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Associations between dietary patterns with obesity and weight change in Chinese adults: China Health and Nutrition Survey (CHNS)

중국 성인의 식이 패턴과 비만 및 체중 변화의 연관성 연구: 중국건강영양조사(CHNS)

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Department of Food and Nutrition
Graduate School
Seoul National University
Yang Chen
陈 阳

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위 원 장 **윤 지 현**

부위원장 **신 동 미**

위 원 **이 정 은**

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Abstract

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Yang Chen

Department of Food and Nutrition

The Graduate School

Seoul National University

Obesity has become a major challenge to population health in China. The prevalence of body mass index (BMI) ≥ 27.5 kg/m^2 has dramatically increased from 4.2% in 1993 to 15.7% in 2015 among the Chinese population aged above 18 years. The modification of diet in lifestyle may play a role in the development of obesity in China, but factors associated with obesity risk should be further explored. Although dietary pattern analysis has drawn attention because it reflects individual's actual dietary habit of nutrients or foods in combination, only a few prior cohort studies have explored a relationship between dietary patterns and chronic disease risk among Chinese adults. Therefore, we aimed to examine dietary patterns in relation to the risk of obesity (BMI ≥ 25 kg/m^2) and weight change in a Chinese cohort study. We analyzed data from 6,677 adults aged 18-65 years in the China Health and Nutrition Survey 1997-2015, an ongoing open-cohort study.

Westernized dietary pattern, traditional Chinese dietary pattern and high-starch plant-based dietary pattern were identified by principal components analysis. We used Cox proportional hazards models for relative risk (RR)s and 95% confidence interval (CI)s and generalized linear model for least-squares means (LS-means) and 95%CIs. High adherence to the Westernized dietary pattern was associated with increased risks of obesity and weight gain. Comparing top with bottom quintiles, RR (95%CI) for obesity (BMI ≥ 25 kg/m^2) was 1.57 (1.26-1.95; P for trend <0.001). LS means of weight change (kg/5-year) were 1.73 (0.98-2.47) and 1.13 (0.39-1.87; P for trend = 0.036) in the top and bottom quintiles, respectively. However, there was a suggestion of inverse association between the traditional Chinese dietary pattern and obesity; RRs (95%CI) compared to the bottom quintile were 0.78 (0.66-0.92) for the 2nd quintile, 0.83 (0.69-0.98) for the 3rd quintile, 0.80 (0.66-0.96) for the 4th quintile, and 0.84 (0.70-1.01) for top quintile (P for trend = 0.045). No significant association for high-starch plant-based dietary patterns were observed. The association between the Westernized dietary pattern and weight gain was stronger in participants in the Southern region, than who lived in the Northern area. In summary, the Westernized dietary pattern was associated with increased risk of obesity and weight gain. We also suggest the evidence that dietary weight management strategies may be effective when implemented in a region-specific way.

Keywords: Dietary pattern, Obesity, Weight change, China

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List of Abbreviations

BMI	Body mass index
CHNS	China Health and Nutrition Survey
FFQ	Food Frequency Questionnaire
LS-means	Least-squares means
MET	Metabolic equivalent task
OR	Odds ratio
RR	Relative risks
SD	Standard Deviation
WHO	World Health Organization
95%CI	95% confidence interval

I. Introduction

The global prevalence of obesity has steadily increased in past decades worldwide. According to the WHO report in 2016, the proportions of overweight (body mass index (BMI) ≥ 25 kg/m^2) or obesity (BMI ≥ 30 kg/m^2) of adults aged 18 years and over were 39% and 13%, respectively (World Health Organization, 2020). The problem of increasing rates of obesity is not only centered around developed countries but in developing countries as well (Finucane et al., 2011). Accompanied by rapid urbanization and motorization in China, the prevalence of obesity (BMI ≥ 27.5 kg/m^2) has dramatically increased from 4.2% in 1993 to 15.7% in 2015 among the China population aged above 18 years (Ma et al., 2021). Obesity is an important risk factor for the development of various chronic diseases including type 2 diabetes (Abdullah et al., 2011), cardiovascular disease (Piché, Poirier, Lemieux, & Després, 2018), and several types of cancers (Gallagher & LeRoith, 2015). It has been suggested that the cause of obesity is complicated and multifactorial factors such as genetic, environmental, and lifestyle (Hruby et al., 2016). The modification of diet in lifestyle is expected to play a role in the prevention of obesity (Malik, Willett, & Hu, 2013).

Since individuals consume nutrients or foods in combination, there is high collinearity among foods or nutrients. From this perspective, dietary pattern analysis, which represents a broader picture of foods and nutrients, may provide a meaningful insight regarding the relationship between diet and the risk of disease. (Hu, 2002).

Several studies have examined the relationship between dietary patterns and obesity. A recent meta-analysis including 17 observational studies reported a lower risk of overweight/obesity with a healthy or prudent pattern, but a higher risk with an unhealthy or Western pattern (Mu, Xu, Hu, Wu, & Bai, 2017). Two of these 17 studies in a meta-analysis and another four studies were conducted in the Chinese population using a cross-sectional design to estimate obesity prevalence in young women aged 18-44 years (Zhang et al., 2015), in adolescents aged 10-12 years (Chan et al., 2014) and in male and female adults (Li & Shi, 2017; Shi et al., 2008; Yu et al., 2015; Zou et al., 2017).

Due to the limited evidence from long-term cohort studies, this study aimed to prospectively examine whether dietary patterns were associated with obesity and weight change in the China Health and Nutrition Survey (CHNS).

II. Literature review

1. Epidemiology of obesity

Obesity is an important risk factor associated with the development of various chronic diseases. The current most widely used index for diagnosing obesity is the body mass index (BMI). The World Health Organization (WHO) defines obesity in adults as BMI ≥ 30 kg/m^2 for the western region, and BMI ≥ 25 kg/m^2 for the Asia-Pacific region (World Health Organization, 2020). The Working Group on Obesity in China recommended a BMI cutoff value of 28 kg/m^2 to define obesity for Chinese populations (Zhou, 2002).

Over the last few decades, the prevalence of obesity among adults has increased worldwide. According to the WHO, the worldwide prevalence of obesity（BMI ≥ 30 kg/m^2） nearly tripled between 1975 and 2016. In 2006, about 13% of adults aged 18 years and over (11% of men and 15% of women) had BMI of 30 kg/m^2 or greater (World Health Organization, 2020). Obesity has been traditionally prevalent in high-income countries, overweight and obesity are now radically on the rise in low- and middle-income countries, including China (Ng et al., 2014).

In China, with rapid urbanization and motorization, obesity has become a major challenge to population health. A recent study (Ma et al., 2021) showed that the prevalence of obesity (BMI ≥ 27.5 kg/m^2) has dramatically increased from 4.2% in 1993 to 15.7% in 2015 among the Chinese population aged above 18 years.

2. Nutrition transition in China

With the rapid economic and social change, the nutrition transition has accelerated in China (Du, Lu, Zhai, & Popkin, 2002). Nutritional transitions are typically characterized by two aspects: food consumption changes and cooking behavior shifts.

Previous researches have shown that egg, poultry, beef, dairy products, processed food, sweet and pork consumption rapidly increased, but the intake of cereals, vegetables decreased over decades in China (Huang et al., 2021; Popkin & Du, 2003; Zhai et al., 2009). These changes have led to a shift in the macronutrient composition of the Chinese diet, from a high-carbohydrate diet to a high-fat diet. Furthermore, a previous study (Zhai et al., 2014) has noted that a decrease in intake of home-prepared foods and foods cooked in healthy ways (e.g., steamed, baked, boiled) and an increase in intake of snacks.

The degree of nutrition transition differs by in China (Wang, Zhai, Du, & Popkin, 2008). In developing countries, people with high socioeconomic status (SES) may be most likely to expose to a western lifestyle, whereas people with low SES seem to maintain a traditional lifestyle. The potential reason is that processed foods are usually costlier than natural food sources (e.g., fresh vegetables, fruits, and low-fat products), and these unhealthy choices are sometimes viewed as privileges of the wealthy (Kim, Symons, & Popkin, 2004).

It is important to identify healthy dietary patterns and examine whether dietary patterns are associated with the risk of chronic disease. To elucidate the etiology of disease development in relation to dietary factors among the population undergoing a nutritional transition.

3. Dietary pattern analysis

The analysis of dietary patterns related to diseases has recently received much attention. Because individuals do not consume foods or nutrients separately but consume them in combination, there are several strengths in studying dietary patterns and disease risk (Hu, 2002; Panagiotakos, 2008).

First, the single nutrient or food analysis approach may be inadequate to account for the complex interactions among nutrients, whereas the dietary pattern analysis can provide a broader picture of foods and nutrients. Additionally, when the effect of a single nutrient is too small to detect, it may be more easily detected by dietary pattern analysis due to the accumulated effect of multiple nutrients. Second, individuals who consume less meat and meat products are generally prone to consume more fruits and vegetables. The correlation of these dietary components may lead to being a confounding bias when using the single nutrient or food analysis approach. Third, studying dietary patterns may be more useful in establishing public health strategies, because the overall dietary patterns may be easier for the public to understand the message and adhere to it.

The two major methods are used to derive dietary patterns: (a) a priori or index-based approach based on current theory and literature, and (b) a posteriori or data-driven approach using factor or cluster analysis to classify dietary patterns. Two methods are useful to identify dietary factors in the search for disease causation.

4. Association of dietary patterns with obesity and weight gain

A meta-analysis of different population studies that assessed the association between a posteriori dietary patterns and the risk of overweight/obesity from four cohort studies and thirteen cross-sectional studies (Mu et al., 2017). The results of the meta-analysis depicted that a prudent/healthy dietary pattern characterized by high intakes of fruits, vegetables, poultry, fish, low-dairy and whole grains had an inverse association with the risk of overweight/obesity risk; odds ratio (OR) (95% confidence interval (CI)) comparing the highest with the lowest categories of prudent/healthy dietary pattern was 0.64 (0.52-0.78; P for trend < 0.001). In contrast, a Western/unhealthy dietary pattern characterized by high intakes of red or processed meats, refined grains, potatoes, sweets, and high-fat dairy was associated with an increased overweight/obesity risk; OR (95%CI) comparing the highest with the lowest categories of Western/unhealthy dietary pattern was 1.65 (1.45-1.87; P for trend < 0.001).

A systematic review of cohort or case-control studies that examined the association between diet quality and weight change, suggested that participants who consumed vegetables, fruits, whole grains, and lower amounts of energy-dense foods had lower weight gain than those who consumed a nutritionally poor diet (Aljadani, Patterson, Sibbritt, & Collins, 2013). But that meta-analysis observed high heterogeneity among studies, possibly because dietary patterns vary according to the ethnic group included.

Several epidemiological studies have investigated the association between a posteriori dietary patterns and obesity outcomes in the Chinese population. Table 1 listed the findings of the studies among child and adolescent populations (Liu et al., 2019; Shang et al., 2012; Zhang et al., 2015; Zhen, Ma, Zhao, Yang, & Wen, 2018). Though there were differences in dietary assessment methods, study designs, the number or type of dietary factor patterns derived, and confounding variables, an increased risk of obesity with Westernized dietary patterns was observed. The Westernized dietary pattern characterized by refined grains, red meat, sweets, and fast foods was associated with a high prevalence of childhood obesity.

Table 2 showed the findings of the studies including the middle-aged or the older population (Shu et al., 2015; Sun, Buys, & Hills, 2014; Xu, Byles, Shi, McElduff, & Hall, 2016; Xu, Hall, Byles, & Shi, 2015; Yuan et al., 2016). Two analyses by Xiaoyue Xu et al. assessed the relationship between dietary patterns derived by factor analysis and obesity or change in BMI/weight among participants aged 60 and older (Xu et al., 2016; Xu et al., 2015). They found that high modern dietary pattern scores (high intakes of fruit, milk, processed and fast food) were associated with a high risk of obesity and BMI increase, whereas a traditional dietary pattern (high intakes of rice, pork, vegetables) had an inverse association with obesity and BMI change. This association was consistent with results from a cross-sectional study from Jiangsu Nutrition Study (Sun et al., 2014). However, a study conducted in Shanghai reported that a rice staple pattern (high loadings on rice, vegetables, pork, starchy root, processed meat) may increase the risk of general obesity (Yuan et al., 2016).

Findings of the Chinese studies of the adult population were shown in Table 3 (Li & Shi, 2017; Shi et al., 2008; Shi et al., 2011; Yu et al., 2015; Zhang et al., 2015; Zou et al., 2017). The most of results in the cross-sectional study showed that the modern pattern (high intakes of fast food, cakes, fried food) was associated with a high prevalence of obesity, but the traditional pattern (high intakes of rice, vegetables, and meat) was associated with a low prevalence of obesity among the adult population.

Additionally, an inverse association between the rice-rich traditional dietary pattern and weight gain was observed in a longitudinal study from Jiangsu Nutrition Study (Shi et al., 2011). Because only a few studies explored the prospective association of dietary patterns on the risk of obesity among adults, further cohort studies are needed.

Table 1. Summary of the findings of dietary patterns and obesity among Chinese children and adolescents

No.	Author (year) Location Study design	Sample	Outcome	Diet assessment method	Dietary patterns identified	Primary results
1	Xianwen Shang (2012) Beijing and four provincial capital cities including Haerbin, Jinan, Shanghai, and Guangzhou Cross-sectional design	5267 participants boys 2643, girls 2624 aged 6–13 years	BMI z-score (WHO)	24-hour dietary recall method; three consecutive days (two weekdays and one weekend day); a combination of factor analysis and cluster analysis	i) Healthy dietary pattern ii) Transitive dietary pattern iii) Western dietary pattern	Children with the Western dietary pattern had a significantly higher odds of obesity [OR (95%CI): 1.80 (1.15–2.81), P=0.0099], compared with children who followed the healthy dietary pattern
2	Jiguo Zhang (2015) China Health and Nutrition Survey (CHNS 2011) Cross-sectional design	1282 participants boys 645, girls 637 aged 7–17 years	BMI z-scores (Chinese standards)	Three consecutive 24-h dietary recalls (two weekdays and one weekend day); factor analysis	i) Modern dietary pattern ii) Traditional north dietary pattern iii) Traditional south dietary pattern	Modern [compared with children in the lowest quartiles, OR (95%CI): 3.10 (1.52–6.32), P=0.0024] and northern [compared with children in the lowest quartiles, OR (95%CI): 2.42 (1.34–4.39), P=0.006] patterns were positively associated with the risks of obesity; there was no significant association between the southern pattern and obesity.
3	Shihan Zhen (2018) China Health and Nutrition Survey (CHNS 2006 - 2011) Longitudinal design	736 participants aged 6–14	BMI z-score (WHO) (2009/2011)	FFQ (in 2006); Factor analysis	i) Traditional Chinese dietary pattern ii ）Modern dietary pattern	**i)** Traditional Chinese dietary pattern was inversely associated with later obesity obesity status was measured in 2011: [compared with children in the lowest quartile, OR (95%CI): 0.19 (0.09–0.40), P<0.001] **ii)** Modern dietary pattern was positively associated with later obesity obesity status was measured in 2011: [compared with children in the lowest quartile, OR (95%CI): 2.02 (1.17–3.48), P=0.078]
4	Dan Liu (2018) China Health and NutritionF Survey (CHNS 2010 - 2012) Cross-sectional design	7988 participants boys 3999, girls 3989 aged 6–17	BMI z-scores (Chinese standards)	FFQ; Factor analysis	i) Traditional Chinese dietary pattern ii) Modern dietary pattern	Westernized pattern was positively associated with the increased risks of childhood obesity [Q4 vs Q1, OR (95%CI): 1.49 (1.21–1.84), P<0.01]

Table 2. Summary of the findings of dietary patterns and obesity among Chinese middle-aged or older adults

No.	Author (year) Location Study design	Sample	Outcome	Diet assessment method	Dietary patterns identified	Primary results
1	Jing Sun (2014) Jiangsu cross-sectional design	1,070 adults aged ≥ 50 years (310 males; 760 females)	BMI ≥ 28 kg/m^2	FFQ; factor analysis	i) Healthy dietary pattern ii) Western dietary pattern iii) Balanced dietary pattern	i) The relative risk ratio related to obesity among adults with a Western dietary pattern is 2.31 (95%CI: 1.15–5.88, p < 0.02), compared to adults with a healthy dietary pattern. ii)The healthy dietary pattern was inversely associated with a likelihood of having obesity (OR (95%CI): 0.51 (0.34–0.79), p = 0.002) compared to a Western dietary pattern
2	Xiaoyue Xu (2015) China Health and Nutrition Survey (CHNS 2009) Cross-sectional design	2745 individuals aged ≥ 60 years	BMI ≥ 28 kg/m^2	24 hour-recall; over three consecutive days; factor analysis	i) Traditional dietary pattern ii) Modern dietary pattern	i) A traditional dietary pattern was inversely associated with the risk of overweight/obesity ii) A modern dietary pattern is significantly related to an increased likelihood of being obese
3	Long Shu (2015) Hangzhou Cross-sectional design	2560 subjects aged 45-60 years	BMI ≥ 28 kg/m^2	FFQ; factor analysis	i) Animal food pattern ii) Traditional Chinese pattern iii) Western fast-food pattern iv) High-salt pattern	Participants in the highest quartile of the animal food pattern had significantly higher BMI and WC (p < 0.05). Conversely, participants in the highest quartile of the traditional Chinese pattern had lower BMI, WHR, and WC than those in the lowest quartile (p < 0.05).
4	Xiaoyue Xu (2016） China Health and Nutrition Survey (CHNS 1991 - 2011) Longitudinal design	6348 observations aged ≥ 60 years	BMI (kg/m^2), weight change (kg)	24 hour-recall; over three consecutive days; factor analysis	i) Traditional dietary pattern ii) Modern dietary pattern	The modern dietary pattern was associated with an increase in BMI, weight, and WC, whereas the traditional dietary pattern led to a decrease in BMI, weight, and WC.
5	Ya-Qun Yuan (2016) Shanghai Cross-sectional design	2046 Residents aged ≥45 years 968 men and 1078 women	BMI ≥ 28 kg/m^2	One-day 24-h dietary recalls; factor analysis	i) Rice staple pattern ii) Wheat staple pattern iii) Snacks pattern iv) Prudent pattern	Men who followed a rice staple pattern had a greater risk of general obesity (Compared with the lowest quartile, PR = 1.800; 95%CI: 0.998–3.226; p= 0.054). Meanwhile, the same pattern showed a protective effect against general obesity in women (Compared with the lowest quartile, PR = 0.745; 95%CI: 0.673–0.807; p= 0.031).

Table 3. Summary of the findings of dietary patterns and obesity among Chinese adults

No.	Author (year) Location Study design	Sample	Outcome	Diet assessment method	Dietary patterns identified	Primary results
1	Z Shi (2008) Changshu City, Jiangsu Province and Beijing Fangshan District, Beijing cross-sectional design	2849 men and women aged ≥ 20 years	BMI ≥ 28 kg/m^2	FFQ; factor analysis	i) 'Macho' dietary pattern ii) 'Traditional' dietary pattern iii) 'Sweet tooth' dietary pattern iv) 'Vegetable-rich' dietary pattern	A positive association between a vegetable-rich food pattern and general obesity; comparing Q4 and Q1, 2.25 (95%CI: 1.45–3.49) in women, 1.82 (95%CI: 1.05–3.14) in men and 2.06 (95%CI: 1.46–2.89) in men and women combined
2	Zumin Shi (2011) Jiangsu Nutrition Study Longitudinal design	1231 adults aged ≥ 20 years	Mean 5-year weight change (kg)	FFQ; factor analysis	i) 'Macho' dietary pattern ii) 'Traditional' dietary pattern iii) 'Sweet tooth' dietary pattern iv) 'Vegetable-rich' dietary pattern	i) The 'traditional' dietary pattern was inversely associated with weight gain (the first quartile as the reference, β =− 2.18;95 % CI = (− 2.91, − 1.45); P <0.001) ii) 'vegetable-rich' dietary pattern was positive associated with weight gain (the first quartile as the reference, β = 1.00 ;95 % CI = (0.25, 1.74)); P=0.005)
3	Canqing Yu (2015) China Kadoorie Biobank (CKB) Cross-sectional design	512,891 men and women aged 18–44 years	BMI ≥ 28 kg/m^2	FFQ; a combination of factor analysis and cluster analysis	i) Traditional southern dietary pattern ii) Traditional northern dietary pattern iii) Western/new affluence dietary pattern	Compared with the individuals following the traditional southern dietary pattern, Western/new affluence dietary pattern had a higher prevalence ratio of obesity (PR = 1.70; 95%CI = 1.67–1.74); traditional northern dietary patterns were more likely to be generally obese (PR = 1.39; 95%CI = 1.36–1.42)
4	Jiguo Zhang (2015) China Health and Nutrition Survey (CHNS 2011) Cross-sectional design	2363 young women aged 18-44 years	BMI ≥ 28 kg/m^2	Three consecutive 24-h dietary recalls (2 weekdays and 1 weekend day); factor analysis	i) Traditional south dietary pattern ii) Traditional north dietary pattern iii) Snack dietary pattern iv) High-protein pattern	i) The traditional south pattern was associated with a decreased risk of general obesity [Compared with the lowest quintile, OR (95%CI): 0.48 (0.29–0.78), P=0.002] ii) The traditional north pattern was found to have a greater risk of general obesity [Compared with the lowest quintile, OR (95%CI): 2.28 (1.38–3.74), P<0.001]
5	Yan Zou (2017) Zhejiang Province Cross-sectional design	5577 adults 2535 male and 3042 female	BMI ≥ 28 kg/m^2	Three consecutive 24-h dietary recalls; factor analysis	i) 'Cereal, animal, and plant food' dietary pattern ii) 'High protein' dietary pattern iii) 'Plant food' dietary pattern iv) 'Poultry' dietary pattern v) 'Beverage' dietary pattern	'cereal, animal, and plant food' (compared with the lowest quartile (Q1); OR = 2.924; 95%CI = 1.147–7.463; P=0.025) and 'beverage' (compared with the lowest quartile (Q1); OR =3.257; 95%CI = 1.372–7.692; P=0.007) patterns were associated with a significantly increased risk of obesity.
6	Ming Li (2017) China Health and Nutrition Survey (CHNS 2009) Cross-sectional design	9499 adults aged over 18 years	BMI ≥ 25 kg/m^2	Three consecutive 24-h dietary recalls; factor analysis (CHNS 1991-2011))	i) Traditional dietary pattern ii) Modern dietary pattern	The "Modern" dietary pattern was positively associated with obesity risk

III. Subjects and Methods

1. Study population

China Health and Nutrition Survey (CHNS), an ongoing prospective household-based cohort study, was initiated in 1989. CHNS has been followed by 10 rounds (i.e., 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, 2011, and 2015) to explore the effect of social, economic, and demographic changes in the Chinese health status. Details of the CHNS are described elsewhere (Popkin, Du, Zhai, & Zhang, 2010; Zhang, Zhai, Du, & Popkin, 2014).

In brief, a multistage, stratified, random cluster was used to draw samples from 15 provinces (Beijing, Chongqing, Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, Shanxi, Shandong, Shanghai, Yunnan, and Zhejiang). The cohort started with 8 provinces and grew to include 7 more provinces. Heilongjiang was added in 1997, Beijing, Shanghai, and Chongqing in 2011, and Yunnan, Zhejiang, and Shanxi in 2015. In this sampling strategy, two cities (usually one provincial capital and one lower-income city) and four counties (one high income, one low income, and two middle income) were randomly selected by a weighted sampling scheme in each province. Then, villages and towns in the counties and urban and suburban sites in the cities were randomly selected. Finally, twenty households were randomly selected and all household members were interviewed in each selected area.

Since 1997, when there were communities with less than 20 households, due to loss of follow-up, new households from the same community had been recruited as replacement samples. New family members of the selected households were also recruited as participants of the cohort. Some participants left the cohort due to unforeseen circumstances but chose to re-participate in later years.

In this study, our analysis initially included 28,751 participants aged 18-65 years from the 1997-2015 surveys, which had information on food names corresponding to the food codes. As shown in Figure 1, we excluded participants at baseline who had missing information on energy intake or did not complete the three-day dietary recall data (n = 2,733), reported implausible energy intake (outside the range of log-transformed mean energy intake ± 3 standard deviation) (n = 23), had missing or extreme anthropometric data (BMI ≤ 10 kg/m^2 or height ≤ 120 cm) (n = 6,131), were currently pregnant or lactating (n = 318), or had been previously diagnosed with cardiovascular disease, diabetes, or cancer (n = 608). We also excluded participants who completed only one round of the survey or did not consecutively attend the surveys (n = 6,907). We further excluded participants who had missing anthropometric data or a BMI of less than or equal to 10 kg/m2 (n = 4,718), were currently pregnant or lactating (n = 55), or had a history of cardiovascular disease, diabetes, or cancer (n = 581) during the follow-up periods.

As a result, a total of 6,677 participants (3,771 women and 2,906 men) were included in this analysis. To determine the association between dietary pattern and obesity risk, 4,903 participants (2,771 women and 2,132 men) were included after excluding those with a BMI of at least 25 kg/m^2 at baseline.

The study was approved by the institutional review committees of the University of North Carolina (USA) and the National Institute of Nutrition and Food Safety (China). Informed consent was obtained from all participants.

Enrollment at baseline (CHNS 1997-2011)
n = 36,865

a. At baseline

- Missing data on age: n = 19
- Age > 65 or age < 18: n = 8,095
- Missing data on energy intake: n = 2,661
- Not completing the three-day dietary recall data: n = 72
- Implausible energy intake: n = 23
- Missing data on height or implausible height (height ≤ 120 cm): n = 5,020
- Missing data on weight: n = 1,109
- Implausible BMI (BMI ≤ 10 kg/m²): n = 2
- Pregnant and lactating: n = 318
- Diagnoses of cardiovascular, diabetes, cancer: n = 608

b. Individuals who completed only one round of the survey, or did not consecutively attend the surveys: n = 6,907

c. During the follow-up periods (up to 2015 survey):

- Missing data on weight: n = 4,713
- Implausible BMI (BMI ≤ 10 kg/m²): n = 5
- Pregnant and lactating: n = 55
- Diagnoses of cardiovascular, diabetes, cancer: n = 581

Total participants included in the weight change analysis
n = 6,677

Total participants included in the obesity analysis
n = 4,903
(n=1,774 of BMI ≥ 25 kg/m^2 at baseline excluded)

Figure 1. Flowchart of participants included in the study (CHNS 1997-2015)

2. Dietary and anthropometric assessments

Individual dietary intake was collected over three consecutive days, randomly allocated from Monday to Sunday, through a 24-hour dietary recall at the individual level and combined with the individual consumption of edible oils and condiments from a household inventory to improve the accuracy of the dietary assessment method as described in detail elsewhere (Popkin, Lu, & Zhai, 2002; Zhai et al., 1996)

To collect household food consumption data, the total amount on hand of all foods at the beginning of the survey, the amount of purchased or self-produced products, and the amount of discarded foods (e.g. spoiled rice, food fed to animals) during the survey period were carefully weighed with Chinese balance scales (before 2004) or digital diet and kitchen scales by a trained field interviewer during the three days. If discarded foods were not weighed, estimated measurements were used. At the end of the survey, all remaining foods were weighed and recorded again. The amount of actual consumption by each household was calculated as following:

Actual consumption = Total amount at the beginning + Total amount purchased/produced - Total amount discarded – Total amount remaining

In the 1997 and 2000 survey year, the unit of measurement was reported as Jin which is a Chinese measurement unit, while as grams in other survey years. We converted Jin into gram to keep our units the same in the household food consumption data (1 jin=500 gram). Individual consumption of cooking oils and condiments was estimated from the household dietary data by the ratio of his or her energy intake to the energy intake of all family members (Shen et al., 2017).

In a three consecutive 24-hour dietary recall, individuals were asked to report all food consumed away from and at home during the past 24 hours. Trained field interviewers used food models and pictures to help individuals in facilitating more complete recalls, and clearly recorded the food category, amount, type of meal, and place of consumption of all food items consumed by the individuals. The unit of measurement in 1997 and 2000 was recorded as Liang which is a Chinese measurement unit, while it was gram in other survey years. We converted Liang to gram (1 liang=50gram). Food items consumed in shared dishes were systematically recorded. The amount of individual consumption in shared dishes was determined by the total amount in the dish and the proportion of the dish that each person consumed. Nutrient intake was calculated by using corresponding versions of the Chinese food composition table (FCT) (Yang, Wang, & Pan, 2009). The average daily food intake or nutrient consumption for each individual was obtained by summing the amount of each food item and then dividing the summation by three.

The validity of the dietary assessment was evaluated in previous research (Yao et al., 2003). It compared total energy intake calculated from combined recall results with energy expenditure measured with the doubly labeled water method. The correlation coefficients were 0.56 for men and 0.60 for women (both p-value < 0.01).

Using standard protocols and uniform equipment (height: SECA Stadiometer 206; weight: electronic weight scale), height and body weight were directly measured at each visit to the nearest 0.1 cm and 0.1 kg with the guidance of trained research assistants. When measuring height and body weight, participants were asked to wear light clothing and to take off their shoes. BMI was calculated as weight divided by the square of height (kg/m^2).

3. Definition of outcomes

Two major outcomes were defined as follows:

(1) incident obesity, defined as BMI ≥ 25 kg/m^2 by the Asian-Pacific guideline (World Health Organization. Regional Office for the Western, 2000).

(2) average weight change per 5 years, which is calculated as the most recently recorded weight minus the baseline weight divided by the follow-up time in years and multiplied by 5.

4. Assessment of covariate

Trained interviewers administered a structured questionnaire to collect information including sociodemographic and lifestyle factors. The region was classified into Northern region (Liaoning, Heilongjiang, and Beijing), Eastern region (Jiangsu, Shandong, and Shanghai), Western region (Chongqing, Guangxi, and Guizhou), and Central region (Henan, Hubei, and Hunan). Urbanization was measured using a validated urbanization index which was developed by Jones-Smith and Popkin (Jones-Smith & Popkin, 2010). It included 12 components to capture community-level physical, social, cultural, and economic environments. The scale has a possible range of 0-120, with a higher score indicating greater urbanization. Alcohol drinking (g/day) during the past year was calculated by summing the daily ethanol intake of all alcoholic beverages included in the questionnaire. The ethanol content per serving of alcoholic beverage was estimated as 19.35g for 1 bottle of beer, 5.1g for 1 Liang of wine, 21.3 Liang of liquor based on the Chinese Food

Composition Table (Yang et al., 2009). The pack-years of smoking was calculated by dose and duration that each participant smoked. The level of leisure physical activity, expressed as metabolic equivalent tasks (METs), was calculated by multiplying the average time spent per week by its typical energy expenditure requirements. Participants were asked the average time spent per week for each of the following leisure physical activities: dancing, aerobics, jogging, swimming, martial arts, and various ball games. Their specific MET values were based on a previous study (Ainsworth et al., 2000; Fong, Ho, & Yip, 2019). The total leisure activity was obtained from the sum of each leisure physical activity (MET-hours per week). Household income was evaluated by household income per capita inflated to 2015. Because the information on whether participants were postmenopausal or not was only investigated in 1993, women were considered postmenopausal if they reported postmenopausal status in the 1993 survey or had reached 50 years and older. This age cut-off was based on the previously reported median age of natural menopause among Chinese women (Li et al., 2012). All the proportion of missing data were below approximately 5%. We assigned the missing values to the most frequent category for categorical variables or the median value for continuous variables.

5. Statistical analysis

The individual food items were aggregated into 35 food groups based on similar nutrient content, biological origin, and culinary usage. The food groups also were referred to a food grouping system shown in the Chinese Food Composition Table (Yang et al., 2009). Details of food groups were described in Table 4. We used baseline dietary intake data to identify dietary patterns. We conducted a principal component analysis using the PROC FACTOR command in SAS (Statistical Analysis System, SAS Institute, Cary, NC, USA) to drive underlying dietary patterns (Hatcher, 1994). To determine the number of factors to be retained, we used eigenvalue (> 1.5), a scree plot, and factor interpretability. The retained three factors were rotated with the varimax rotation to minimize the correlation within the factors and to increase its interpretability. Factor loadings were extracted for each of the food groups across the retained factors. The dietary factors were labeled according to the food groups with a factorial load ≥ 0.2 or ≤ -0.2. For each individual, factor scores were assigned by summing the standardized intake of food groups weighted by their factor loadings. Given that they had a high correlation with total energy intake, we used the residual method to adjust for total energy intake on the factor scores (Willett & Stampfer, 1986).

Each dietary pattern score at baseline was categorized into quintiles, and the first quintile was used as the reference for all analyses. The baseline demographic characteristics of participants were expressed as mean ± standard deviation (SD) for continuous variables and numbers and percentages for categorical variables according to the quintiles of each dietary pattern score.

The multivariable Cox proportional hazards regression model was used to assess the relative risks (RRs) and 95% confidence intervals (CIs) of obesity associated with each dietary pattern score. Person-time of follow-up for each participant was calculated from the date of recruitment to the date when participants were diagnosed with obesity, the date of death, or the date of last participation, whichever occurred first. Multiple linear regressions were used to calculate the least-squares means (LS-means) with 95% confidence intervals (CIs) for the association between each dietary pattern score and average body weight change (kg/5-years).

For both the obesity and weight change analysis, we adjusted for age (continuous, years), sex, energy intake (continuous, kcal), marital status (never married, married, and divorced), physical activity (0, 0 <-18, 18 <-36, and >36 MET-h/wk), smoking status (0, 0<-10, 10<-20, 20<-30 and >30 pack-years), alcohol drinking (0, 0 <-6, 6 <-12, 12 <-24, and >24 g/day), region (Northern, Eastern, Western, and Central regions), education level (illiteracy, primary school, junior high school, and high school or higher), household income per capita inflated to 2015 values (tertile, RMB), and urbanization index (tertile). For weight change analysis, we additionally adjusted for baseline body weight (continuous, kg). Additional adjustment for menopause status did not change the estimates for women and were not included in the final model. A test for linear trend was performed by assigning the median value of each quintile to the corresponding participant and treating the value as a continuous variable. We estimated RRs (95%CIs) for obesity for a one-unit increase in each score. We evaluated the potential modification in the subgroup analyses of age (<42 or ≥42, median) and region (Southern region or Northern region). P for interaction was tested using the likelihood ratio test or Wald test.

We further applied several sensitivity analyses to see whether the overall associations would persist. In the association between dietary patterns and obesity (BMI ≥ 25 kg/m^2), 1) we treated the outcome as BMI ≥ 23 kg/m^2. In the association between dietary patterns and average body weight change (kg/5 years),

1) we censored the participants who reached over 65 y of age during the follow-up period to minimize bias from age-related weight loss, 2) we restricted our analyses to the participants with BMI < 30 kg/m^2 at baseline, 3) we excluded the participants with less than three years of follow-up, and 4) we truncated change in weight at the 1st and 99th percentiles to minimize the influence of outliers.

All statistical tests with a two-sided $p < 0.05$ were considered statistically significant. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA).

Table 4. Examples of food components for each food group

Food group	Examples of food items
1. Rice and its products	Polished round- Grained rice, Glutinous rice, Rice noodles, Rice cake
2. Wheat and its products	Wheat flour, Wheat grain, Wheat noodles, Wheat macaroni.Wheat gluten
3. Buns and breads	Bun, Butter bread, Salty bread
4. Deep-fried products	Deep-fried dough stick, Deep-fried cake with red bean paste and sugar, Deep-fried sweet sesame seed ball, Deep-fried rice flour doughnut, Deep-fried soybean, Deep-fried broad bean
5. Corn and its products	Corn, Cornflour, Corn grits, Cornflake
6. Coarse grain	Barley, Oats, Foxtail millet, Sorghum, Brown rice, Ready to eat cereals
7. Starch vegetables and its products	Potato, Yam, Taro, Lotus root, Water chestnut, Cassava, Arrowhead, Potato starch, Starch noodle, Starch jelly sheet
8. Leafy green vegetables	Spinach, Romaine or leaf lettuce, Bok choi, Mustard greens
9. Cruciferous vegetables	Broccoli, Cabbage, Cauliflower, Brussels sprouts, Radish
10. Orange-red vegetables	Carrots, Yellow (winter) squash, Sweet potato, Beetroot, Red onions, Tomato
11. Other vegetables	Celery, Green pepper, Eggplant, Summer squash, Ginger, Scallion, Mushrooms, Fresh or dried seaweed, Black-moss, Pea with pods, Soybean sprouts
12. Preserved vegetables	Canned tomato sauce, Preserved vegetables, Vegetables in soy sauce
13. Legumes	Kidney beans, Lima beans, Soybeans, Black beans
14. Legumes products	Tofu, Tofu products, Red/mung bean paste, Fermented soybean curd, Sweetened and un-sweetened soy milk, Soy milk powder, Broad-bean paste
15. Nuts and seeds	Sesame, Sunflower, Watermelon seeds, Lotus seeds, Peanuts, Walnuts, Almonds, Hazelnuts, Pine-nuts, Pistachios, Cashew nuts, Peanut butter
16. Fruits and fresh juices	Fresh fruits, Fresh fruit juices
17. Preserved fruit	Dried and canned fruit (added sugar), Dried dates, Dried longan
18. Red meats	Pork, Beef, Lamb, Donkey, Rabbit
19. Poultry	Chicken, Duck, Goose
20. Organ meats	Liver, Kidney, Large intestine, Ear, Feet, Pork blood curd, Duck blood curd, Pork tendon, Beef tendon
21. Processed meats	Sausages, Ham, Luncheon meat, Dried meat, Smoked meat, Salted meat
22. Eggs and its products	Whole eggs, Yolk, White, Preserved eggs
23. Fish and seafood	Fresh- and salt-water fish, Dried fish, Shellfish
24. Low-fat dairy products	Skim or low-fat milk, Yogurt, Cottage cheese, Low-fat cheese
25. High-fat dairy products	Whole milk, Whole milk powder, Cream cheese. Cream, Butter, Ice cream
26. Western-style fast-food	Fried chicken, Sandwich, Hamburger, Hotdog, Pizza
27. Instant foods	Instant noodles, Instant multigrain porridge, Refined grain ready-to-eat cereals, Frozen dumplings
28. Sweets and snacks	Biscuit, Cracker, Jelly, Jam, Chocolate, Honey, Sugar, Candies, Cake, Cookies, Pie, Pastries, Corn Crisps, Onion Rings, Potato Chips, Popcorn
29. Sugar-sweetened beverages	Fruit or flavored drinks, Soft drinks
30. Coffee and tea	Tea, Coffee
31. Alcoholic beverages	Liquors, Wine, Vodka, Cocktails, Whiskey, Beer
32. Condiments and spice	Soy sauce, Vinegar, Salt, Star anise, White pepper, Mayonnaise
33. Vegetable oils	Soybean oil, Tea oil, Rapeseed oil, Olive oil
34. Animal oils	Beef tallow, Duck fat
35. Chinese medicinal materials	Semen Cassiae, Dried Tangerine, Momordica Grosvenori

IV. Results

1. Characteristics of the baseline dietary patterns

Three major dietary patterns were identified by the factor analysis, which explained 17% of the variance (Table 5). The Westernized dietary pattern was characterized by a high intake of high-fat dairy products, fruits and fresh juices, buns and breads, instant foods, eggs, sweets and snacks, deep-fried products, coarse grain, Western-style fast foods, nuts and seeds, and sugar-sweetened beverages combined with a low intake of rice, animal oil, preserved vegetables, and leaf green vegetables. The traditional Chinese dietary pattern was characterized by a high intake of rice, red meats, fish, poultry, organ meats, and leafy green vegetables combined with a low intake of wheat, corn, coarse grain, and buns and breads. The high-starch plant-based dietary pattern was characterized by a high intake of legumes, other vegetables, starch vegetables, orange-red vegetables, fruits and fresh juices, and preserved vegetables combined with a low intake of leafy green vegetables, cruciferous vegetables, and wheat products.

Table 5. Factor loadings[a] for food groups of the three dietary patterns

Food group	Westernized dietary pattern	Traditional Chinese dietary pattern	High-starch plant-based dietary pattern
High-fat dairy products	0.46	0.21	
Fruits and fresh juices	0.45	0.21	0.24
Buns and breads	0.43	-0.25	
Instant foods	0.42		
Eggs and its products	0.42		
Sweets and Snacks	0.36		
Deep-fried products	0.34		
Low-fat dairy products	0.33		
Coarse grain	0.28	-0.27	
Western-style fast foods	0.25		
Nuts and seeds	0.25		
Sugar-sweetened beverages	0.23		
Legumes			
Coffee and tea			
Preserved fruit			
Preserved vegetables	-0.26		0.21
Animal oils	-0.34		
Rice and its products	-0.58	0.53	
Red meats		0.51	
Fish and seafood		0.47	
Poultry		0.38	
Organ meats		0.24	
Alcoholic beverages			
Others			
Corn and its products		-0.43	

Table 5. Factor loadings[a] for food groups of the three dietary patterns (*continued*)

Food group	Westernized dietary pattern	Traditional Chinese dietary pattern	High-starch plant-based dietary pattern
Wheat and its products		-0.61	-0.20
Legumes			0.61
Other vegetables			0.55
Starch vegetable			0.46
Orange-red vegetables			0.27
Vegetable oils			
Processed meats			
Condiments and spice			
Cruciferous vegetables			-0.23
Leafy green vegetables	-0.21	0.21	-0.48
% of variability explained	6.66	5.74	4.20

[a]Factor loadings that were −0.20 and +0.20 are not shown for simplicity.

2. General characteristics of the study participants

The mean (± SD) age of the 6,677 participants was 43.11 ± 11.84 years. Their mean average weight change per 5 years was +1.15 kg. A total of 1,326 new cases of obesity were documented during a mean of 8.62 years (42276.55 person-years) of follow-up. As shown in Table 6, we found increasing levels of weight, BMI, leisure physical activity, and household income with increasing scores of the Westernized dietary pattern. Higher proportion of participants with high Westernized dietary pattern scores lived in the Northern region and had higher levels of urbanization and education compared to those with lower scores. Higher protein and fat percent energy intake were observed in participants with high Westernized dietary pattern scores compared to those with lower scores. Participants with high traditional Chinese dietary pattern scores tended to have higher levels of leisure physical activity, household income compared to those with lower scores. Contrary to the Westernized dietary pattern, a high proportion of participants who followed traditional Chinese dietary patterns lived in the Southern region. Higher levels of urbanization and education were observed in participants with high traditional Chinese dietary pattern scores. Participants in the highest quintile of traditional Chinese dietary pattern scores tended to consume a lower percent energy intake from carbohydrates, but higher percent energy intake from protein compared to those in the lowest quintile. For the high-starch plant-based dietary pattern, participants with high high-starch plant-based dietary pattern scores tended to live in the Northern region and engage in leisure physical activity.

Table 6. Baseline characteristics according to quintiles of dietary patterns in men and women combined

	Westernized dietary pattern			Traditional Chinese dietary pattern			High-starch plant-based dietary pattern		
	Quintile 1	**Quintile 3**	**Quintile 5**	**Quintile 1**	**Quintile 3**	**Quintile 5**	**Quintile 1**	**Quintile 3**	**Quintile 5**
No. of participants	1335	1335	1335	1335	1335	1335	1335	1335	1335
Baseline age (y)	43.26±11.52	42.54±11.56	43.61±12.45	43.26±11.52	42.54±11.56	43.61±12.45	43.19±11.79	42.95±12.09	43.17±11.64
Baseline weight (kg)	55.26±9.21	61.31±10.33	65.44±12.33	55.26±9.21	61.31±10.33	65.44±12.33	59.59±11.17	60.85±11.38	61.63±11.33
Baseline BMI (kg/m^2)	22.11±2.88	23.39±3.27	24.00±3.63	22.11±2.88	23.39±3.27	24.00±3.63	22.96±3.27	23.32±3.44	23.31±3.35
Leisure physical activity (MET-h/wk)	1.65±8.16	4.80±16.30	12.34±28.64	1.65±8.16	4.80±16.30	12.34±28.64	4.96±19.78	6.34±18.92	6.88±22.47
Alcohol drinking (g/day)	8.19±22.28	9.15±23.97	9.14±23.79	8.19±22.28	9.15±23.97	9.14±23.79	9.49±24.48	7.70±21.77	10.69±25.64
Household income per capita (1,000 RMB) [a]	5.40±6.33	9.38±10.72	18.92±18.91	5.40±6.33	9.38±10.72	18.92±18.91	8.47±11.38	11.72±13.45	10.86±12.79
Area[b]									
North	226 (16.9)	550 (41.2)	896 (67.1)	226 (16.9)	550 (41.2)	896 (67.1)	460 (34.5)	493 (36.9)	809 (60.6)
South	1109 (83.1)	785 (58.8)	439 (32.9)	1109 (83.1)	785 (58.8)	439 (32.9)	875 (65.5)	842 (63.1)	526 (39.4)
Urbanization index[c]									
Low	662 (49.6)	322 (24.1)	80 (6.0)	662 (49.6)	322 (24.1)	80 (6.0)	492 (36.9)	265 (19.9)	409 (30.6)
Median	517 (38.7)	425 (31.8)	237 (17.8)	517 (38.7)	425 (31.8)	237 (17.8)	452 (33.9)	395 (29.6)	393 (29.4)
High	156 (11.7)	588 (44.0)	1018 (76.3)	156 (11.7)	588 (44.0)	1018 (76.3)	391 (29.3)	675 (50.6)	533 (39.9)
Education level[d]									
Illiteracy	410 (30.7)	211 (15.8)	68 (5.1)	410 (30.7)	211 (15.8)	68 (5.1)	316 (23.7)	198 (14.8)	217 (16.3)
Primary or junior high school	760 (56.9)	714 (53.5)	454 (34.0)	760 (56.9)	714 (53.5)	454 (34.0)	679 (50.9)	626 (46.9)	686 (51.4)
High school or vocational-technical school	123 (9.2)	297 (22.2)	494 (37.0)	123 (9.2)	297 (22.2)	494 (37.0)	250 (18.7)	344 (25.8)	288 (21.6)
Some college or above	14 (1.0)	97 (7.3)	312 (23.4)	14 (1.0)	97 (7.3)	312 (23.4)	67 (5.0)	153 (11.5)	133 (10.0)

Table 6. Baseline characteristics according to quintiles of dietary patterns in men and women combined (*continued*)

	Westernized dietary pattern			Traditional Chinese dietary pattern			High-starch plant-based dietary pattern		
	Quintile 1	**Quintile 3**	**Quintile 5**	**Quintile 1**	**Quintile 3**	**Quintile 5**	**Quintile 1**	**Quintile 3**	**Quintile 5**
Smoking status[d]									
Non-smoker	940 (70.4)	926 (69.4)	962 (72.1)	924 (69.2)	990 (74.2)	864 (64.7)	928 (69.5)	962 (72.1)	910 (68.2)
Former smoker	14 (1.0)	24 (1.8)	34 (2.5)	14 (1.0)	20 (1.5)	30 (2.2)	18 (1.3)	32 (2.4)	30 (2.2)
Current smoker	371 (27.8)	379 (28.4)	336 (25.2)	385 (28.8)	317 (23.7)	435 (32.6)	376 (28.2)	337 (25.2)	392 (29.4)
Daily nutrient intake									
Energy intake (kcal/d)	2189±695.4	2057±674.1	2141±650.9	2252±655.4	1912±612.1	2308±685.5	2295±669.0	1959±637.4	2241±673.8
Carbohydrate intake (% of energy intake)	63.88±12.34	54.84±13.14	48.99±10.86	63.97±10.63	55.74±12.58	47.71±12.39	58.25±13.72	54.08±13.14	57.54±12.55
Protein intake (% of energy intake)	11.37±2.59	13.07±3.15	14.92±3.68	12.09±2.17	12.90±3.36	15.07±3.82	12.78±2.96	13.41±3.63	12.85±3.39
Fat intake (% of energy intake)	24.31±12.11	31.27±12.62	35.10±10.47	23.41±10.51	30.80±12.14	36.11±11.66	27.96±12.56	31.80±12.26	28.78±11.71

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); MET-h, metabolic task equivalent-hours; RMB, Ren Min Bi
Values are mean±SD for continuous variable and % for categorical variables.
[a]Total net household income inflated to 2015.
[b]North region (Beijing, Liaoning, Heilongjiang, Shandong, Henan); South region (Shanghai, Jiangsu, Hubei, Hunan, Guangxi, Guizhou, Chongqing).
[c]Urbanization index was developed by Jones-Smith and Popkin, including 12 components to capture community-level physical, social, cultural, and economic environments.
[d]A few participants did not have data on these variables.

3. Associations between dietary patterns and obesity

The associations between each dietary pattern and obesity incidence in the men and women combined are shown in Table 7. An increase in the Westernized dietary pattern score was significantly associated with an increased risk of obesity with multivariate adjustments for lifestyle factors, sex, age, and energy intake. RR (95%CI) comparing the top and bottom quintiles was 2.13 (1.78-2.56; P for trend < 0.001), which was slightly attenuated to 1.57 (1.26-1.95) after further adjusting for SES-related variables. A per one-unit score increase was associated with an 18% higher risk of obesity (RR, 1.18; 95%CI, 1.10-1.26). In contrast, we observed an inverse association between the traditional Chinese dietary pattern and obesity; RRs (95%CI) compared to the bottom quintile were 0.78 (0.66-0.92) for the 2nd quintile, 0.83 (0.69-0.98) for the 3rd quintile, 0.80 (0.66-0.96) for the 4th quintile, and 0.84 (0.70-1.01) for top quintile (P for trend = 0.045). RR (95%CI) for a per one-unit increase in traditional Chinese dietary pattern score was 0.95 (0.89-1.01). For the high-starch plant-based dietary pattern score, no significant association was observed.

Table 7. Relative risks (RRs) and 95% confidence intervals (95%CIs) of incident obesity (BMI ≥ 25kg/m^2) according to quintiles of dietary patterns in men and women combined

	Total population (n= 4,903)						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend[d]**	**Per one unit increase**
Westernized dietary pattern							
Person-years of follow up	11457.89	9552.61	8618.44	7216.31	5431.29		
Cases, No.	269	267	278	278	234		
Model 1[a]	1.00	1.24 (1.05-1.47)	1.47 (1.24-1.74)	1.83 (1.54-2.16)	2.14 (1.79-2.56)	<.001	1.30 (1.23-1.37)
Model 2[b]	1.00	1.25 (1.06-1.49)	1.47 (1.24-1.74)	1.83 (1.55-2.18)	2.13 (1.78-2.56)	<.001	1.30 (1.23-1.37)
Model 3[c]	1.00	1.15 (0.97-1.37)	1.25 (1.04-1.50)	1.48 (1.22-1.79)	1.57 (1.26-1.95)	<.001	1.18 (1.10-1.26)
Traditional Chinese dietary pattern							
Person-years of follow up	9265.07	8428.55	8543.22	8432.69	7607.03		
Cases, No.	343	257	254	236	236		
Model 1[a]	1.00	0.81 (0.69-0.95)	0.81 (0.68-0.95)	0.79 (0.67-0.93)	0.89 (0.76-1.05)	0.050	0.97 (0.92-1.02)
Model 2[b]	1.00	0.80 (0.68-0.94)	0.80 (0.68-0.94)	0.78 (0.66-0.92)	0.87 (0.74-1.03)	0.027	0.96 (0.91-1.01)
Model 3[c]	1.00	0.78 (0.66-0.92)	0.83 (0.69-0.98)	0.80 (0.66-0.96)	0.84 (0.70-1.01)	0.045	0.95 (0.89-1.01)
High-starch plant-based dietary pattern							
Person-years of follow up	10021.34	8185.79	7834.49	7797.53	8437.4		
Cases, No.	289	261	240	235	301		
Model 1[a]	1.00	1.10 (0.93-1.31)	1.05 (0.88-1.24)	1.00 (0.84-1.19)	1.14 (0.97-1.34)	0.249	1.00 (0.95-1.05)
Model 2[b]	1.00	1.10 (0.93-1.30)	1.04 (0.87-1.23)	0.99 (0.83-1.18)	1.14 (0.97-1.34)	0.262	1.00 (0.95-1.05)
Model 3[c]	1.00	1.02 (0.86-1.22)	0.93 (0.78-1.11)	0.89 (0.74-1.06)	1.03 (0.86-1.22)	0.964	0.98 (0.93-1.03)

Abbreviations: RR, relative risk; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), and alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day).

[c]Model 3 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <-30 and > 30 pack-years), alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

3.1. Associations between dietary patterns and obesity by sex

Table 8 presents RRs of incident obesity according to each dietary pattern score among men. In the Westernized dietary pattern, RR (95%CI) for the highest compared to the lowest quintile was 1.57 (1.14-2.17; P for trend = 0.001). RR (95%CI) per one-unit increment of the Westernized dietary pattern score was 1.19 (1.09-1.30). In the traditional Chinese dietary pattern, RRs (95%CI) compared to the bottom quintile were 0.90 (0.70-1.15) for the 2nd quintile, 0.74 (0.57-0.97) for the 3rd quintile, 0.74 (0.56-0.98) for the 4th quintile, and 0.82 (0.62-1.08) for top quintile (P for trend = 0.051). RR (95%CI) per one-unit increment of the traditional Chinese dietary pattern score was 0.93 (0.86-1.01). No significant association was observed for the high-starch plant-based dietary pattern in relation to obesity incidence; RR (95%CI) comparing the highest to the lowest quintile was 1.02 (0.78-1.33; P for trend = 0.940).

Table 9 shows RRs of incident obesity according to each dietary pattern score among women. In the Westernized dietary pattern, RRs (95%CIs) were 1.55 (1.14-2.11; P for trend = 0.004) for the highest compared to the lowest quintile, and 1.16 (1.05-1.28) per one-unit increment. The traditional Chinese dietary pattern had no significant association with obesity incidence; RR (95%CI) comparing the highest to the lowest quintile was 0.82 (0.63-1.05; P for trend = 0.233). In the high-starch plant-based dietary pattern, RR (95%CI) comparing the highest to the lowest quintile was 1.05 (0.83-1.32; P for trend = 0.792).

Table 8. Relative risks (RRs) and 95% confidence intervals (95%CIs) of incident obesity (BMI ≥ 25kg/m^2) according to quintiles of dietary patterns in men

	Men (n=2,132)						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend[d]**	**Per one unit increase**
Westernized dietary pattern							
Person-years of follow up	4976.04	4207.35	3795.49	3204.39	2404.27		
Cases. No.	117	108	115	134	125		
Model 1[a]	1.00	1.11 (0.85-1.45)	1.33 (1.03-1.72)	1.98 (1.54-2.54)	2.61 (2.01-3.38)	<.001	1.38 (1.29-1.47)
Model 2[b]	1.00	1.11 (0.85-1.45)	1.31 (1.01-1.70)	1.97 (1.53-2.54)	2.56 (1.97-3.34)	<.001	1.37 (1.28-1.47)
Model 3[c]	1.00	1.00 (0.76-1.31)	1.01 (0.76-1.34)	1.39 (1.04-1.86)	1.57 (1.14-2.17)	0.001	1.19 (1.09-1.30)
Traditional Chinese dietary pattern							
Person-years of follow up	4069.8	3547.34	3877.51	3703	3389.89		
Cases. No.	147	125	110	102	115		
Model 1[a]	1.00	0.98 (0.77-1.24)	0.80 (0.62-1.02)	0.81 (0.62-1.04)	1.04 (0.81-1.33)	0.513	1.01 (0.94-1.08)
Model 2[b]	1.00	0.95 (0.75-1.21)	0.78 (0.61-1.01)	0.78 (0.61-1.01)	0.99 (0.77-1.27)	0.335	0.99 (0.92-1.07)
Model 3[c]	1.00	0.90 (0.70-1.15)	0.74 (0.57-0.97)	0.74 (0.56-0.98)	0.82 (0.62-1.08)	0.051	0.93 (0.86-1.01)
High-starch plant-based dietary pattern							
Person-years of follow up	4472.52	3370.02	3542.05	3482.77	3720.19		
Cases. No.	128	119	112	114	126		
Model 1[a]	1.00	1.23 (0.95-1.58)	1.06 (0.82-1.37)	1.07 (0.83-1.39)	1.09 (0.85-1.40)	0.774	1.00 (0.93-1.07)
Model 2[b]	1.00	1.20 (0.93-1.55)	1.03 (0.80-1.34)	1.04 (0.80-1.34)	1.09 (0.85-1.39)	0.820	1.00 (0.93-1.07)
Model 3[c]	1.00	1.05 (0.81-1.37)	0.95 (0.73-1.23)	0.94 (0.72-1.22)	1.02 (0.78-1.33)	0.940	1.00 (0.92-1.08)

Abbreviations: RR, relative risk; CI, confidence interval.

[a]Model 1 was adjusted for age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), and alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day).

[c]Model 3 was adjusted for age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <-30 and > 30 pack-years), alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

Table 9. Relative risks (RRs) and 95% confidence intervals (95%CIs) of incident obesity (BMI ≥ 25kg/m^2) according to quintiles of dietary patterns in women

	Women (n=2,771)						
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend[d]	Per one unit increase
Westernized dietary pattern							
Person-years of follow up	6483.04	5353.2	4803.28	4054.95	2994.54		
Cases. No.	154	160	159	148	106		
Model 1[a]	1.00	1.34 (1.07-1.67)	1.53 (1.22-1.91)	1.72 (1.37-2.16)	1.73 (1.34-2.23)	<.001	1.21 (1.12-1.31)
Model 2[b]	1.00	1.35 (1.08-1.69)	1.54 (1.23-1.93)	1.73 (1.37-2.18)	1.74 (1.34-2.27)	<.001	1.22 (1.12-1.32)
Model 3[c]	1.00	1.27 (1.01-1.60)	1.39 (1.10-1.78)	1.57 (1.22-2.03)	1.55 (1.14-2.11)	0.004	1.16 (1.05-1.28)
Traditional Chinese dietary pattern							
Person-years of follow up	5144.9	4758.54	4852.7	4677.54	4255.33		
Cases. No.	198	134	132	144	119		
Model 1[a]	1.00	0.71 (0.57-0.89)	0.70 (0.56-0.87)	0.83 (0.67-1.03)	0.76 (0.61-0.96)	0.025	0.93 (0.87-1.00)
Model 2[b]	1.00	0.71 (0.57-0.89)	0.70 (0.56-0.88)	0.83 (0.67-1.04)	0.77 (0.61-0.97)	0.035	0.94 (0.87-1.01)
Model 3[c]	1.00	0.72 (0.57-0.92)	0.77 (0.61-0.99)	0.92 (0.72-1.16)	0.82 (0.63-1.05)	0.233	0.95 (0.87-1.03)
High-starch plant-based dietary pattern							
Person-years of follow up	5603.65	4755.9	4334.29	4214.66	4780.51		
Cases. No.	160	144	127	127	169		
Model 1[a]	1.00	1.07 (0.85-1.34)	1.03 (0.81-1.30)	1.02 (0.81-1.30)	1.14 (0.92-1.42)	0.284	1.01 (0.94-1.08)
Model 2[b]	1.00	1.07 (0.85-1.34)	1.03 (0.81-1.30)	1.03 (0.81-1.31)	1.15 (0.93-1.43)	0.254	1.01 (0.94-1.08)
Model 3[c]	1.00	1.02 (0.81-1.29)	0.95 (0.74-1.21)	0.95 (0.74-1.21)	1.05 (0.83-1.32)	0.792	0.98 (0.91-1.05)

Abbreviations: RR, relative risk; CI, confidence interval.

[a]Model 1 was adjusted for age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), and alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day).

[c]Model 3 was adjusted for age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <-30 and > 30 pack-years), alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

3.2. Subgroup analysis of dietary patterns and obesity

Results for stratified analysis in the men and women combined are presented in Table 10. A statistically significant interaction by age at baseline was observed for the association between Westernized dietary pattern and obesity risk. The association between the Westernized dietary pattern and obesity risk was more pronounced among young adults. Comparing top with bottom quintiles, the RRs (95%CIs) for obesity were 1.62 (95%CI, 1.18-2.23; P for trend < 0.001) among those aged < 42 years and 1.58 (95%CI, 1.16-2.14; P for trend < 0.001) among those aged ≥ 42 years.

Table 10. Relative risks (RRs) and 95% confidence intervals (95%CIs) of incident obesity (BMI ≥ 25kg/m²) according to quintiles of dietary patterns within subgroups in men and women combined

	Westernized dietary pattern						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend**	**P for interaction**
Age, years							0.037
< 42 years							
No. of cases / person-years	133 / 5272.65	138 / 4423.17	152 / 4676.44	148 / 3739.65	103 / 2622.21		
RR (95%CI)[a]	1.00	1.24 (0.96-1.58)	1.20 (0.93-1.55)	1.55 (1.18-2.03)	1.62 (1.18-2.23)	<.001	
≥ 42 years							
No. of cases / person-years	136 / 6185.24	129 / 5129.45	126 / 3942.01	130 / 3476.67	131 / 2809.08		
RR (95%CI)	1.00	1.10 (0.85-1.41)	1.30 (1.00-1.69)	1.46 (1.10-1.92)	1.58 (1.16-2.14)	<.001	
Region							0.917
North							
No. of cases / person-years	40 / 1490.17	69 / 2164.54	134 / 3716.16	192 / 4296.34	164 / 3770.64		
RR (95%CI)	1.00	1.18 (0.80-1.75)	1.37 (0.96-1.96)	1.66 (1.17-2.34)	1.55 (1.08-2.24)	0.015	
South							
No. of cases / person-years	229 / 9967.73	198 / 7388.07	144 / 4902.28	86 / 2919.98	70 / 1660.65		
RR (95%CI)	1.00	1.16 (0.95-1.41)	1.19 (0.95-1.49)	1.17 (0.88-1.54)	1.58 (1.14-2.20)	0.011	
	Traditional Chinese dietary pattern						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend**	**P for interaction**
Age, years							0.848
< 42 years							
No. of cases / person-years	191 / 4744.05	130 / 4284.96	116 / 4048.72	117 / 3888.33	120 / 3768.05		
RR (95%CI)	1.00	0.73 (0.57-0.93)	0.73 (0.57-0.94)	0.82 (0.63-1.07)	0.83 (0.64-1.08)	0.162	
≥ 42 years							
No. of cases / person-years	152 / 4521.01	127 / 4143.59	138 / 4494.5	119 / 4544.35	116 / 3838.98		
RR (95%CI)	1.00	0.85 (0.66-1.09)	0.94 (0.73-1.21)	0.78 (0.61-1.01)	0.83 (0.63-1.08)	0.122	
Region							0.881
North							
No. of cases / person-years	287 / 7189.9	147 / 4272.4	79 / 1963.96	49 / 1197.85	37 / 813.74		
RR (95%CI)	1.00	0.76 (0.62-0.94)	0.87 (0.67-1.13)	0.92 (0.67-1.26)	0.93 (0.65-1.34)	0.272	
South							
No. of cases / person-years	56 / 2075.17	110 / 4156.15	175 / 6579.26	187 / 7234.84	199 / 6793.29		
RR (95%CI)	1.00	0.97 (0.69-1.35)	0.99 (0.73-1.36)	0.96 (0.70-1.32)	1.02 (0.75-1.40)	0.799	

Table 10. Relative risks (RRs) and 95% confidence intervals (95%CIs) of incident obesity (BMI ≥ 25kg/m²) according to quintiles of dietary patterns within subgroups in men and women combined (continued)

	High-starch plant-based dietary pattern						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for Trend**	**P for interaction**
Age, years							0.582
< 42 years							
No. of cases / person-years	144 / 4551.15	123 / 3955.39	128 / 4134.38	116 / 3934.66	163 / 4158.54		
RR (95%CI)	1.00	0.95 (0.74-1.22)	0.90 (0.70-1.15)	0.86 (0.66-1.11)	1.10 (0.86-1.41)	0.437	
≥ 42 years							
No. of cases / person-years	145 / 5470.19	138 / 4230.39	112 / 3700.11	119 / 3862.87	138 / 4278.87		
RR (95%CI)	1.00	1.10 (0.86-1.40)	0.94 (0.73-1.22)	0.90 (0.70-1.16)	0.93 (0.72-1.19)	0.319	
Region							0.202
North							
No. of cases / person-years	114 / 3085.36	99 / 2270.1	96 / 2620.59	117 / 3149.65	173 / 4312.15		
RR (95%CI)	1.00	1.09 (0.82-1.45)	0.88 (0.66-1.18)	0.85 (0.65-1.13)	0.94 (0.73-1.21)	0.431	
South							
No. of cases / person-years	175 / 6935.98	162 / 5915.69	144 / 5213.91	118 / 4647.88	128 / 4125.26		
RR (95%CI)	1.00	1.02 (0.82-1.27)	0.98 (0.78-1.23)	0.93 (0.73-1.18)	1.10 (0.87-1.39)	0.638	

Abbreviations: RR, relative risk; CI, confidence interval.

[a]Models were adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile), except the corresponding subgroup variates.

3.3. Sensitivity analysis of dietary patterns and obesity

A similar association between the Westernized dietary pattern and obesity risk was observed when the analyses were repeated for the associations between dietary patterns and overweight or obesity (BMI $\geq$ 23 kg/m^2) (Table 11). An increase in the Westernized dietary pattern score was significantly associated with increasing risk of overweight or obesity [RR (95%CI) comparing the highest to the lowest quintile: 1.41 (1.15-1.73); P for trend = 0.001]. However, the association between the traditional Chinese dietary pattern and obesity risk did not persist.

Table 11. Relative risks (RRs) and 95% confidence intervals (95%CIs) of incident overweight or obesity (BMI ≥ 23kg/m^2) according to quintiles of dietary patterns in men and women combined

	Total population (n=3,503)						
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend[d]	Per one unit increase
Westernized dietary pattern							
Person-years of follow up	7197.02	6537.8	5618.15	4797.33	3666.94		
Cases. No.	308	305	301	287	273		
Model 1[a]	1.00	1.11 (0.95-1.30)	1.28 (1.09-1.50)	1.49 (1.27-1.76)	1.91 (1.62-2.26)	<.001	1.25 (1.19-1.32)
Model 2[b]	1.00	1.12 (0.96-1.31)	1.28 (1.09-1.50)	1.50 (1.27-1.77)	1.91 (1.61-2.26)	<.001	1.25 (1.19-1.32)
Model 3[c]	1.00	1.07 (0.91-1.26)	1.11 (0.93-1.31)	1.19 (0.99-1.43)	1.41 (1.15-1.73)	0.001	1.14 (1.07-1.21)
Traditional Chinese dietary pattern							
Person-years of follow up	5778.3	5786.44	5660.09	5560.73	5031.69		
Cases. No.	343	282	281	277	291		
Model 1[a]	1.00	0.79 (0.67-0.92)	0.82 (0.70-0.96)	0.86 (0.74-1.01)	1.01 (0.87-1.19)	0.890	1.01 (0.96-1.06)
Model 2[b]	1.00	0.78 (0.67-0.92)	0.81 (0.69-0.95)	0.85 (0.72-1.00)	1.00 (0.86-1.18)	0.759	1.00 (0.95-1.06)
Model 3[c]	1.00	0.81 (0.68-0.95)	0.89 (0.75-1.06)	0.94 (0.79-1.12)	1.04 (0.87-1.24)	0.618	1.01 (0.96-1.07)
High-starch plant-based dietary pattern							
Person-years of follow up	6579.42	5360.66	5156.91	5130.65	5589.61		
Cases. No.	312	279	294	271	318		
Model 1[a]	1.00	1.07 (0.91-1.26)	1.15 (0.98-1.35)	1.03 (0.88-1.22)	1.10 (0.94-1.28)	0.390	1.00 (0.95-1.05)
Model 2[b]	1.00	1.07 (0.91-1.26)	1.14 (0.97-1.34)	1.02 (0.86-1.20)	1.09 (0.93-1.28)	0.426	1.00 (0.95-1.05)
Model 3[c]	1.00	1.05 (0.88-1.23)	1.07 (0.91-1.27)	0.96 (0.81-1.14)	1.03 (0.87-1.22)	0.983	0.98 (0.94-1.04)

Abbreviations: RR, relative risk; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), and alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day).

[c]Model 3 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking (0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

4. Associations between dietary patterns and weight change

The average 5-year weight change (in kg) according to adherence to each dietary pattern is shown in Table 12. After adjustment for potential confounders, increasing Westernized dietary pattern scores were associated with increased levels of weight gain. LS-means (95%CIs) of the lowest and the highest quintiles of the westernized dietary pattern scores for average body weight change(kg) over 5 years were 1.13 (0.39-1.87) and 1.73 (0.98-2.47); P for trend = 0.036). In contrast, no significant associations were observed in the traditional Chinese dietary pattern or the high-starch plant-based dietary pattern.

Table 12. Least-squares means (LS-means) and 95% confidence intervals (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns in men and women combined

	Total population (n= 6,677)					
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend[d]
Westernized dietary pattern						
Weight change, median (kg/5 years)	1.03	1.07	0.98	1.02	0.88	
Model 1[a]	1.39 (0.98-1.81)	0.90 (0.49-1.31)	1.22 (0.81-1.63)	1.43 (1.02-1.84)	0.88 (0.47-1.29)	0.312
Model 2[b]	2.06 (1.30-2.82)	1.64 (0.91-2.37)	2.08 (1.35-2.82)	2.33 (1.59-3.08)	1.76 (1.00-2.53)	0.776
Model 3[c]	1.13 (0.39-1.87)	1.01 (0.30-1.72)	1.73 (1.02-2.44)	2.04 (1.32-2.76)	1.73 (0.98-2.47)	0.036
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	1.11	0.99	0.91	0.99	1.02	
Model 1[a]	1.21 (0.80-1.62)	1.39 (0.98-1.81)	0.99 (0.58-1.41)	1.06 (0.65-1.47)	1.17 (0.75-1.58)	0.572
Model 2[b]	2.05 (1.30-2.80)	2.16 (1.42-2.90)	1.75 (1.02-2.48)	1.86 (1.12-2.60)	2.01 (1.27-2.75)	0.629
Model 3[c]	1.85 (1.13-2.58)	1.76 (1.04-2.47)	1.18 (0.47-1.89)	1.20 (0.48-1.91)	1.55 (0.84-2.27)	0.109
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	0.9	0.84	1.15	1.06	1.05	
Model 1[a]	0.93 (0.52-1.35)	0.94 (0.53-1.36)	1.16 (0.75-1.58)	1.51 (1.10-1.92)	1.27 (0.86-1.68)	0.092
Model 2[b]	1.70 (0.97-2.44)	1.78 (1.04-2.52)	1.97 (1.24-2.70)	2.32 (1.59-3.06)	2.00 (1.26-2.74)	0.163
Model 3[c]	1.34 (0.63-2.06)	1.33 (0.61-2.05)	1.52 (0.81-2.23)	1.76 (1.05-2.47)	1.57 (0.85-2.29)	0.255

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition to variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

4.1. Associations between dietary patterns and weight change by sex

Table 13 presents the LS-means of weight change (kg over 5 years) according to each dietary pattern score in men. In the Westernized dietary pattern, the LS-means (95%CIs) of the lowest and the highest quintiles of the scores for average body weight change(kg) over 5 years were 1.02 (-0.14-2.19) and 1.93 (0.74-3.11); P for trend = 0.059). There were no significant association in the traditional Chinese dietary pattern or the high-starch plant-based dietary pattern.

Table 14 presents the LS-means according to each dietary pattern score in women. There were no clear associations between dietary patterns and weight change.

Table 13. Least-squares means (LS-means) and 95% confidence intervals (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns in men

	Men (n=2,906)					
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend[d]**
Westernized dietary pattern						
Weight change, median (kg/5 years)	1.20	1.03	1.12	1.22	0.78	
Model 1[a]	1.75 (1.03-2.47)	0.98 (0.26-1.70)	1.36 (0.64-2.07)	1.90 (1.18-2.62)	0.54 (-0.18-1.25)	0.086
Model 2[b]	2.64 (1.42-3.86)	2.12 (0.93-3.30)	2.66 (1.47-3.86)	3.28 (2.09-4.48)	2.01 (0.75-3.26)	0.559
Model 3[c]	1.02 (-0.14-2.19)	0.94 (-0.19-2.06)	1.76 (0.62-2.89)	2.55 (1.42-3.68)	1.93 (0.74-3.11)	0.059
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	1.33	0.99	1.02	1.26	0.98	
Model 1[a]	1.58 (0.86-2.30)	1.71 (0.99-2.43)	0.52 (-0.20-1.24)	1.47 (0.75-2.19)	1.26 (0.53-1.98)	0.387
Model 2[b]	2.97 (1.76-4.19)	2.98 (1.80-4.16)	1.66 (0.47-2.85)	2.61 (1.42-3.80)	2.48 (1.28-3.68)	0.257
Model 3[c]	2.30 (1.16-3.45)	2.05 (0.94-3.17)	0.56 (-0.57-1.69)	1.36 (0.23-2.50)	1.67 (0.54-2.81)	0.087
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	1.00	0.99	1.25	1.16	1.22	
Model 1[a]	1.03 (0.31-1.76)	1.27 (0.55-1.99)	1.08 (0.36-1.80)	1.62 (0.90-2.34)	1.53 (0.81-2.25)	0.256
Model 2[b]	2.17 (1.00-3.35)	2.53 (1.32-3.75)	2.35 (1.17-3.54)	2.94 (1.76-4.11)	2.82 (1.61-4.04)	0.184
Model 3[c]	1.46 (0.35-2.58)	1.36 (0.20-2.51)	1.52 (0.40-2.64)	1.87 (0.76-2.99)	1.82 (0.66-2.97)	0.328

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition to variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

Table 14. Least-squares means (LS-means) and 95% confidence intervals (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns in women

	Women (n=3,771)					
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend[d]
Westernized dietary pattern						
Weight change, median (kg/5 years)	0.91	1.07	0.97	0.77	0.86	
Model 1[a]	1.11 (0.63-1.58)	0.92 (0.45-1.39)	1.15 (0.68-1.62)	0.92 (0.45-1.39)	1.05 (0.58-1.52)	0.909
Model 2[b]	0.71 (-0.86-2.27)	0.50 (-1.04-2.04)	0.78 (-0.76-2.32)	0.53 (-1.01-2.07)	0.49 (-1.06-2.04)	0.631
Model 3[c]	-0.29 (-1.85-1.26)	-0.37 (-1.89-1.16)	0.17 (-1.35-1.69)	-0.03 (-1.56-1.49)	-0.02 (-1.55-1.51)	0.504
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	0.98	1.00	0.81	0.88	0.98	
Model 1[a]	0.90 (0.43-1.37)	1.13 (0.66-1.60)	1.01 (0.54-1.48)	1.00 (0.53-1.46)	1.10 (0.63-1.57)	0.673
Model 2[b]	0.34 (-1.21-1.90)	0.55 (-0.99-2.10)	0.56 (-0.97-2.09)	0.61 (-0.93-2.14)	0.78 (-0.76-2.32)	0.253
Model 3[c]	-0.13 (-1.67-1.41)	-0.06 (-1.59-1.47)	-0.17 (-1.69-1.34)	-0.19 (-1.71-1.33)	0.09 (-1.44-1.61)	0.690
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	0.76	0.91	1.10	0.98	0.98	
Model 1[a]	0.76 (0.29-1.23)	0.80 (0.33-1.27)	1.10 (0.63-1.58)	1.30 (0.83-1.77)	1.17 (0.70-1.64)	0.109
Model 2[b]	0.34 (-1.21-1.89)	0.40 (-1.15-1.95)	0.62 (-0.91-2.16)	0.82 (-0.71-2.34)	0.55 (-0.99-2.09)	0.385
Model 3[c]	-0.32 (-1.85-1.21)	-0.23 (-1.77-1.30)	-0.07 (-1.59-1.45)	0.09 (-1.42-1.60)	-0.10 (-1.62-1.43)	0.405

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition to variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

4.2. Subgroup analysis of dietary patterns and weight change

Analyses of the associations between dietary patterns and average 5-year weight change (in kg) stratified by age at enrollment and residence are shown in Table 15. There was significant effect modification of the association in the Westernized dietary pattern by residence (North, South) (P for interaction = 0.049). In the Southern region, where the urbanization index is higher than that in the Northern region in this study, there was a more pronounced association between the Westernized dietary pattern and weight gain (P for trend < 0.001) compared to the Northern region. When stratified by age, the association between the Westernized dietary pattern and weight gain was limited to young adults, but the interaction was not statistically significant.

Table 15. Least-squares means (LS-means) and 95% confidence intervals (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns within subgroups in men and women combined

	Westernized dietary pattern						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend**	**P for interaction**
Age, years							0.767
< 42 years							
N	587	616	636	622	572		
LS-mean (95%CI)[a]	2.63 (1.28-3.97)	2.57 (1.26-3.88)	2.81 (1.50-4.12)	3.82 (2.50-5.13)	3.57 (2.19-4.95)	0.015	
≥ 42 years							
N	748	720	699	714	763		
LS-mean (95%CI)	0.25 (-0.87-1.36)	0.02 (-1.07-1.10)	1.18 (0.08-2.29)	0.80 (-0.30-1.91)	0.48 (-0.64-1.61)	0.612	
Region							0.049
North							
N	226	348	550	793	896		
LS-mean (95%CI)	0.62 (-0.95-2.20)	0.78 (-0.63-2.19)	1.30 (-0.01-2.60)	1.14 (-0.11-2.38)	0.50 (-0.74-1.74)	0.400	
South							
N	1109	988	785	543	439		
LS-mean (95%CI)	1.48 (0.68-2.28)	1.37 (0.58-2.15)	2.00 (1.17-2.82)	2.50 (1.62-3.39)	2.86 (1.90-3.81)	<.001	
	Traditional Chinese dietary pattern						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend**	**P for interaction**
Age, years							0.650
< 42 years							
N	648	615	607	586	577		
LS-mean (95%CI)	3.36 (2.03-4.70)	3.15 (1.83-4.47)	2.72 (1.41-4.02)	3.00 (1.67-4.34)	3.03 (1.71-4.36)	0.388	
≥ 42 years							
N	687	721	728	750	758		
LS-mean (95%CI)	0.82 (-0.30-1.95)	0.86 (-0.24-1.95)	0.16 (-0.92-1.24)	0.09 (-1.01-1.18)	0.64 (-0.46-1.74)	0.297	
Region							0.400
North							
N	1133	794	421	277	188		
LS-mean (95%CI)	0.88 (-0.32-2.08)	1.30 (0.07-2.54)	0.29 (-1.07-1.65)	0.19 (-1.28-1.66)	1.34 (-0.30-2.98)	0.655	
South							
N	202	542	914	1059	1147		
LS-mean (95%CI)	1.79 (0.63-2.96)	1.76 (0.88-2.64)	1.75 (0.96-2.54)	1.82 (1.03-2.60)	2.05 (1.28-2.83)	0.379	

Table 15. Least-squares means (LS-means) and 95% confidence intervals (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns within subgroups in men and women combined (continued)

	High-starch plant-based dietary pattern						
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for Trend**	**P for interaction**
Age, years							0.487
< 42 years							
N	586	606	619	603	619		
LS-mean (95%CI)	2.81 (1.48-4.14)	2.56 (1.25-3.87)	3.32 (2.01-4.63)	3.1 (1.78-4.43)	3.42 (2.10-4.74)	0.090	
≥ 42 years							
N	749	730	716	733	716		
LS-mean (95%CI)	0.38 (-0.72-1.47)	0.61 (-0.49-1.72)	0.28 (-0.81-1.38)	0.89 (-0.18-1.97)	0.26 (-0.84-1.36)	0.921	
Region							0.738
North							
N	460	409	493	642	809		
LS-mean (95%CI)	0.72 (-0.62-2.06)	0.32 (-1.06-1.70)	0.55 (-0.78-1.88)	1.54 (0.27-2.80)	0.77 (-0.46-2.00)	0.486	
South							
N	875	927	842	694	526		
LS-mean (95%CI)	1.61 (0.81-2.41)	1.91 (1.12-2.71)	2.07 (1.28-2.87)	1.69 (0.86-2.51)	2.12 (1.24-3.00)	0.280	

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Models were adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB) urbanization index (tertile), and baseline body weight (continuous, kg), except the corresponding subgroup variates.

4.3. Sensitivity analysis of dietary patterns and weight change

In four sensitivity analyses in which we 1) censored the data at age 65 years during the follow-up, 2) excluded participants whose baseline BMIs were > 30 kg/m^2, 3) excluded participants whose follow-up periods were less than three years, or 4) participants who were in the 1^{st} or 99^{th} percentile of weight change (Table 16-19), the point estimates were in the same direction as the estimates observed in the main analysis.

Table 16. LS-means (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary pattern in men and women combined, after censoring age of 65 year

	Total population (n= 6,340)					
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend[d]**
Westernized dietary pattern						
Weight change, median (kg/5 years)	1.07	1.17	1.01	1.09	0.98	
Model 1[a]	1.44 (1.02-1.87)	0.98 (0.55-1.41)	1.32 (0.89-1.75)	1.47 (1.04-1.89)	0.93 (0.51-1.36)	0.290
Model 2[b]	2.12 (1.32-2.92)	1.73 (0.96-2.50)	2.18 (1.41-2.96)	2.37 (1.59-3.15)	1.82 (1.01-2.64)	0.733
Model 3[c]	1.21 (0.43-1.98)	1.09 (0.34-1.84)	1.84 (1.09-2.59)	2.12 (1.36-2.87)	1.83 (1.05-2.62)	0.038
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	1.19	1.03	0.99	1.04	1.08	
Model 1[a]	1.27 (0.84-1.70)	1.43 (1.00-1.86)	1.06 (0.63-1.49)	1.14 (0.72-1.57)	1.25 (0.82-1.68)	0.673
Model 2[b]	2.11 (1.31-2.90)	2.22 (1.44-2.99)	1.82 (1.06-2.59)	1.96 (1.18-2.74)	2.10 (1.32-2.87)	0.749
Model 3[c]	1.93 (1.17-2.70)	1.84 (1.08-2.59)	1.26 (0.51-2.00)	1.29 (0.54-2.05)	1.67 (0.91-2.42)	0.155
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	0.99	0.92	1.22	1.16	1.08	
Model 1[a]	1.04 (0.61-1.47)	0.99 (0.57-1.42)	1.23 (0.80-1.66)	1.56 (1.13-1.99)	1.32 (0.89-1.75)	0.149
Model 2[b]	1.82 (1.04-2.59)	1.85 (1.07-2.62)	2.06 (1.28-2.83)	2.39 (1.62-3.16)	2.06 (1.28-2.84)	0.227
Model 3[c]	1.47 (0.71-2.22)	1.40 (0.65-2.16)	1.62 (0.87-2.37)	1.84 (1.09-2.59)	1.64 (0.88-2.39)	0.348

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition to variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

Table 17. LS-means (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns in men and women combined, after excluding participants who reported BMI ≥ 30 kg/m^2 at baseline

	Total population (n=6,461)					
	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**	**P for trend[d]**
Westernized dietary pattern						
Weight change, median (kg/5 years)	1.07	1.12	1.00	1.11	0.99	
Model 1[a]	1.47 (1.09-1.84)	1.23 (0.86-1.61)	1.28 (0.91-1.66)	1.64 (1.27-2.02)	1.33 (0.96-1.70)	0.926
Model 2[b]	2.07 (1.37-2.76)	1.81 (1.15-2.48)	1.88 (1.21-2.54)	2.24 (1.56-2.91)	1.80 (1.11-2.50)	0.734
Model 3[c]	1.62 (0.93-2.31)	1.50 (0.84-2.16)	1.73 (1.07-2.39)	2.13 (1.46-2.80)	1.79 (1.11-2.48)	0.353
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	1.14	1.08	0.99	1.00	1.04	
Model 1[a]	1.31 (0.94-1.69)	1.62 (1.24-1.99)	1.38 (1.00-1.75)	1.37 (1.00-1.74)	1.28 (0.91-1.66)	0.719
Model 2[b]	1.90 (1.22-2.58)	2.13 (1.46-2.81)	1.92 (1.26-2.58)	1.95 (1.28-2.62)	1.86 (1.19-2.53)	0.771
Model 3[c]	1.86 (1.19-2.54)	1.97 (1.31-2.64)	1.62 (0.96-2.28)	1.63 (0.97-2.30)	1.65 (0.99-2.31)	0.285
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	0.91	0.98	1.21	1.14	1.10	
Model 1[a]	1.12 (0.74-1.50)	1.15 (0.78-1.52)	1.43 (1.06-1.81)	1.73 (1.36-2.11)	1.52 (1.14-1.89)	0.039
Model 2[b]	1.72 (1.05-2.38)	1.77 (1.10-2.44)	1.99 (1.33-2.66)	2.28 (1.62-2.94)	1.97 (1.30-2.64)	0.174
Model 3[c]	1.57 (0.91-2.24)	1.56 (0.90-2.23)	1.78 (1.12-2.44)	2.01 (1.36-2.67)	1.77 (1.10-2.43)	0.265

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition to variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

Table 18. LS-means (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns in men and women combined, after excluding participants with less than 3 years of follow-up

	Total population (n=6,188)					
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend[d]
Westernized dietary pattern						
Weight change, median (kg/5 years)	1.05	1.05	1.00	1.02	0.92	
Model 1[a]	1.38 (1.01-1.75)	0.86 (0.49-1.23)	1.09 (0.72-1.46)	1.44 (1.07-1.81)	0.98 (0.61-1.35)	0.569
Model 2[b]	2.32 (1.63-3.01)	1.91 (1.25-2.57)	2.27 (1.61-2.93)	2.73 (2.06-3.40)	2.30 (1.60-3.00)	0.487
Model 3[c]	1.43 (0.77-2.09)	1.28 (0.65-1.91)	1.91 (1.28-2.55)	2.43 (1.79-3.07)	2.25 (1.59-2.92)	0.001
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	1.07	1.00	0.96	0.99	1.08	
Model 1[a]	1.15 (0.77-1.52)	1.25 (0.88-1.63)	1.08 (0.70-1.45)	1.08 (0.71-1.45)	1.19 (0.81-1.56)	0.920
Model 2[b]	2.34 (1.66-3.03)	2.40 (1.73-3.07)	2.17 (1.50-2.83)	2.18 (1.52-2.85)	2.32 (1.65-2.99)	0.726
Model 3[c]	2.14 (1.48-2.79)	1.98 (1.34-2.62)	1.61 (0.97-2.24)	1.54 (0.90-2.18)	1.91 (1.27-2.55)	0.169
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	0.93	0.86	1.17	1.01	1.08	
Model 1[a]	1.05 (0.68-1.43)	0.98 (0.61-1.35)	1.13 (0.76-1.50)	1.21 (0.84-1.58)	1.37 (1.00-1.74)	0.148
Model 2[b]	2.13 (1.46-2.80)	2.15 (1.48-2.82)	2.26 (1.60-2.92)	2.36 (1.70-3.03)	2.49 (1.82-3.16)	0.146
Model 3[c]	1.79 (1.15-2.43)	1.68 (1.04-2.32)	1.83 (1.20-2.46)	1.80 (1.16-2.43)	2.06 (1.42-2.71)	0.242

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated to 2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition to variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

Table 19. LS-means (95%CIs) of average body weight change(kg) over 5 years according to quintiles of dietary patterns in men and women combined, after excluding the 1st and 99th percentiles of weight change

	Total population (n= 6,544)					
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend[d]
Westernized dietary pattern						
Weight change, median (kg/5 years)	1.04	1.03	0.99	1.01	0.92	
Model 1[a]	1.29 (1.05-1.54)	1.13 (0.88-1.37)	0.95 (0.70-1.19)	1.19 (0.94-1.43)	1.24 (0.99-1.48)	0.872
Model 2[b]	1.74 (1.29-2.20)	1.62 (1.19-2.06)	1.49 (1.05-1.93)	1.79 (1.34-2.23)	1.86 (1.41-2.32)	0.268
Model 3[c]	1.37 (0.92-1.82)	1.36 (0.92-1.79)	1.37 (0.93-1.80)	1.70 (1.26-2.13)	1.85 (1.40-2.30)	0.006
Traditional Chinese dietary pattern						
Weight change, median (kg/5 years)	1.12	0.99	0.92	1	1.01	
Model 1[a]	1.22 (0.97-1.46)	1.16 (0.91-1.41)	1.16 (0.91-1.41)	1.13 (0.88-1.37)	1.13 (0.88-1.38)	0.594
Model 2[b]	1.71 (1.26-2.16)	1.69 (1.25-2.14)	1.70 (1.27-2.14)	1.69 (1.25-2.14)	1.71 (1.27-2.15)	0.996
Model 3[c]	1.66 (1.22-2.10)	1.54 (1.11-1.98)	1.46 (1.03-1.89)	1.43 (0.99-1.87)	1.55 (1.11-1.98)	0.413
High-starch plant-based dietary pattern						
Weight change, median (kg/5 years)	0.90	0.91	1.13	1.07	1.03	
Model 1[a]	1.03 (0.78-1.27)	1.03 (0.79-1.28)	1.17 (0.92-1.41)	1.28 (1.04-1.53)	1.29 (1.04-1.53)	0.062
Model 2[b]	1.51 (1.07-1.95)	1.59 (1.15-2.03)	1.72 (1.28-2.15)	1.85 (1.42-2.29)	1.82 (1.38-2.26)	0.050
Model 3[c]	1.38 (0.94-1.81)	1.42 (0.99-1.86)	1.54 (1.11-1.98)	1.64 (1.21-2.07)	1.66 (1.22-2.09)	0.076

Abbreviations: LS-mean, least-squares mean; CI, confidence interval.

[a]Model 1 was adjusted for sex (male, female), age (continuous, years), and energy intake (continuous, kcal/d).

[b]Model 2 was adjusted for sex (male, female), age (continuous, years), energy intake (continuous, kcal/d), physical activity (0, 0 <- 18, 18 <- 36, and > 36 MET-h/wk), smoking status (0, 0 <- 10, 10 <- 20, 20 <- 30 and > 30 pack-years), alcohol drinking(0, 0 <- 6, 6 <- 12, 12 <- 24, and > 24 g/day), region (Northern region, Eastern region, Western region, and Central region), education level (illiteracy, primary school, junior high school, and high school or higher), marital status (never married, married, and divorced), household income per capita inflated-2015 (tertile, RMB), and urbanization index (tertile).

[c]Model 3 was additionally adjusted for baseline body weight (continuous, kg) in addition-variables in Model 2.

[d]P for trend was calculated using the median value of each quintile category as a continuous variable.

V. Discussion

In the CHNS cohort study, we identified three major dietary patterns; Westernized dietary pattern, traditional Chinese dietary pattern, and high-starch plant-based dietary pattern. Individuals who scored high on the Westernized dietary pattern ate more high-fat dairy products, fruits and fresh juices, buns and breads, instant foods, eggs, sweets and snacks, deep-fried products, coarse grain, Western-style fast foods, nuts and seeds, and sugar-sweetened beverages. In general, participants living in the Northern region were more likely to adopt this pattern. However, individuals who had high traditional Chinese dietary pattern scores tended to eat more rice, red meats, fish, poultry, organ meats, and leafy green vegetables. The traditional Chinese dietary pattern was more commonly observed in individuals who were living in the Southern region than those in the Northern region. Individuals who had high scores on high-starch plant-based dietary pattern ate more legumes, other vegetables, starch vegetables, orange-red vegetables, fruits and fresh juices, and preserved vegetables.

The key findings of our study are as follows; 1) the Westernized dietary pattern was associated with increased obesity risk as well as body weight gain, and this association was more pronounced among individuals in the Southern region compared to those in the Northern region; 2) However, the traditional Chinese dietary pattern was marginally associated with a lower obesity risk; 3) No association was observed in the high-starch plant-based dietary pattern.

The similar dietary patterns identified in our study were observed among previous studies in Chinese adults (Shi et al., 2011; Wang et al., 2011). In a nationally representative cross-sectional study (2002 CNNHS) (Wang et al., 2011), the three food patterns ‘Yellow Earth’, ‘Green water’, ‘Newly Affluent’, and ‘Western Adopters’ were identified by a validated semi-quantitative food frequency questionnaire. Our traditional Chinese dietary pattern was similar to the ‘Green water’ dietary pattern, a typical traditional diet in South China, in which rice is a staple food. Westernized dietary pattern in our study resembled a combination of the ‘Yellow Earth’ dietary pattern (a typical traditional diet in North China, in which wheat products are a staple food) and the ‘Western Adopters’ pattern (high in beef, lamb, dairy products, soft beverage, cake, and juice), which represents a rapid eating behavior transition from the traditional diet to a Western diet over the last few decades (Wang et al., 2008). In the Jiangsu Nutrition Study (Shi et al., 2011), the vegetable-rich pattern (high in whole grains, root vegetables, and fresh and pickled vegetables) was similar to the starch-rich vegetable-based dietary pattern in our study.

Our findings for the Westernized dietary pattern were consistent with a recent meta-analysis study that showed a 65% increased risk for obesity associated with the Western dietary pattern (high loading of red /processed meat, refined grains, potatoes, sweets, and high-fat dairy) (Mu et al., 2017). In addition, several Chinese population studies (Li & Shi, 2017; Liu et al., 2019; Sun et al., 2014; Xu et al., 2016; Yu et al., 2015; Zhen et al., 2018) reported that a Western-style dietary pattern characterized by high intakes of fast foods, sugary beverages, and desserts was associated with an increased risk of obesity. However, most of these studies were cross-sectional and limited to a specific region. We found a suggestion of inverse association for the traditional Chinese dietary pattern with obesity occurrence. Several cross-sectional studies (Liu et al., 2019; Sun et al.,

2014) and prospective studies (Xu et al., 2016; Zhen et al., 2018) in the Chinese population observed that a traditional dietary pattern was inversely associated with obesity risk. However, in the Chinese middle-aged and elderly populations lived in Shanghai (Yuan et al., 2016), a rice staple pattern (high intakes of rice, vegetables, pork, poultry, starchy roots/tubers, organ meats, processed meats, and seeds/nuts) was associated with an increased risk of obesity in men. We did not find a clear association between the traditional Chinese dietary pattern and 5-year weight gain. Further prospective studies are warranted to examine a long-term weight gain with the traditional Chinese dietary pattern.

Several potential mechanisms explain how the Westernized dietary pattern is associated with obesity risk and weight changes. The Westernized dietary pattern was characterized by a high intake of instant foods, sweets and snacks, deep-fried products, and Western-style fast foods which was shown to increase weight gain (Isganaitis & Lustig, 2005; Mozaffarian, Hao, Rimm, Willett, & Hu, 2011). The association between the Westernized dietary pattern and obesity as well as weight gain in the present study could be partly explained by higher intakes of fat with higher scores of the Westernized dietary pattern. Fat intake was the highest among participants in the highest quintile of the Westernized dietary pattern. A long-term Chinese study reported that high fat intake was positively associated with the risk of overweight and obesity (BMI $\geq$ 25 kg/m^2) because dietary fat intake is a contributor to positive energy balance (Wang, Wang, Zhang, Popkin, & Du, 2020).

We found that, in the Southern region, the Westernized dietary pattern was associated with weight gain to a greater extent than in the Northern region. Individuals in relatively affluent regions could have easier access to high-calorie foods (e.g., fast food and sweets) and maintain a sedentary lifestyle due to the increasing number of restaurants and motorized transportation. Our study suggests the need for region-specific dietary weight management strategies in China.

This study strengths include the use of a large nationwide sample of Chinese adults and a prospective follow-up design. We used three consecutive days of 24 h dietary recall methods to record dietary intake, which provided detailed food information. This study also has several limitations. First, because dietary information was based on a self-reported assessment at baseline, a non-differential misclassification of dietary intake was possible. Second, we did not examine changes in diet and obesity risk. Third, although we adjusted for the majority of known confounding variables in our model, residual or unknown confounding bias may still exist.

VI. Conclusion

In the conclusion, our findings provide evidence that the Westernized dietary pattern, which was characterized by high consumption of high-fat dairy products, fruits and fresh juices, buns and breads, instant foods, eggs, sweets and snacks, deep-fried products, and coarse grain, was associated with weight gain and risk of obesity among Chinese adults. There was a suggestion of inverse association for the traditional Chinese dietary pattern with obesity occurrence. This result showed that the focus of public health policy should shift toward replacing the nutrient-dense foods and beverages with healthy dietary choices.

Our results have also shown that the following of the Westernized dietary pattern may be related to the regional socioeconomic status, and the Westernized dietary pattern was associated with weight gain to a greater extent among participants living in the Southern region than in the Northern region. Our study supports the need of enhanced resources of dietary education programs and nutrition policies tailoring populations in the high SES regions. In other words, dietary weight management strategies may be effective when implemented in a region-specific way.

Bibliography

Abdullah, A., Stoelwinder, J., Shortreed, S., Wolfe, R., Stevenson, C., Walls, H., de Courten, M., & Peeters, A. (2011). The duration of obesity and the risk of type 2 diabetes. *Public Health Nutrition, 14*(1), 119-126.

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., O'Brien, W. L., Bassett, D. R., Schmitz, K. H., Emplaincourt, P. O., Jacobs, D. R., & Leon, A. S. (2000). Compendium of Physical Activities: an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise, 32*(9).

Aljadani, H., Patterson, A., Sibbritt, D., & Collins, C. (2013). The association between dietary patterns and weight change in adults over time: a systematic review of studies with follow up. *JBI Evidence Synthesis, 11*(8), 272-316.

Chan, R., Chan, D., Lau, W., Lo, D., Li, L., & Woo, J. (2014). A Cross-sectional Study to Examine the Association Between Dietary Patterns and Risk of Overweight and Obesity in Hong Kong Chinese Adolescents Aged 10–12 Years. *Journal of the American College of Nutrition, 33*(6), 450-458.

Du, S., Lu, B., Zhai, F., & Popkin, B. M. (2002). A new stage of the nutrition transition in China. *Public Health Nutrition, 5*(1a), 169-174.

Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., Singh, G. M., Gutierrez, H. R., Lu, Y., Bahalim, A. N., Farzadfar, F., Riley, L. M., & Ezzati, M. (2011). National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. *The Lancet, 377*(9765), 557-567.

Fong, T. C. T., Ho, R. T. H., & Yip, P. S. F. (2019). Effects of urbanization on metabolic syndrome via dietary intake and physical activity in Chinese adults: Multilevel mediation analysis with latent centering. *Soc Sci Med, 234*, 112372.

Gallagher, E. J., & LeRoith, D. (2015). Obesity and Diabetes: The Increased Risk of Cancer and Cancer-Related Mortality. *Physiological reviews, 95*(3), 727-748.

Hatcher, L. (1994). A Step-by-Step Approach to Using the SAS System for Factor Analysis and Structural Equation Modeling. *Cary, NC: SAS Institute Inc.*

Hruby, A., Manson, J. E., Qi, L., Malik, V. S., Rimm, E. B., Sun, Q., Willett, W. C., & Hu, F. B. (2016). Determinants and Consequences of Obesity. *American journal of public health, 106*(9), 1656-1662.

Hu, F. B. (2002). Dietary pattern analysis: a new direction in nutritional epidemiology. *Current Opinion in Lipidology, 13*(1).

Huang, L., Wang, Z., Wang, H., Zhao, L., Jiang, H., Zhang, B., & Ding, G. (2021). Nutrition transition and related health challenges over decades in China. *European Journal of Clinical Nutrition, 75*(2), 247-252.

Isganaitis, E., & Lustig, R. H. (2005). Fast food, central nervous system insulin resistance, and obesity. *Arterioscler Thromb Vasc Biol, 25*(12), 2451-2462.

Jones-Smith, J. C., & Popkin, B. M. (2010). Understanding community context and adult health changes in China: Development of an urbanicity scale. *Social Science & Medicine, 71*(8), 1436-1446.

Kim, S., Symons, M., & Popkin, B. M. (2004). Contrasting Socioeconomic Profiles Related to Healthier Lifestyles in China and the United States. *American Journal of Epidemiology, 159*(2), 184-191.

Li, L., Wu, J., Pu, D., Zhao, Y., Wan, C., Sun, L., Shen, C.-e., Sun, W., Yuan, Z., Shen, Q., He, X., Jiang, J., Luo, N., He, Y., Qian, Q., Cai, P., & Zhang, M. (2012). Factors associated with the age of natural menopause and menopausal symptoms in Chinese women. *Maturitas*, *73*(4), 354-360.

Li, M., & Shi, Z. (2017). Dietary Pattern during 1991–2011 and Its Association with Cardio Metabolic Risks in Chinese Adults: The China Health and Nutrition Survey. *Nutrients*, *9*(11).

Liu, D., Zhao, L.-Y., Yu, D.-M., Ju, L.-H., Zhang, J., Wang, J.-Z., & Zhao, W.-H. (2019). Dietary Patterns and Association with Obesity of Children Aged 6–17 Years in Medium and Small Cities in China: Findings from the CNHS 2010–2012. *Nutrients, 11*(1).

Ma, S., Xi, B., Yang, L., Sun, J., Zhao, M., & Bovet, P. (2021). Trends in the prevalence of overweight, obesity, and abdominal obesity among Chinese adults between 1993 and 2015. *International Journal of Obesity, 45*(2), 427-437.

Malik, V. S., Willett, W. C., & Hu, F. B. (2013). Global obesity: trends, risk factors and policy implications. *Nature Reviews Endocrinology, 9*(1), 13-27.

Mozaffarian, D., Hao, T., Rimm, E. B., Willett, W. C., & Hu, F. B. (2011). Changes in Diet and Lifestyle and Long-Term Weight Gain in Women and Men. *New England Journal of Medicine*, *364*(25), 2392-2404.

Mu, M., Xu, L.-F., Hu, D., Wu, J., & Bai, M.-J. (2017). Dietary Patterns and

Overweight/Obesity: A Review Article. *Iranian journal of public health, 46*(7), 869-876.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M., Achoki, T., AlBuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., Guzman, N. A., Ammar, W., Anwari, P., Banerjee, A., Barquera, S., Basu, S., Bennett, D. A., Bhutta, Z., Blore, J., Cabral, N., Nonato, I. C., Chang, J. C., Chowdhury, R., Courville, K. J., Criqui, M. H., Cundiff, D. K., Dabhadkar, K. C., Dandona, L., Davis, A., Dayama, A., Dharmaratne, S. D., Ding, E. L., Durrani, A. M., Esteghamati, A., Farzadfar, F., Fay, D. F., Feigin, V. L., Flaxman, A., Forouzanfar, M. H., Goto, A., Green, M. A., Gupta, R., Hafezi-Nejad, N., Hankey, G. J., Harewood, H. C., Havmoeller, R., Hay, S., Hernandez, L., Husseini, A., Idrisov, B. T., Ikeda, N., Islami, F., Jahangir, E., Jassal, S. K., Jee, S. H., Jeffreys, M., Jonas, J. B., Kabagambe, E. K., Khalifa, S. E., Kengne, A. P., Khader, Y. S., Khang, Y. H., Kim, D., Kimokoti, R. W., Kinge, J. M., Kokubo, Y., Kosen, S., Kwan, G., Lai, T., Leinsalu, M., Li, Y., Liang, X., Liu, S., Logroscino, G., Lotufo, P. A., Lu, Y., Ma, J., Mainoo, N. K., Mensah, G. A., Merriman, T. R., Mokdad, A. H., Moschandreas, J., Naghavi, M., Naheed, A., Nand, D., Narayan, K. M., Nelson, E. L., Neuhouser, M. L., Nisar, M. I., Ohkubo, T., Oti, S. O., Pedroza, A., Prabhakaran, D., Roy, N., Sampson, U., Seo, H., Sepanlou, S. G., Shibuya, K., Shiri, R., Shiue, I., Singh, G. M., Singh, J. A., Skirbekk, V., Stapelberg, N. J., Sturua, L., Sykes, B. L., Tobias, M., Tran, B. X., Trasande, L., Toyoshima, H., van de Vijver, S., Vasankari, T. J., Veerman, J. L., Velasquez-Melendez, G., Vlassov, V. V., Vollset, S. E., Vos, T., Wang, C., Wang, X., Weiderpass, E., Werdecker, A., Wright, J. L., Yang, Y. C., Yatsuya, H., Yoon, J., Yoon, S. J., Zhao, Y., Zhou, M., Zhu, S., Lopez, A. D., Murray, C. J., & Gakidou, E. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet, 384*(9945), 766-781.

Panagiotakos, D. (2008). α-priori versus α-posterior methods in dietary pattern analysis: a review in nutrition epidemiology. *Nutrition Bulletin, 33*(4), 311-315.

Piché, M.-E., Poirier, P., Lemieux, I., & Després, J.-P. (2018). Overview of Epidemiology and Contribution of Obesity and Body Fat Distribution to Cardiovascular Disease: An Update. *Progress in Cardiovascular Diseases, 61*(2), 103-113.

Popkin, B. M., & Du, S. (2003). Dynamics of the Nutrition Transition toward the Animal Foods Sector in China and its Implications: A Worried Perspective. *The Journal of Nutrition, 133*(11), 3898S-3906S.

Popkin, B. M., Du, S., Zhai, F., & Zhang, B. (2010). Cohort Profile: The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. *International Journal of Epidemiology, 39*(6), 1435-1440.

Popkin, B. M., Lu, B., & Zhai, F. (2002). Understanding the nutrition transition: measuring rapid dietary changes in transitional countries. *Public Health*

Nutrition, 5(6a), 947-953.

Shang, X., Li, Y., Liu, A., Zhang, Q., Hu, X., Du, S., Ma, J., Xu, G., Li, Y., Guo, H., Du, L., & Ma, G. (2012). Dietary Pattern and Its Association with the Prevalence of Obesity and Related Cardiometabolic Risk Factors among Chinese Children. *PLOS ONE, 7*(8), e43183.

Shen, X., Fang, A., He, J., Liu, Z., Guo, M., Gao, R., & Li, K. (2017). Trends in dietary fat and fatty acid intakes and related food sources among Chinese adults: a longitudinal study from the China Health and Nutrition Survey (1997–2011). *Public Health Nutrition, 20*(16), 2927-2936.

Shi, Z., Hu, X., Yuan, B., Hu, G., Pan, X., Dai, Y., Byles, J. E., & Holmboe-Ottesen, G. (2008). Vegetable-rich food pattern is related to obesity in China. *International Journal of Obesity, 32*(6), 975-984.

Shi, Z., Yuan, B., Hu, G., Dai, Y., Zuo, H., & Holmboe-Ottesen, G. (2011). Dietary pattern and weight change in a 5-year follow-up among Chinese adults: results from the Jiangsu Nutrition Study. *British Journal of Nutrition, 105*(7), 1047-1054.

Shu, L., Zheng, P.-F., Zhang, X.-Y., Si, C.-J., Yu, X.-L., Gao, W., Zhang, L., & Liao, D. (2015). Association between Dietary Patterns and the Indicators of Obesity among Chinese: A Cross-Sectional Study. *Nutrients, 7*(9).

Sun, J., Buys, N. J., & Hills, A. P. (2014). Dietary Pattern and Its Association with the Prevalence of Obesity, Hypertension and Other Cardiovascular Risk Factors among Chinese Older Adults. *International Journal of Environmental Research and Public Health, 11*(4).

Wang, D., He, Y., Li, Y., Luan, D., Yang, X., Zhai, F., & Ma, G. (2011). Dietary patterns and hypertension among Chinese adults: a nationally representative cross-sectional study. *BMC Public Health, 11*(1), 925.

Wang, L., Wang, H., Zhang, B., Popkin, B. M., & Du, S. (2020). Elevated Fat Intake Increases Body Weight and the Risk of Overweight and Obesity among Chinese Adults: 1991–2015 Trends. *Nutrients*, *12*(11).

Wang, Z., Zhai, F., Du, S., & Popkin, B. (2008). Dynamic shifts in Chinese eating behaviors. *Asia Pac J Clin Nutr, 17*(1), 123-130.

Willett, W., & Stampfer, M. J. (1986). Total energy intake: implications for epidemiologic analyses. *American Journal of Epidemiology, 124*(1), 17-27.

World Health Organization. (2020). Obesity and Overweight. Retrieved from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

World Health Organization. Regional Office for the Western, P. (2000). *The Asia-Pacific perspective : redefining obesity and its treatment*: Sydney : Health Communications Australia.

Xu, X., Byles, J., Shi, Z., McElduff, P., & Hall, J. (2016). Dietary pattern transitions, and the associations with BMI, waist circumference, weight and hypertension in a 7-year follow-up among the older Chinese population: a longitudinal study. *BMC Public Health, 16*(1), 743.

Xu, X., Hall, J., Byles, J., & Shi, Z. (2015). Dietary Pattern Is Associated with Obesity in Older People in China: Data from China Health and Nutrition Survey (CHNS). *Nutrients, 7*(9).

Yang, Y. X., Wang, G. Y., & Pan, X. C. (2009). *China Food Composition Table 2009*. Peking University Medical Press: Beijing, China.

Yao, M., McCrory, M. A., Ma, G., Tucker, K. L., Gao, S., Fuss, P., & Roberts, S. B.

(2003). Relative influence of diet and physical activity on body composition in urban Chinese adults. *The American Journal of Clinical Nutrition, 77*(6), 1409-1416.

Yu, C., Shi, Z., Lv, J., Du, H., Qi, L., Guo, Y., Bian, Z., Chang, L., Tang, X., Jiang, Q., Mu, H., Pan, D., Chen, J., Chen, Z., & Li, L. (2015). Major Dietary Patterns in Relation to General and Central Obesity among Chinese Adults. *Nutrients, 7*(7).

Yuan, Y.-Q., Li, F., Meng, P., You, J., Wu, M., Li, S.-G., & Chen, B. (2016). Gender Difference on the Association between Dietary Patterns and Obesity in Chinese Middle-Aged and Elderly Populations. *Nutrients, 8*(8).

Zhai, F., Guo, X., Popkin, B. M., Ma, L., Wang, Q., Shuigao, W. Y., Ge, J., & Keyou. (1996). Evaluation of the 24-Hour Individual Recall Method in China. *Food and Nutrition Bulletin, 17*(2), 1-7.

Zhai, F., Wang, H., Du, S., He, Y., Wang, Z., Ge, K., & Popkin, B. M. (2009). Prospective study on nutrition transition in China. *Nutrition Reviews, 67*(s1), S56-S61.

Zhai, F. Y., Du, S. F., Wang, Z. H., Zhang, J. G., Du, W. W., & Popkin, B. M. (2014). Dynamics of the Chinese diet and the role of urbanicity, 1991-2011. *Obes Rev, 15 Suppl 1*(0 1), 16-26.

Zhang, B., Zhai, F. Y., Du, S. F., & Popkin, B. M. (2014). The China Health and Nutrition Survey, 1989–2011. *Obesity Reviews, 15*(S1), 2-7.

Zhang, J., Wang, H., Wang, Y., Xue, H., Wang, Z., Du, W., Su, C., Zhang, J., Jiang, H., Zhai, F., & Zhang, B. (2015). Dietary patterns and their associations with childhood obesity in China. *British Journal of Nutrition, 113*(12), 1978-1984.

Zhang, J. G., Wang, Z. H., Wang, H. J., Du, W. W., Su, C., Zhang, J., Jiang, H. R., Zhai, F. Y., & Zhang, B. (2015). Dietary patterns and their associations with general obesity and abdominal obesity among young Chinese women. *European Journal of Clinical Nutrition, 69*(9), 1009-1014.

Zhen, S., Ma, Y., Zhao, Z., Yang, X., & Wen, D. (2018). Dietary pattern is associated with obesity in Chinese children and adolescents: data from China Health and Nutrition Survey (CHNS). *Nutrition Journal, 17*(1), 68.

Zhou, B.-F. (2002). Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults--study on optimal cut-off points of body mass index and waist circumference in Chinese adults. *Biomedical and environmental sciences : BES, 15*(1), 83-96.

Zou, Y., Zhang, R., Xia, S., Huang, L., Meng, J., Fang, Y., & Ding, G. (2017). Dietary Patterns and Obesity among Chinese Adults: Results from a Household-Based Cross-Sectional Study. *International Journal of Environmental Research and Public Health, 14*(5).

국문 초록

중국 성인의 식이 패턴과 비만 및 체중 변화의 연관성 연구: 중국건강영양조사(CHNS)

서울대학교 대학원 식품영양학과

진양

중국의 성인 비만율 (BMI > 27.5 kg/m^2)은 1993년 4.2%에서 2015년 15.7%로 증가하였고, 이러한 비만율의 증가는 중국 및 전세계의 건강을 위협하는 요소로 부각되고 있다. 중국의 비만율이 증가하는 주요한 원인으로 중국인들의 식생활 변화를 생각할 수 있으나, 비만 위험과 관련한 식이 요인에 대한 중국 연구가 부족한 상황이다. 식이 패턴 분석은 영양소나 음식을 복합적으로 섭취하는 식이의 특성을 반영할 수 있기 때문에 영양역학 분야에서 널리 활용되고 있다. 하지만 중국에서 비만위험에 영향을 미치는 식이 패턴에 대한 코호트 연구는 아직 부족하다. 따라서 본 연구에서는 중국 코호트 연구 데이터를 사용해서 비만 (BMI ≥ 25 kg/m^2)의 위험과 체중변화와 관련된 식이 패턴을 조사하고자 했다. 본 연구는 1997-2015년 중국건강영양조사 (China Health and Nutrition Survey, CHNS)에 참여한 18세 이상 65세 이하의 중국 성인 6,677명

을 대상으로 분석을 진행하였다. 요인분석(factor analysis)을 사용하여 서양 식이 패턴 (Westernized dietary pattern), 중국전통 식이 패턴 (traditional Chinese dietary pattern), 고전분 식물성 식이 패턴 (high-starch plant-based dietary pattern)을 추출하였다. 식이 패턴과 비만과의 연관성을 분석하기 위해 Cox 비례위험 모델(Cox proportional hazards model)을 이용하여 상대위험도 (relative risk, RR)와 95% 신뢰구간(confidence intervals, CI)을 산출하였다. 식이 패턴과 체중 변화 사이의 연관성을 살펴보기 위해 일반화 선형 모델 (generalized linear model)을 이용하여 식이 패턴 점수에 따른 체중 변화의 최소 제곱 평균(least square means)과 95% 신뢰구간을 산출하였다. 서양 식이 패턴 점수가 높을수록 비만 위험 및 체중 증가 정도가 증가하였다. 다변량 모델에서 서양 식이 패턴 점수의 제5오분위에 속한 집단은 제1오분위 집단에 비해 비만 발생 위험이 1.57배 높았다 (1.26-1.95; P for trend <0.001). 서양 식이 패턴 점수의 제5오분위와 제1오분위에서 체중 증가의 최소 제곱 평균 (95%CI)은 1.73 (0.98-2.47)과 1.13 (0.39-1.87; P for trend =0.036) kg/5 year이었다. 반면에 중국전통 식이 패턴 점수가 높을수록 비만의 위험이 감소하는 경향성이 나타났다. 제1오분위 대비 제2~5오분위에서 비만의 상대위험도 (95%CI)는 각각 0.78 (0.66-0.92), 0.83 (0.69-0.98), 0.80 (0.66-0.96), 0.84 (0.70-1.01)이었다 (P for trend = 0.045). 고전분 식물성 식이 패턴은 비만 및 체중 변화와 유의한 연관성을 보이지 않았다. 거주

지역에 따라 서양 식이 패턴과 체중 증가와의 연관성을 살펴보았을 때, 중국 남부 지방 거주자는 북부 지역 거주자에 비하여 체중 증가와의 연관성이 더 뚜렷하게 관찰되었다. 요약하면, 서양 식이 패턴을 따를수록 체중 증가 정도와 비만 위험이 증가하였다. 특히 경제 성장이 빠른 남부 지방에서 체중 증가와의 연관성이 더 뚜렷하게 관찰되었다. 본 연구 결과는 중국의 지역적 위치를 고려한 체중관리 식이지침을 개발하는 데 근거 자료로 쓸 수 있을 것으로 기대한다.

주요어: 식사패턴, 비만, 체중 변화, 중국건강영양조사, 코호트

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