding Variable         240         600 (18.8)         1.63 (25.2-167)           image: Non-Warding Variable         250         250 (25.2)         1.22 (0.42-4.60)           image: Non-Warding Variable         250         216 (24.2)         1.20 (0.26-1.62)           conversight         250         216 (24.2)         1.20 (0.26-1.62)           conversight         250         216 (14.2)         1.20 (12.6-4.60)           orean wardin         1232         220 (19.1)         1.29 (1.2-4.60)           orean wardin         1232         220 (19.1)         1.29 (1.2-4.60)           orean wardin         101         1.90 (1.2)         1.24 (1.62-1.62)           orean wardin         102         1.20 (1.2)         1.44 (0.78-2.51)           orean wardin         101         1.90 (12.0)         1.90 (1.2)         1.90 (1.2)           1.0-2.59         under weight         201         1.20 (1.20 (1.7)         1.24 (1.67-1.57)           orean wardin         102         220 (14.0)         1.38 (1.72-1.64)         1.90 (1.6)           orean weight         102         220 (14.0)		under weight	118	14 (11.9)	0.87 (0.48~1.55)	<b>_</b>	
over weight börner innoken former innoken innom i weight oceanity         273 280         372 (15,8) 404         14.3 (122-167)           under weight oceanity         282 280 (12,2)         1152 (0,34-2.40) 1160         14.3 (122-167)           under weight oceanity         282 280 (12,2)         1160         14.5 (127-16)           under weight oceanity         282 280 (12,2)         280 (12,2)         146 (117-16)           under weight oceanity         282 280 (12,2)         280 (12,2)         146 (117-16)           under weight over weight         154 282 28 (12,1)         136 (11,3)         156 282 28 (12,1)         136 (11,3)           FIR         under weight over weight         110         196 (16)         156 (16,2)         146 (14,2)           1.0-2.29         under weight over weight         110         282 (12,4)         138 (0,58-134)         0.435           1.0-2.29         under weight over weight         110         282 (14,5)         1160 (16)         136 (10,2-12)         0.435           23.0         under weight over weight         172         287 (15,5)         146 (14)         284         140 (14)         128 (14-1.22)           440         110         138 (0,58-134)         140 (14)         128 (14-1.22)         0.435           100         1107		normal weight	2401	303 (12.6)	1(Ref)		
desity         9406         9407         91         14         12         12         13		over weight	2735	372 (13.6)	1.09 (0.92~1.29)	-+-	
former smokers         under weight over weight 100         52         13         132         0.94-2.40 (149)         144           Vertrest over weight over weight 100         52         13         11.02         10.02 <td< td=""><td></td><td>obesity</td><td>3404</td><td>640 (18.8)</td><td>1.43 (1.22~1.67)</td><td></td><td></td></td<>		obesity	3404	640 (18.8)	1.43 (1.22~1.67)		
under weight over weight deter wei	former smokers						
normal weight         887         206 (23.2)         1(Fef)           oor weight         108         206 (23.2)         1(Fef)           ourtent smokers         008         216 (24.2)         1.28 (0.86-1.5)           ormal weight         20         20.2         21.6 (1.4)         1.4 (1.17-1.6)           ourtent smokers         108 (25.2)         21.6 (1.4)         1.28 (1.17-1.6)         0.495           oor weight         202         20.2 (23.1)         1.09 (1.6)         0.99 (7.5-1.27)         0.435           romal weight         00         20.2 (23.1)         1.19 (1.1-1.73)         0.435           romal weight         00         20.2 (23.1)         1.19 (1.1-1.2 (23.1)         0.435           romal weight         20.2 (23.1)         1.28 (1.05-2.5 (1.1)         0.104         0.104           romal weight         20.2 (23.1)		under weight	92	31 (33.7)	1.52 (0.94~2.46)		
over weight         683         216 (24.2)         1.08 (0.86-1.35)           obestij         056         314 (1.17-1.6)         1.43 (1.17-1.6)           over weight         25         11 (44)         2.81 (2.4.2.66)           over weight         252         207 (15)         106 (0.7.6-1.27)           obestij         1232         207 (15)         1.08 (1.0.7-1.27)           over weight         104         200 (12.0)         1.44 (0.70-2.51)           over weight         101         109 (1.10)         1.56 (1.1.7.6)           over weight         101         102 (1.2.7.7.4)         0.435           over weight         101         101 (1.1.7.6)         1.08 (1.0.7-1.25)           over weight         102         22 (2.4.1)         1.38 (0.8-2.4)           over weight         102         22 (2.4.1)         1.38 (0.8-2.4)           over weight         272         26 (1.7.1)         1.04 (0.7-1.25)           obestij         272         26 (1.2.1)         1.38 (0.17-1.64)           over weight         102         22 (1.4.5)         1.110 (1.9-1.25)           obestij         222 (4.4.5)         1.110 (1.9-1.25)         0.104           over weight         202 (1.6.1)         1.20 (0.9-1.21)		normal weight	887	206 (23.2)	1(Ref)	•	
obesity         1006         334 (21.4)         1.4 (17-1.6)           under weight oper weight 55         11 (40)         2.81 (2.2-6.60)           PIR 323         232 (11.2)         2.81 (2.2-6.60)         1.99 (1.7-1.2)           oper weight oper wei		over weight	893	216 (24.2)	1.08 (0.86~1.35)	<b></b> .	
under weight over weight (154)         25 (15)         11 (44) (154)         28 (154)         (154) (154)         0 (154)		obesity	1065	334 (31.4)	1.45 (1.17~1.8)		
under weight normal weight deel weight server ser	current smokers						
normal weight         120         139 (113)         19 (113)		under weight	25	11 (44)	2.88 (1.24~6.69)		
Open Weight Cobesity         12:8 (2:1)         2:53 (1:1)         0:59 (1:6)         0:59 (1:6)         0.435           <1.0		normal weight	/20	139 (19.3)	1(Hel)	T T	
Pirit Octor         Outor         Outor <t< td=""><td></td><td>over weight</td><td>1230</td><td>236 (19.1)</td><td>0.99 (0.76~1.27)</td><td></td><td></td></t<>		over weight	1230	236 (19.1)	0.99 (0.76~1.27)		
Print         U-33           c1.0         under weight         60         20 (20)         1.4 (0.79-2.51)           1.0-2.99         under weight         101         196 (18)         10 (16)           1.0-2.99         under weight         102         22 (12,4)         1.38 (1.7-1.42,24)           1.0-2.99         under weight         107         25 (23,4)         1.38 (1.7-1.42,24)           23.0         under weight         202         25 (23,4)         1.38 (1.7-1.42,24)           400 reweight         107         25 (23,4)         1.38 (1.7-1.42,24)           410 remel weight         509         11 (18,6)         1.38 (1.7-1.42,24)           4263         355 (17.4)         1.48 (1.87-1.25)         400 (18.7-1.25)           0 devely         222         1.52 (1.51,111 (19,1-1.32)         400 (18.7-1.25)           0 devely         222 (14.51,111 (19,1-1.32)         400 (18.7-1.25)         400 (18.7-1.25)           0 devely         222 (14.51,111 (19,1-1.32)         400 (18.7-1.25)         400 (18.7-1.25)           0 devely         222 (14.51,111 (19,10-1.32)         400 (18.7-1.25)         400 (18.7-1.25)           0 devely         230         440 (18.7)         1.25 (10,12-1.20)         400 (18.7-1.25)           0 devely	DID	obesity	1040	430 (27.6)	1.39 (1.1~1.75)		0.425
Loc         under weight over weight tobesity         69 1215         29 (29) 2915         14 (179-251) (1964)         14 (179-251) (1964)         14 (177-251)           1.0-2.99         under weight over weight tobesity         101         190 (18) 125         138 (0.85-2.34) (1964)         147 (14-2.34) (1964)         147 (14-2.34) (1964)           23.0         under weight over weight tobesity         107         25 (22,4) (1964)         138 (0.85-2.34) (1964)         146 (177-164) (1964)         146 (177-164) (1964)           23.0         under weight over weight tobesity         222         28 (14,5) (1964)         138 (1.72-164) (1964)         146 (16,7) (136 (1,72-165) (1964)         140 (19,7) (136 (1,92-125) (137 (1,72-164)         0.104           Wes         under weight cover weight over weight cover weight tobesity         223         42 (20,7) (137 (1,32-173)         140 (19,7) (137 (1,32-173)         0.104           No         under weight cover wei	rin -10						0.435
under weight over weight 102.59         0.4 (200 )         1.04 (200 )         1.05 (10.2-1.34)           1.0-2.59         under weight over weight 2015         25 (23.4)         1.38 (10.5-2.34)           2.3.0         under weight over weight 2015         355 (17.7)         1.04 (20.5-2.34)           2.3.0         under weight over weight 2014         355 (17.7)         1.04 (20.5-2.34)           440 (18.7)         1.38 (1.7-1.64)	<1.0	and an analysis	20	00 (00)	1.4 (0.70, 0.51)		
Inc-2:99         under weight oerwalk         1215         948 (25.6)         1.77 (1.4-2.4)           1.0-2:99         under weight oerwalk         1215         948 (25.6)         1.77 (1.4-2.4)           23.0         under weight oerwalk         153         237 (15.7)         1148 (15.3)         105           24.0         356 (1.1)         1.38 (1.65-2.4)         1.0-2.20         1.0-2.20         1.0-2.20           25.0         under weight oerwalk         527 (15.7)         1148 (1.1)-1.40         1.38 (1.67-1.62)         1.0-2.21           25.0         under weight oerwalk         527 (14.7)         1.38 (1.0-1.52)         1.0-1.52)         0.104           Whypertension         under weight oerwalk         200         42 (20.7)         1.3 (0.9-1.82)         0.104           No         under weight oerwalk         200         42 (20.7)         1.3 (0.9-1.82)         0.104           No         under weight oerwalk         200         42 (20.7)         1.3 (0.9-1.82)         0.104           No         under weight oerwalk         200         42 (20.7)         1.3 (0.9-1.82)         0.104           No         under weight oerwalk         214 (42.5)         1.11 (1.2-1.7)         0.104         0.104           No         under weight		under weight	09	20 (29)	1.4 (0.76~2.51)		
Under weight coewing         201 (1):10:2:29         201 (2):20:22         201 (2):20:22 <th< td=""><td></td><td>normal weight</td><td>1101</td><td>147 (18.3)</td><td>1 (nel)</td><td></td><td></td></th<>		normal weight	1101	147 (18.3)	1 (nel)		
1.0-2.59         Cost (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10         2.00 (200)         1.10 <td></td> <td>ohoritu</td> <td>1215</td> <td>249 (28.6)</td> <td>1.05 (0.82~1.34)</td> <td></td> <td></td>		ohoritu	1215	249 (28.6)	1.05 (0.82~1.34)		
under weight remai vergint developed version developed version	1.0-2.99	outony	1615	0.10 (20.0)			
Promit length         101         272 (16.7)         1(196)         102		under weight	107	25 (23.4)	1.38 (0.85~2 24)		
ever weight ober verget ober verget 23.0         2040 2572         205 (17.2 106 (64)         138 (1.17-1.65) 138 (1.17-1.64)           33.0         under weight over weight ober verget ober verget 222 28 (14.5)         146 (0.67-1.25) 138 (1.17-1.64)         149 (1.07-1.65) 149 (1.17-1.64)           Hypertension No         under weight over weight 223 440 (19.7)         1.24 (1.04-1.32) 1.24 (1.04-1.32)         0.104           We under weight ober verget ober verget verget verget verget ober verget ober verget obe		normal weight	1631	273 (16.7)	1(Ref)	🖕 T	
z3.0         under weight over weight best         2272         916 (24)         1.38 (1,17-1.64)           Hypertension No         under weight over weight best         2222         440 (19,7)         1.26 (1,0+1.36)         0           Yspertension No         under weight over weight best         232         240 (19,7)         1.3 (0,9-1.48)         0         0.104           Ytes         under weight over weight over weight obestly         232         440 (19,7)         1.3 (0,9-1.88)         0         0.104           Ytes         under weight over weight over weight over weight over weight obestly         232         440 (19,7)         1.28 (1,12-1.13)         0         0         0.104           Ytes         under weight over weight over weight over weight over weight over weight over weight over weight obestly         232         44 (43.8) (19,80)         2.04(0,95-4.34) (19,80)         0         0.104           Wes         under weight over weight obestly         232         45 (20,9)         1.35 (0,95-1.91) (19,80)         0         0         0         0         0.769           Vie         under weight over weight obestly         232         46 (20,7)         1.26 (0,65-1.91) (19,80)         0         0         0         0         0         0         0.769         0.769           Vie		over weight	2043	355 (17.4)	1.04 (0.87~1.25)		
23.0         under weight over weight over weight over weight seewity         230         11 (16 / 1572 / 222 (14 / 1722 / 172 /		obesity	2572	616 (24)	1.38 (1.17~1.64)	Ĩ <b>-</b> ♣-	
under weight over weight beset         99 (157)         11 (16,6) (167)         13,80,7-2,74) (16,7)         14         15         11 <t< td=""><td>≥3.0</td><td>~</td><td></td><td></td><td></td><td></td><td></td></t<>	≥3.0	~					
wight visit         157         228 (14.5)         (1647)           voer weight voer weight         228         440 (19.7)         1.15 (1.0 ± 1.0 ± 0.0 ±		under weight	59	11 (18.6)	1.38(0.7~2.74)	<b>—</b>	
over weight obesity         1722 222         271 (15.7) 420 (19.7)         1.1 (10.9-1-30) 1.26 (10-1-15)         0.104           No         under weight over weight obesity         223         420 (19.7)         1.26 (10-1-15)         0.104           Wes         under weight over weight obesity         230         424 (20.7)         1.3 (0.9-1.88)         0.104           Wes         under weight over weight obesity         25         44 (43.8) (19.8)         2.04(0.96-4.3) (10.90-132)         0.769           Via         under weight over weight over weight over weight obesity         235         45 (20.9) (1.36 (20.9-1.52)         0.769         0.769           Via         under weight over weight obesity         235         46 (20.5) (1.56 (20.9) (1.32 (1.20-1.5))         0.769         0.769           Via         under weight over weight obesity         236         46 (20.5) (1.56 (20.9) (1.56 (		normal weight	1573	228 (14.5)	1(Ref)	•	
obesity         222         440 (19.7)         1.26 (1.04-1.52)         0.104           No         under weight         233         42 (20.7)         1.3 (0.9-1.83)         0.104           No         under weight         230         42 (20.7)         1.3 (0.9-1.83)         0.104           Yes         under weight         230         42 (20.7)         1.3 (0.9-1.83)         0.000           Yes         under weight         234         424 (1.04)         1.764         0.000           Ves         under weight         201         2.4 (1.43, 20.7)         1.57 (1.33-1.73)         0.000           Ves         under weight         2372         600 (27)         1.23 (0.99-1.52)         0.709           Ves         under weight         215         45 (20.5)         1.01 (0.81-1.27)         0.000           No         under weight         215         45 (20.5)         1.25 (0.39-1.31)         0.709           Ves         under weight         215         45 (20.5)         1.35 (0.39-1.43)         0.709           Ves         under weight         215         45 (20.5)         1.59 (0.25-1.63)         0.709           Ves         under weight         225         1.52 (0.32-1.50)         0.709         0.709<		over weight	1722	271 (15.7)	1.11 (0.91~1.36)	++-	
Wppertension         0.104           No         under weight over weight obeelity         205 205         426 (20.7) 1.28 (20.9-18)         1.3 (0.9-188)           under weight obeelity         246 205         252 (15) 1.57 (0.35-123)         1.4 (0.35-123)         1.4 (0.35-123)           Vers         under weight own weight 0000 weight own weight 0000 weight 00000 weight 0000 weight 000		obesity	2228	440 (19.7)	1.26 (1.04~1.52)		
No         under weight normal weight over ver over over ver over over over over over ver over over ver ov	Hypertension						0.104
under weight normal weight obesity         203         42 (20.7)         1.3 (0.9-1.83)           under weight obesity         304         45 (1.1)         1.6 (0.9-1.83)           versit         456         522 (15)         1.0 (0.95-1.23)           under weight ower weight 169         1.6 (2.3, 1.1)         1.9 (1.9-1.27)           ower weight 169         1.6 (2.3, 1.1)         1.0 (0.81-1.27)           ower weight 178         2.372         60 (27)         1.2 (0.9-1.22)           ower weight 199         2.372         60 (27)         1.2 (0.9-1.27)           ower weight 199         2.579         1.05 (0.2-1.21)         0.709           No         under weight 100 (0.9-1.22)         1.3 (0.9-1.22)         0.709           Vies         under weight 2.20         2.02         1.15 (0.9-1.27)         0.709           Vies         under weight 2.20         2.21         1.3 (0.9-1.21)         0.709           Vies         2.23         2.04 (2.5)         1.57 (0.6-1.42)         0.709           Vies         2.23         2.23 (2.5)         1.56 (0.2-1.42)         0.709           Vies         2.23         2.23 (2.5)         1.65 (0.7-1.42)         0.709	No						
normal weight over weight besuit         236 /257         482 (14.6) /264         1/Fer /264         1/Fer /274		under weight	203	42 (20.7)	1.3 (0.9~1.88)	++	
wor weight obesity         3460         522(15)         1.07 (0.85)-1.23)           wind         under weight normal weight oer weight oer weight oer weight oer weight         32         14 (43.8)         2.04(0.56-4.34)           1016         1.01 (0.81-1.27)         1.01 (0.81-1.27)         1.01 (0.81-1.27)           0000         0000 (0.99-1.52)         1.09 (0.81-1.27)           0000         0000 (0.99-1.52)         0.709           No         under weight oer weight         215         45 (20.5)         1.55 (0.95-1.91)           verset         under weight oer weight         227         1.05 (0.29-1.21)         0.709           Wes         under weight oer weight         20         1.15 (0.15)         1.57 (0.54-4.31)         0.709           Wes         under weight oer weight         20         1.05 (20.29)         1.35 (0.55-1.45)         0.709           Wes         under weight oer weight         20         1.15 (0.55)         1.57 (0.54-4.31)         0.709           Wes         under weight oer weight         20         1.15 (0.55)         1.57 (0.56-1.45)         0.700           0.00000000000000000000000000000000000		normal weight	3309	484 (14.6)	1(Ref)	+	
obesity         3643         764 (21)         1.51 (1.35-1.73)           under weight         32         1.4 (43.8)         2.40(36-4.34)           normal weight         32         302 (21.8)         1.01 (0.81-1.27)           over weight         1386         302 (21.8)         1.01 (0.81-1.27)           obesity         2372         640 (27)         1.23 (0.90-1.52)         0.709           No         under weight         215         45 (20.9)         1.35 (0.95-1.91)         0.709           Vies         under weight         215         570 (0.54-1.31)         0.80+1.21)         0.709           Vies         under weight         20         11 (55)         1.57 (0.64-4.31)         0.70           oer weight         20         20.51         1.58 (0.57-1.65)         0.60+1.21)         0.709           Vies         under weight         20         211 (55)         1.57 (0.64-4.31)         0.70           oer weight         20         20.51         1.58 (0.75-1.65)         0.60         0.60           obesity         20.50         1.68 (0.75-1.65)         0.60         0.60         0.60         0.60		over weight	3480	522 (15)	1.07 (0.93~1.23)	-+-	
Vies         under weight normal weight over weight below in the state over weight state         22         14 (43.8) (443.8)         2.04(0.96-4.34) (1/Her)         0 <th0< th="">         0         <th0< th="">         0</th0<></th0<>		obesity	3643	764 (21)	1.51 (1.33~1.73)		
Under weight normal weight obesity         232 186         1 (45.8) 187         2.8 (J.058-4.3) 187         Interf (J.0.81-1.27)           CVD         Under weight obesity         2372 2372         640 (27)         1.23 (J.0.91-1.27)         0.709           Under weight over weight obesity         215         45 (20.9)         1.35 (J.0.95-1.91)         0.709           Vies         Under weight over weight over weight over weight over weight 232         205 (J.0.91-1.21)         1.67 (J.0.4431)         0.709           Vies         Under weight over weight 232         205 (J.0.91, J.2.71, J.0.60, J.0.91, J.2.12, J.0.91,	Yes						
normal weight         699         164 (23.5)         1(Fler)           over weight         2372         640 (27)         1.23 (0.95–1.52)         0.709           Vio         under weight         215         45 (20.5)         1.55 (0.95–1.61)         0.709           View         under weight         215         640 (27)         1.23 (0.95–1.61)         0.709           View         under weight         215         670 (15.6)         1.56 (0.95–1.61)         0.709           View         under weight         201         1105 (20.3)         1.39 (1.25–1.56)         0.709           view         202         202 (20.5)         1.57 (0.64–4.21)         0.709           view         202         202 (20.5)         1.57 (0.64–4.21)         0.709           view         203         1105 (20.3)         1.65 (0.75–1.65)         0.709           view         203         126 (20.5)         1.56 (0.75–1.65)         0.70           view         736         203 (40.6)         1.65 (1.72–1.6)         0.70		under weight	32	14 (43.8)	2.04(0.96~4.34)	<u>↓</u>	
over weight obesity         1386         302 (21.8)         1.01 (0.81-1.27)         0.61-1.27)           CVD         obesity         2372         640 (27)         1.23 (0.91-1.52)         0.709           No         under weight over weight         215         45 (20.9)         1.35 (0.95-1.52)         0.709           Visi         under weight obesity         2372         907 (15.4)         1.06 (0.94-1.21)         0.709           Visi         under weight over weight over weight over weight over weight over weight 230         52 (25.5)         1.57 (0.64-4.31)         0.64-4.31           Visi         under weight over weight over weight over weight over weight over weight 230         1.63 (0.75-1.45)         0.50 (0.75-1.45)         0.50 (0.75-1.45)		normal weight	699	164 (23.5)	1(Ref)	•	
Obesity         2372         640 (27)         1.23 (0.99-1.52)         0.709           No         under weight         215         45 (20.5)         1.55 (0.95-1.51)         0.709           version weight         258         55 (21.5)         1.56 (0.95-1.51)         0.709           version weight         4546         670 (15.6)         1.56 (0.94-1.21)         0.709           version         under weight         250         1.55 (0.50-1.55)         0.709           version         0.715 (20.9)         1.39 (1.23-1.56)         0.709           version         0.105 (20.5)         1.57 (0.64-4.31)         0.709           version         0.20 154 (25.6)         1.56 (0.75-1.65)         0.709           obesity         736         290 (40.6)         1.6 (1.17-2.16)         0.709		over weight	1386	302 (21.8)	1.01 (0.81~1.27)	- <b>+</b> -	
CVU         0.709           No         under weight         215         45 (20.9)         1.35 (0.85-1.91)           normal weight         0582         552 (15)         1 (Fler)         04-1.21)           over weight         236         670 (15.4)         1.06 (0.94-1.21)         04-1.21)           obesity         2797         1105 (20.9)         1.33 (1.23-1.66)         04-1.21)           onormal weight         20         11 (55)         1.57 (0.64-4.31)         04-1.21)           ower weight         20         10 (20.2)         15 (20.51-1.65)         04-1.21)           ower weight         20         50 (52.6)         1.58 (0.75-1.45)         04-1.21)           ower weight         205         152 (20.5)         1.58 (0.75-1.45)         04-1.21)           ower weight         205         1.58 (0.75-1.45)         04-1.45         04-1.45		obesity	2372	640 (27)	1.23 (0.99~1.52)		
NO under weight 215 45(20.5) 1.35(0.35-1.31) normal weight 255 2(15) 1(164) core weight 265 2(15) 1(164) (164) 271 (150(0.1-1.21) desivity 257 115(0.01) 1.39(1.23-1.56) under weight 20 11(150, 1.39) 1.39(1.23-1.56) under weight 20 11(150, 1.39) 1.39(1.23-1.56) over weight 20 11(150, 1.39) 1.59(0.75-1.45) over weight 258 154(2.56) 1.65(0.75-1.45) obesity 736 299 (40.6) 1.6(1.17-2.16)	CVD						0.709
under weight         215         45 (20.9)         1.35 (0.95-1.91)           normal weight         2682         552 (15)         (16)           over weight         2682         552 (15)         1.05 (0.94-1.21)           obesity         279         105 (20.9)         1.36 (0.94-1.21)           normal weight         20         11 (55)         1.57 (0.64-4.31)           normal weight         20         12 (55)         1.57 (0.54-4.31)           over weight         20         12 (55)         1.57 (0.54-4.31)           over weight         20         15 (20.51)         1.69 (0.75-1.45)           over weight         20         15 (20.51)         1.59 (0.75-1.45)	No						
normal weight 2682 2552 (15) 1(Fe/H) over weight 2672 2552 (15) 1.056 (0.94-1.21) obesity 5279 1105 (20.9) 1.39 (1.25-1.56) under weight 20 11 (155) 1.57 (0.64-4.31) normal weight 230 154 (29.6) 1.05 (0.75-1.45) over weight 530 154 (29.6) 1.55 (1.17-2.16) obesity 736 299 (40.6) 1.5 (1.17-2.16)		under weight	215	45 (20.9)	1.35 (0.95~1.91)		
over weight         4346         670 (15.4)         1.06 (0.94-1.21)           obesity         2529         1105 (20.91, 1.26)         1.06 (20.4-1.21)           under weight         20         11 (55)         1.57 (0.54-4.31)           normal weight         20         11 (55)         1.57 (0.54-4.31)           over weight         20         12 (55)         1.57 (0.54-4.31)           over weight         20         13 (1.25)         1.57 (0.54-4.31)           over weight         20         15 (2.55)         1.58 (0.75-1.45)           over weight         20         15 (2.56)         1.58 (0.75-1.45)		normal weight	3682	552 (15)	1(Hef)	•	
opesity         5279         1105 (20.9)         1.39 (1.29-1.66)           under weight         20         11 (55.)         1.57 (0.64-4.31)           normal weight         209         11 (55.)         1.57 (0.64-4.31)           over weight         209         154 (23.6)         1.56 (0.76-1.45)           obesity         736         298 (40.6)         1.56 (1.77-1.45)		over weight	4346	670 (15.4)	1.06 (0.94~1.21)	<b>•</b>	
ves under weight 20 11 (55) 1.67 (0.64–4.31) normal weight 28 86 (28.4) 1 (Fel) over weight 28 15 82 (25.6) 1.68 (0.75–1.45) obeetity 736 298 (40.6) 1.6 (1.17–2.16)		obesity	6279	1105 (20.9)	1.39 (1.23~1.56)		
under weight 20 11(55) 1.57 (0.64-4.31) normal weight 22 96 92(24), 1(Fker) over weight 230 154 (25.6) 1.05 (0.75-1.45) obesity 736 299 (40.6) 1.6 (1.17-2.16)	Yes						
normal weight 326 bis (28:4) [1/48] over weight 326 bis (26:5 1.68 (0.75-1.45) obeeldy 738 288 (40.6) 1.6 (1.17-2.18)		under weight	20	11 (55)	1.67 (0.64~4.31)		
over witight 520 154 (24.6) 1.05 (0.76–1.45)		normal weight	326	90 (29.4)	1(Hel)	T.	
0000011 / 30 200 (40.0) 1.0 (1.1/~2.18)		over weight	320 790	134 (29.6)	1.6 (1.17 0.10)		
		obesity	/30	239 (40.6)	1.0 (1.17~2.18)		
0.50 0.60 10 2.0						0.50 0.80 1.0 2.0	

Fig. 3 Subgroup analysis of the association between BMI and the risk of CIAD. Adjusted for age, sex, race, PIR, education level, energy intake, physical activity, smoking status, drinking status, blood eosinophil counts, hypertension and CVD. Abbreviations: BMI: body mass index; PIR: poverty-income ratio; CVD: Cardiovascular diseases



Several studies confirmed that obesity is an independent risk factor for chronic respiratory diseases, especially asthma and COPD [15–18]. A Mendelian randomization study revealed that obesity increases the possibility of COPD (BMI: OR = 1.429; WC:

Fig. 4 Subgroup analysis of the association between WC and the risk

of CIAD. Adjusted for age, sex, race, PIR, education level, energy intake,

physical activity, smoking status, drinking status, blood eosinophil

PIR: poverty-income ratio; CVD: Cardiovascular diseases

counts, hypertension and CVD. Abbreviations: BMI: body mass index;

Variable	Total	Event (%)	OR (95%CI)		P for interaction
					0.067
normal	2653	463 (17.5)	1(Ref)	<b></b>	
obesity	2270	461 (20.3)	1.17 (1-1.37)	L_	
obosity	LLIO	401 (20.0)	(		
normal	2009	272 (13.5)	1(Ref)	•	
obesity	3106	659 (21.2)	1.29 (1.08~1.53)		
normal	1630	278 (17.1)	1(Ref)	•	
obesity	3456	799 (23.1)	1.22 (1.03~1.44)	<b></b>	
					0.006
normal	4000	840 (18)	1/0=0		
normai	4026	643 (16)	T(Het)	<b>.</b>	
obesity	3372	639 (19)	1.1 (0.97~1.26)	<b>—</b>	
normal	2266	370 (16.3)	1(Ref)	•	
obesity	5460	1280 (23.4)	1.31 (1.14~1.5)		
					0.642
normal	1307	198 (15.1)	1(Bef)	<b>_</b>	
- Secolt -	1007	007 (00.0)	1,00,000,4,50)	<b>T</b>	
upesity	1915	367 (20.2)	1.23 (0.98~1.53)		
normal	1332	230 (17.3)	1(Ref)	•	
obesity	2099	480 (22.9)	1.18 (0.97~1.44)		
normal	3653	585 (16)	1(Ref)	<b>•</b>	
obositu	4010	1052 (21.8)	12/106 126	T	
obesity	4010	1002 (21.0)	1.2 (1.00~1.30)		
					0.802
normal	3640	468 (12.9)	1(Ref)	•	
obesity	5018	861 (17.2)	1.2 (1.05~1.37)		
normal	1377	307 (22.3)	1(Ref)	•	
obeeity	1560	480 (30.8)	1.94 (1.03-1.5)		
obtaily	1500	400 (00.0)	124 (1.00-1.0)		
normal	1275	238 (18.7)	1(Ref)	• •	
obesity	2254	578 (25.6)	1.16 (0.96~1.4)	++-	
					0.242
normal	1319	237 (18)	1(Ref)	<u> </u>	
obesity	1870	476 (25.5)	1.45 (1.19, 1.78)		
000010	1010	110 (2010)		· · · · · · · · · · · · · · · · · · ·	
normal	2536	419 (16.5)	1(Ref)	•	
obesity	3817	850 (22.3)	1.14 (0.98~1.32)	++-	
normal	2437	357 (14.6)	1(Ref)	•	
obesity	3145	593 (18.9)	1.13 (0.96~1.32)	_ <b>↓</b>	
,		. ,		-	0.094
					0.004
normal	5188	763 (14.7)	1(Ref)	• •	
obesity	5447	1049 (19.3)	1.27 (1.14~1.43)		
normal	1104	250 (22.6)	1(Ref)	•	
obesity	3385	870 (25.7)	1.03 (0.86~1.22)	_ <b>_</b>	
obout,		. ,		•	0.4
oboard					~.7
obolity					
oboardy					
normal	5819	880 (15.1)	1(Ref)	•	
normal	5819 7703	880 (15.1) 1492 (19.4)	1(Ref) 1.17 (1.06~1.29)	•	
normal	5819 7703	880 (15.1) 1492 (19.4)	1(Ref) 1.17 (1.06~1.29)	•	
normal obesity	5819 7703 473	880 (15.1) 1492 (19.4) 133 (28.1)	1(Ref) 1.17 (1.06~1.29) 1(Ref)	*	
normal obesity normal	5819 7703 473	880 (15.1) 1492 (19.4) 133 (28.1) 427 (37.8)	1(Ref) 1.17 (1.06–1.29) 1(Ref) 1.36 (1.04–1.76)	+	
	variable normal obesity normal obesi	variab         Total           normal         2633           obesity         2633           normal         2633           obesity         2630           normal         2631           obesity         2630           normal         1302           obesity         2630           normal         2630           obesity         2630           normal         2630           obesity         2630           normal         2630           normal         1307           obesity         2630           normal         2737           normal         2630           normal         2630           normal         2737           normal         2737           normal         2737           normal         2737           normal         2737           normal         2737	Variab         Variab         Variab         Variab           narmal         2653         463 (7.5)           narmal         2000         272 (7.5)           narmal         2000         693 (7.5)           narmal         1820         261 (7.5)           obesito         1300         693 (7.5)           narmal         1820         294 (7.3)           obesito         1302         630 (7.6)           obesito         2302         630 (7.6)           obesito         1302         201 (7.2)           narmal         1302         201 (7.2)           obesito         1302         201 (7.2)           obesito         1302         201 (7.2)           narmal         1302         201 (7.2)           obesito         1302         201 (7.2)           narmal         1302         201 (7.2)           narmal         2102         201 (7.2)<	Varial         Form         Control         Control         Control           narmal         2553         463 (7.5)         1(Ref)           narmal         2000         221 (1.5)         1.71 (-1.37)           narmal         2000         221 (1.5)         1.74 (1.4.37)           narmal         2000         620 (1.2)         1.20 (1.04-1.5)           narmal         1800         202 (1.2)         1.40 (1.04-1.5)           abeato         2030         203 (1.0)         1.20 (1.04-1.5)           narmal         4200         630 (1.0)         1.71 (1.4-1.5)           abeato         2372         230 (1.5)         1.71 (1.4-1.5)           narmal         1202         200 (7.3)         1.71 (1.4-1.5)           abeato         1302         200 (7.3)         1.71 (1.4-1.5)           abeato         1302         200 (7.3)         1.71 (1.4-1.5)           abeato         1400         460 (2.2)         1.71 (1.4-1.5)           abeato         2400         460 (2.2)         1.71 (1.6-1.37)           abeato         2401         1.71 (1.6-1.37)         1.71 (1.6-1.37)           abeato         2401 (2.3)         1.71 (1.6-1.37)         1.71 (1.6.3.3)           abeato	Variabe         Total         Event (%)         OR (95%C)           normal         2053         453 (17.5)         1(Ref)           obesity         2020         421 (23.2)         1.71 (1-1.37)           normal         2000         272 (13.5)         1(Ref)           obesity         3100         0.90 (21.2)         1.20 (1.06-1.53)           normal         1800         279 (23.1)         1.22 (1.03-1.44)           obesity         3450         799 (23.1)         1.22 (1.03-1.44)           obesity         3472         839 (19)         1.10.07-1.29)           normal         1202         203 (16.2)         1.28 (1.04-1.5)           obesity         1905         367 (22.2)         1.23 (0.38-1.53)           normal         1302         200 (17.3)         1(Ref)           obesity         1915         367 (22.2)         1.23 (0.38-1.53)           normal         1302         200 (17.2)         1.6(A)           obesity         1915         367 (22.1)         1.8 (0.37-1.44)           obesity         1916         102 (21.8)         1.2 (1.08-1.36)           normal         1307         362 (12.9)         1.2 (1.08-1.36)           normal         1377

	Model 1		Model 2		Model 3		
	HR (95%CI)	P-value	HR (95%CI)	P-value	HR (95%CI)	P-value	
BMI (kg/m <sup>2</sup> )							
< 18.5	3.1 (1.7–5.62)	< 0.001	2.85 (1.56-5.22)	0.001	2.44 (1.31-4.55)	0.005	
18.5-24.9	1(Ref)		1(Ref)		1(Ref)		
25-29.9	0.66 (0.45-0.98)	0.04	0.65 (0.43-0.96)	0.032	0.58 (0.39–0.87)	0.009	
≥30	0.71 (0.49-1.02)	0.066	0.7 (0.48-1.02)	0.065	0.59 (0.4–0.87)	0.008	
Trend test	0.86 (0.76-0.97)	0.012	0.86 (0.76-0.97)	0.013	0.82 (0.72-0.93)	0.002	
WC (cm)							
Normal	1(Ref)		1(Ref)		1(Ref)		
Obese	0.7 (0.52–0.94)	0.02	0.77 (0.56-1.06)	0.107	0.68 (0.49-0.95)	0.023	

Table 3 Multivar	riable-adjusted HRs and	d 95% CIs for obesity	y in relation to all-cause mortality
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Model 1 was adjusted for age; Model 2 was adjusted for age, sex, race, PIR, education level, energy intake and physical activity; Model 3 was adjusted for Model 2 plus smoking status, drinking status, blood eosinophil counts, hypertension and CVD

Abbreviations: Normal weight group is the reference group. BMI body mass index, WC waist circumference, PIR poverty-income ratio, CVD Cardiovascular diseases



**Fig. 5** Restricted cubic spline analyses the association of BMI (**a**), WC (**b**) and all-cause mortality in patients with chronic inflammatory airway diseases (CIAD). Adjusted for age, sex, race, PIR, education level, energy intake, physical activity, smoking status, drinking status, blood eosinophil counts, hypertension and CVD. Abbreviations: BMI: body mass index; PIR: poverty-income ratio; CVD: Cardiovascular diseases

OR = 1.591), asthma (BMI: OR = 1.358; WC: OR = 1.515) and acute bronchitis (BMI: OR = 1.252;WC: OR = 1.237) [19]. A cross-sectional survey has demonstrated that obesity is related to symptoms of dyspnea, and about 1/4 of dyspnea symptoms are caused by obesity [20]. This is consistent with the research results of Marta et al. [16], who found that both general and abdominal obesity were associated with respiratory symptoms. Additionally, they divided obese people into abdominal obesity and general obesity based on WC and BMI. The result revealed that after adjusting for relevant covariates, abdominal obesity was independently associated with asthma and chronic bronchitis, while general obesity was significantly associated with COPD and asthma after adjustment for abdominal obesity. Both a cohort study and a prospective study have affirmed that in the asthmatic population, individuals with obesity have lower predictive values of forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) compared with individuals with non-obesity [21, 22]. Moreover, obesity increases frequency and severity of asthma exacerbations [23]. However, a cross-sectional study from western China suggested that overweight and obesity are protective factors for COPD, the odds ratio (OR) were 0.614 (95% CI 0.517-0.730, P<0.001) and 0.572 (95% CI 0.449–0.721, P<0.001), respectively. The inconsistent results may be due to inconsistencies in study populations and sample sizes. Therefore, we need more studies with larger sample sizes and more rigorous research designs.

Obesity is the consequence of an excessive accumulation of adipose tissue, which is an active endocrine organ that can secrete a variety of cytokines and hormones [24–26]. CIAD (including COPD, asthma and chronic bronchitis) are closely related to inflammation, while adipokine that promotes the occurrence and development of inflammation mainly originates from adipose tissue. Therefore, as a low-grade systemic inflammation driven by phenotypic changes in adipose tissue-related macrophages, obesity is very likely to cause inflammatory airway diseases such as asthma and COPD [27, 28]. On the other hand, patients with obesity

	BMI (kg/m <sup>2</sup> ) groups	All-cause mortality	
		HR (95%CI)	P-value
Model I: The linear model	< 18.5	2.44 (1.31–4.55)	0.005
	18.5–24.9	1(Ref)	
	25–29.9	0.58 (0.39–0.87)	0.009
	≥30	0.59 (0.4–0.87)	0.008
	Trend test	0.82 (0.72–0.93)	0.002
Model II: Two-segment non-linear model	The turning point of BMI (kg/m <sup>2</sup> )		
	≤ 32.4 (slope1)	0.92 (0.88–0.97)	< 0.001
	> 32.4 (slope2)	1.02 (0.97–1.06)	0.52
	LRT		0.001

Adjusted for age, sex, race, PIR, education level, energy intake, physical activity, smoking status, drinking status, blood eosinophil counts, hypertension and CVD. Normal weight group is the reference group

Abbreviations: BMI body mass index, PIR poverty-income ratio, CVD Cardiovascular diseases, LRT likelihood ratio test

have an increase in peripheral blood leukocytes, which may lead to increased inflammation and the production of more pro-inflammatory mediators [29]. The inflammatory process underlying both diseases could be one of the potential connecting links between both diseases. However, the precise relevance of inflammation as a mediator between both processes has yet to be fully elucidated [30]. Additionally, obesity has an impact on the ventilatory mechanics of the population, which may play an important role in the association between CIAD and obesity [31].

In our prospective cohort study, results suggest that BMI and WC are inversely related to mortality in population with CIAD. Moreover, the CIAD mortality rate among underweight population was nearly 2.5 times higher than that among normal-weight, while overweight and obesity were significantly associated with a decreased risk of all-cause mortality compared to normal weight population.

Obesity is a major risk factor for chronic non-communicable diseases worldwide and is associated with increased diseases incidence and mortality [7, 23, 32]. Obesity can lead to low-grade chronic systemic inflammation, which predisposes individuals to an increased risk of morbidity and mortality. In contrast, numerous researches have shown that obesity is a protective factor for COPD mortality [10, 33], which is known as the "obesity paradox". Yet the relationships between obesity and mortality in patients with COPD and asthma were also inconsistent [34]. A dose-response metaanalysis revealed a nonlinear dose-response relationship between BMI and mortality in COPD patients [35]. When the BMI was 30 kg/m<sup>2</sup>, the mortality rate was lowest, and when the BMI was greater than 32 kg/ m<sup>2</sup>, the BMI was not related to the mortality rate. The results are basically consistent with our study. We found there was a non-linear association between BMI and all-cause mortality, and the turning point value of BMI was 32.4 kg/m<sup>2</sup>. The mortality of CIAD patients was lowest when BMI was 32.4 kg/m<sup>2</sup>. When BMI  $\leq$  32.4 kg/m<sup>2</sup>, all-cause mortality decreased with increasing BMI. However, when BMI > 32.4 kg/m<sup>2</sup>, there was no association between BMI and all-cause mortality.

There are many different explanations for the obesity paradox, but there is currently no unified understanding. One of the most accepted explanations is that current obesity indicators cannot effectively distinguish body composition, including fat mass and muscle mass [10, 36]. Another explanation is the influence of confounding factors, such as smoking status. Research has found that the obesity paradox does not exist in nonsmoking patients [37]. At last, most researches ignore the possible bias caused by obesity levels. Our study suggests that when BMI  $\leq$  32.4 kg/m<sup>2</sup>, obesity was positively associated with all-cause mortality, while when BMI > 32.4 kg/m<sup>2</sup>, obesity has no significant association with all-cause mortality.

The major strength of our study is that we used both BMI and waist circumference to analysis the relationship between obesity and CIAD. BMI and waist circumference are predictors of different obesity types, which can avoid some possible biases. Second, our study is representative of a large sample of the population, which made our research conclusions more reliable. Third, in this study, we established three models, adjusting for major covariates that may affect the risk of CIAD, including age, gender, ethnicity, poverty-income ratio, education level, physical activity, energy intake, drinking status, smoking status, blood eosinophil counts, and comorbidities (hypertension and cardiovascular disease). After adjusting for potential confounders, our findings remained relatively stable. At last, we collected death data on CIAD patients to analysis the association between different body weights and the risk of all-cause mortality. Additionally, our conducted two models (the linear model and two-segment non-linear model) to analyze the association between BMI and all-cause mortality and found the turning point of BMI. This may contribute to providing an appropriate weight range for the prevention and prognosis of CIAD.

There are several limitations in this study. First, this study is an observational study and cannot determine the causal relationship between obesity and CIAD. Second, the diagnosis of CIAD came from self-reported questionnaires, which is prone to bias and may miss some patients who have never seen a doctor. Third, in multivariate analysis and cox regression analysis, we adjusted for many major confounders, but there may still be some unknown confounders. Moreover, we adjusted for smoking status among all participants, but we did not conduct stratified analyzes by smoking amount and smoking duration, which may cause certain biases. Finally, we investigated the association between obesity and the incidence of total CIAD (including asthma, COPD and chronic bronchitis) as well as all-cause mortality in patients with CIAD. CIAD (including asthma, COPD and chronic bronchitis) is not a specific respiratory disease, but a type of respiratory disease, mainly related to airway inflammatory response. There have been numerous researchers on the link between a particular respiratory disease and obesity. However, the aim of this study is to investigate the relationship between obesity and a certain type of respiratory disease to provide an overall impression and to facilitate further research.

#### Conclusion

In conclusion, our study found that underweight and obesity were associated with the increased risk of CIAD compared to normal weight. Underweight was associated with increased all-cause mortality, while overweight was associated with reduced all-cause mortality. There was a non-linear association between BMI and all-cause mortality in patients with CIAD. The mortality of CIAD patients was lowest when BMI was 32.4 kg/m<sup>2</sup>. When BMI  $\leq$  32.4 kg/m<sup>2</sup>, BMI was positively associated with all-cause mortality, while when BMI > 32.4 kg/m<sup>2</sup>, BMI had no significant association with all-cause mortality. Therefore, overweight and mild obesity (BMI  $\leq$  32.4 kg/m<sup>2</sup>) are beneficial for the prognosis of CIAD, while being underweight is detrimental to the prognosis of CIAD.

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#### Authors' contributions

SL designed the study, analyzed the data, interpreted the results and edited the manuscript. HZ collected the data. ZL took part in revising and critically reviewing the article. All the authors contributed to the revision of the manuscript and approved the final version.

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#### Availability of data and materials

Publicly available datasets were analyzed in this study. This data can be found here: https://www.cdc.gov/nchs/nhanes/search/default.aspx.

#### Declarations

#### Ethics approval and consent to participate

The entire research study passed the ethical review of the National Center for Health Statistics (NCHS) in the United States, and informed consent was obtained from all participants.

#### Consent for publication

Not applicable.

#### **Competing interests**

The authors declare no competing interests.

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