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Associations between perceived stress and BMI and waist circumference in Chinese adults: data from the 2015 China Health and Nutrition Survey

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Abstract

Objectives: To assess the association between perceived stress and adiposity among Chinese adults.
Design: Cross-sectional study. Perceived stress was assessed using the 14-item perceived stress scale. Associations between quintiles of perceived stress and BMI and waist circumference were assessed using linear regression models and multinomial regression models. Estimates were adjusted for sociodemographic characteristics.
Setting: 2015 China Health and Nutrition Survey: 12 provinces covering a variety of geographic, economic development and health indicator situations.
Participants: A total of 8385 adults of both sexes, aged 18–99 years, were included.
Results: Overall, the mean perceived stress score was 22·7 (6·2), mean BMI was 24·3 (3·6) kg/m^2 and prevalence of obesity (BMI ≥ 30 kg/m^2) was 6·0 %. There were inverse associations between perceived stress quintiles with continuous BMI (P < 0·001), BMI categories (P = 0·015) and waist circumference (P = 0·047). Compared to adults in the lowest quintile of perceived stress, adults in the highest quintile of perceived stress had 0·44 kg/m^2 lower mean BMI (95 % CI: −0·67, −0·21), 0·72 times the prevalence of obesity (95 % CI: 0·55, 0·94) and 0·73 times the prevalence of abdominal obesity (95 % CI: 0·61, 0·88). Results were similar when using Chinese-specific cut-points.
Conclusion: Our results showed inverse associations between perceived stress quintiles and adiposity among Chinese adults. Future studies should aim to better understand the directionality of the observed associations and the potential biological and behavioural mechanisms underlying these associations in the Chinese population.

Keywords
Stress
BMI
Waist circumference
China Health and Nutrition Survey

The prevalence of overweight and obesity is increasing worldwide, and high body weight is one of the risk factors for many chronic diseases, such as diabetes, cardiovascular disease, and some cancers[1]. The prevalence of overweight and obesity has increased in the Chinese population in the past decade[2,3]. According to the results of Chinese national surveys, the prevalence of overweight increased from 37·4 % in 2000 to 41·2 % in 2014; the prevalence of obesity increased from 8·6 % in 2000 to 12·9 % in 2014 and the prevalence of abdominal obesity increased from 13·9 % in 2000 to 24·9 % in 2014[4]. With implications for future chronic disease, overweight and obesity have become one of the most serious public health problems in China.

Numerous studies have examined the risk factors for obesity among Chinese adults, ranging from biological to behavioural factors such as genes[5], diet patterns[6,7], physical activity[8] and sleep patterns[9]. These studies found that certain polymorphisms in the adipokine genes, a high-fat diet, lack of physical activity and sedentary lifestyle, and insufficient sleep were all associated with high body weight and obesity, consistent with previous studies on the risk factors for obesity worldwide[10,11].

In addition to these factors, stress is a daily occurrence in modern life. Several studies have found that stress is positively associated with overweight and obesity. Adults experiencing chronic stressors are more likely to be obese and have higher waist circumference compared with adults

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experiencing no stressors[12–14]. Stress has been known to influence weight change through physiological processes, food intake, physical activity levels, sleep patterns and sedentary behaviours[14–17]. On the other hand, stress may also be associated with weight loss. For example, the Whitehall II study found that adults with the lowest quintile of BMI at baseline lost weight at follow-up if they were under high job stress[18].

To date, the associations between stress and obesity have mainly been examined in Western countries. In recent years, mental health problems, including perceived stress, have become increasingly common in China. Nearly 11–15 % of Chinese population experienced poor mental health and many adults report experiencing high levels of stress[19]. Considering the possible health effects of chronic stress on obesity and subsequent chronic disease risk, it is important to understand if there is a relationship between perceived stress and obesity in China, as has been observed in Western countries. Therefore, the objective of the present study was to examine the relationship between perceived stress and adiposity using a national sample of Chinese adults. We further examined whether these associations varied by rural or urban residential areas, as food availability may be different depending on residential areas[20,21], and mental stress levels may also be different among residential areas[22], both of which could influence perceived stress and adiposity outcomes.

Methods

Study sample

The China Health and Nutrition Survey (CHNS) is an international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Health at the Chinese Center for Disease Control and Prevention (CCDC). The survey began in 1989 and was repeatedly carried out every 2–4 years through 2015. Recruitment involved a multistage, random cluster process to draw respondents from 12 provinces and municipal cities that vary substantially in geography, economic development, resources and health indicators. The survey includes a variety of nutritional and health indicators of residents. Data for CHNS 2015 were released in June 2018 and is publicly available (https://www.cpc.unc.edu/projects/china/data/datasets/longitudinal). Data from the 2015 CHNS were used in the present study because it was the only survey that included the assessment of perceived stress.

Respondents with missing BMI (*n* 1066), implausible BMI (>65 kg/m^2 or <10 kg/m^2) (*n* 5), missing waist circumference (*n* 35) and implausible waist circumference (<20 cm) (*n* 36) were excluded from the analytic sample. Respondents with missing or implausible educational level and marital status (*n* 20) were also excluded from the analytic sample. The primary analytic sample was comprised of 8385 adults aged 18–99 years.

Perceived stress

Perceived stress was measured by the 14-item perceived stress scale[23], a measure of perceived psychological stress that has been translated into Chinese, with demonstrated good validity and reliability in the Chinese population[24]. The 14-item scale includes seven positive questions and seven negative questions. Positive questions assessed the ability to cope with existing stress, while negative questions assessed lack of control in life and negative affective responses[24]. Adults were asked to rate the frequencies of their feelings and thoughts during the last month using a five-point Likert scale (never, almost never, sometimes, fairly often and very often). Response choices for positive questions were reverse-coded, and all responses were summed to create an overall perceived stress score. The overall perceived stress score ranged from 0 to 56 (Cronbach's α is 0·81 in the present study), and higher scores indicate greater perceived stress. Similar to prior studies, perceived stress was further categorised into quintiles based on population cut-points (quintile 1: range 0–17; quintile 2: range 18–22; quintile 3: range 23–25; quintile 4: range 26–27 and quintile 5: range 28–52).

BMI

Adults' weight and height were measured by trained CHNS staff. Height was measured, without shoes or cap, to the nearest 0·2 cm, and weight was measured to the nearest 0·1 kg. BMI was calculated as weight (kg) divided by the square of height (m). BMI was categorised using WHO cut-points: underweight, <18·5 kg/m^2; normal weight, 18·5–24·9 kg/m^2; overweight but not obese, 25·0–29·9 kg/m^2 and obese, ≥30·0 kg/m^2. BMI was further categorised using cut-points established by the National Health and Family Planning Commission of China (NHFPC) for Chinese adults: underweight, <18·5 kg/m^2; normal weight, 18·5–23·9 kg/m^2; overweight but not obese, 24·0–27·9 kg/m^2 and obese, ≥28·0 kg/m^2[25].

Waist circumference

Waist circumference was also measured by trained CHNS staff at the horizontal position of the lower margin of the rib arch and the midline of the iliac crest. Waist circumference was measured to the nearest 0·1 cm. In the present study, waist circumference was categorised using WHO cut-points: moderate abdominal obesity was defined as >94 cm and ≤102 cm for males and >80 cm and ≤88 cm for females; abdominal obesity was defined as >102 cm for males and >88 cm for females[26]. We also used Chinese-specific cut-points for waist circumference: moderate abdominal obesity was defined as ≥85 cm and <90 cm for males and ≥80 cm and <85 cm for females;

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abdominal obesity was defined as ≥90 cm for males and ≥85 cm for females[25].

Covariates

Sociodemographic covariates in the analysis included age, sex, education level, marital status, residential area, employment status and personal income level. All covariates were self-reported by adults in CHNS. Age was categorised as 18–34, 35–44, 45–54, 55–65 and >65 years; sex was classified as female and male; education level included primary school or less than primary school, middle school, high school, and college or higher than college; marital status included married or not married. Residential areas of adults were constructed from the CHNS original sampling unit. Sampling units, including cities, county towns, suburban villages and rural villages, are officially identified by the National Bureau of Statistics of China. CHNS classifies suburban villages and rural villages as rural areas and classifies cities and county towns as urban areas. Employment status included employed or not employed at the time of the survey, and personal income level was categorised into three tertiles (low: ≤16 000 RMB; medium: 16 000·01–32 000 RMB and high: >32 000 RMB) based on adults' income.

Statistical analysis

Descriptive analyses were conducted using chi-squared test for categorical variables and ANOVA for continuous variables to analyse differences in demographic characteristics by perceived stress quintiles, BMI and waist circumference among adults. Mean (SD) was reported for continuous variables and per cent (%) was reported for categorical variables.

Multivariate linear regression models were used to examine the relationship between perceived stress quintiles and continuous BMI. Results are presented as β-coefficients and 95 % CI. We tested the tolerance and autocorrelation of multivariate linear regression models and used robust linear regression to account for heteroscedasticity. We further examined a potential non-linear relationship between perceived stress and BMI using restricted cubic splines. Multinomial logistic regression models were used to examine the relationship between perceived stress quintiles and BMI categories, with normal weight as the base group. Multinomial logistic regression models were also used to examine the relationships between perceived stress quintiles and waist circumference categories, with normal waist circumference as the base group. Results from multinomial logistic regression models are presented as relative prevalence ratios and 95 % CI. All models adjusted for age, sex, education level, marital status, residential area, employment status and personal income level.

Effect modification by residential area on the associations of perceived stress and BMI and waist circumference was examined using likelihood-ratio tests. Statistical significance was considered at $P < 0{\cdot}05$ and statistical analyses were conducted using Stata SE 16.0 (StataCorp.).

Results

Sample characteristics

The average age of the adults was 53·9 (14·1) years and 52·2 % of the adults were female. Approximately 12·9 % of adults had at least a college education and 30·2 % of adults had a primary school education or fewer years. The majority of the adults were married (88·7 %), lived in rural areas (59·6 %) and were employed at the time of the survey (52·9 %). Adults' average personal annual income was 29 282·9 (27 911·1) RMB.

The average perceived stress score of adults was 22·7 (6·2). Figure 1 presents the distribution of perceived stress among all adults and Figure 2 shows the distributions of perceived stress by adults' socio-economic characteristics. Table 1 shows the distribution of perceived stress quintiles by socio-demographic characteristics of the adults. Adults were more likely to be in the upper quintiles of perceived stress if they were with higher age ($P = 0{\cdot}002$), were female ($P = 0{\cdot}048$), had lower education levels ($P < 0{\cdot}001$), were not married ($P < 0{\cdot}001$), living in rural areas ($P < 0{\cdot}001$), were not employed at the time of the survey ($P = 0{\cdot}007$) and had lower personal annual income ($P < 0{\cdot}001$).

Table 2 shows the distributions of BMI and waist circumference among all adults and by perceived stress quintiles. The average BMI of adults was 24·3 (3·6) kg/m^2. Using the WHO BMI categories, 4·1 % of the adults were underweight, 34·5 % were overweight but not obese and 6·0 % were obese. Using the Chinese-specific BMI categories, 4·1 % of the adults were underweight, 36·1 % were overweight but not obese and 14·5 % were obese. Adults in the lower quintiles of perceived stress ($P = 0{\cdot}013$) were more likely to be in higher BMI categories using WHO cut-points.

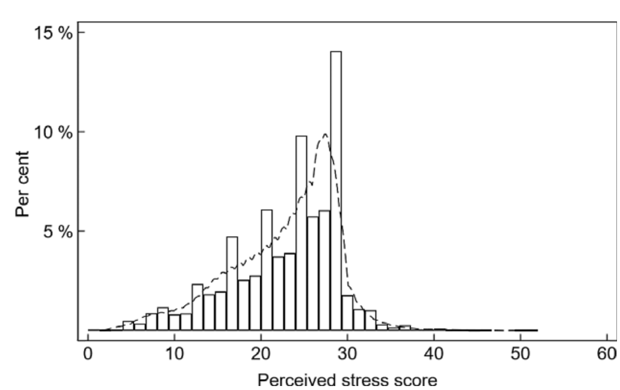

Fig. 1 Distribution of perceived stress among adults in China Health and Nutrition Survey 2015 (*n* 8385). ▭ the histogram is the observed density of perceived stress; ----- the dash line is the estimated density of perceived stress

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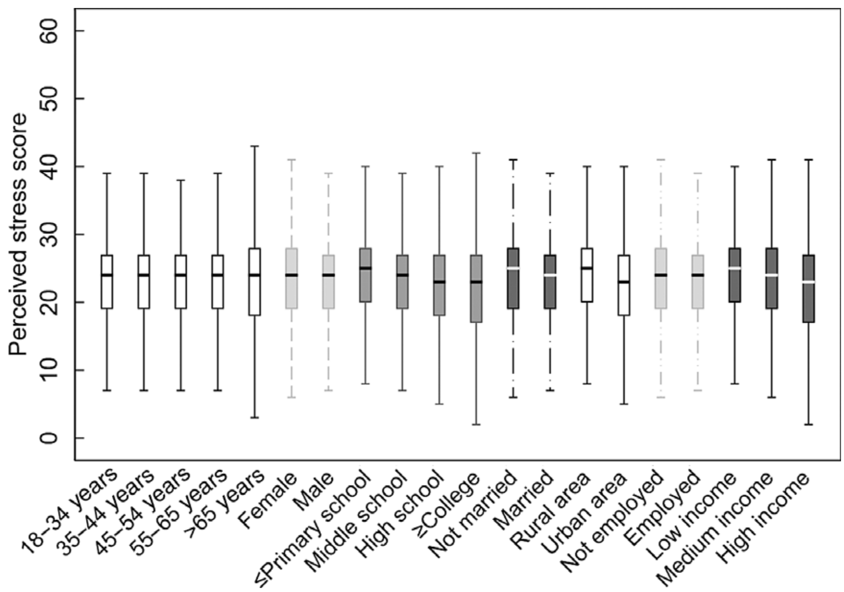

Fig. 2 Distributions of perceived stress across socio-economic categories among adults in China Health and Nutrition Survey 2015 (*n* 8385). Box plots: box is interquartile range, the horizontal bar inside the box is the median, whiskers extend 1·5 interquartile range on each side of the box and the values outside the whiskers are not plotted. X-axis represents adults' socio-economic characteristics

Table 1 Sociodemographic characteristics by quintiles of perceived stress among adults in China Health and Nutrition Survey 2015 (*n* 8385)*

			Perceived stress† (*n* (%))										
			Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5		
	All adults		(*n* 1728)		(*n* 1690)		(*n* 1531)		(*n* 1317)		(*n* 2119)		
Characteristics	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*P* value‡
Age (years)													0·002
18–34	892	10·6	165	18·5	216	24·2	155	17·4	146	16·4	210	23·5	
35–44	1286	15·3	242	18·8	257	20·0	258	20·1	218	17·0	311	24·2	
45–54	1974	23·5	412	20·9	377	19·1	386	19·6	308	15·6	491	24·9	
55–65	2433	29·0	517	21·3	492	20·2	412	16·9	404	16·6	608	25·0	
>65	1800	21·5	392	21·8	348	19·3	320	17·8	241	13·4	499	27·7	
Sex													0·048
Female	4373	52·2	886	20·3	853	19·5	811	18·6	665	15·2	1158	26·5	
Male	4012	47·9	842	21·0	837	20·9	720	18·0	652	16·3	961	24·0	
Education level													<0·001
≤Primary school	2536	30·2	388	15·3	468	18·5	490	19·3	407	16·1	783	30·9	
Middle school	2696	32·2	568	21·1	528	19·6	501	18·6	432	16·0	667	24·7	
High school	2071	24·7	487	23·5	460	22·2	340	16·4	322	15·6	462	22·3	
≥College	1082	12·9	285	26·3	234	21·6	200	18·5	156	14·4	207	19·1	
Marital status													<0·001
Not married	951	11·3	172	18·1	194	20·4	150	15·8	138	14·5	297	31·2	
Married	7434	88·7	1556	20·9	1496	20·1	1381	18·6	1179	15·9	1822	24·5	
Residential area													<0·001
Rural area	4995	59·6	897	18·0	949	19·0	925	18·5	840	16·8	1384	27·7	
Urban area	3390	40·4	831	24·5	741	21·9	606	17·9	477	14·1	735	21·7	
Employment status													0·007
Not employed	3953	47·1	789	20·0	755	19·1	712	18·0	635	16·1	1062	26·9	
Employed	4432	52·9	939	21·2	935	21·1	819	18·5	682	15·4	1057	23·9	
Personal income level													<0·001
Low	2715	32·4	426	15·7	470	17·3	546	20·1	465	17·1	808	29·8	
Medium	2830	33·8	579	20·5	628	22·2	450	15·9	436	15·4	737	26·0	
High	2840	33·9	723	25·5	592	20·9	535	18·8	416	14·7	574	20·2	

*Percentages may not add to 100 due to rounding.
†Cut-points for categorical perceived stress: quintile 1: 0–17; quintile 2: 18–22; quintile 3: 23–25; quintile 4: 26–27 and quintile 5: 28–52.
‡*P* value is for chi-square test of perceived stress quintiles.

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Table 2 Distribution of BMI and waist circumference by perceived stress quintiles among adults in the China Health and Nutrition Survey 2015 (*n* 8385)

		All adults		Perceived stress* Quintile 1 (*n* 1728)		Quintile 2 (*n* 1690)		Quintile 3 (*n* 1531)		Quintile 4 (*n* 1317)		Quintile 5 (*n* 2119)		
		n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*P* value†
BMI (kg/m²)‡	Mean (SD)	24·3 (3·6)		24·7 (3·7)		24·3 (3·6)		24·2 (3·5)		24·2 (3·7)		24·2 (3·6)		<0·001
WHO BMI categories§,‖														0·013
	Underweight	343	4·1	55	3·2	61	3·6	68	4·4	68	5·2	91	4·3	
	Overweight	2889	34·5	626	36·2	568	33·6	519	33·9	470	35·7	706	33·3	
	Obesity	500	6·0	127	7·4	106	6·3	79	5·2	64	4·9	124	5·9	
Chinese-specific BMI categories¶														0·078
	Underweight	343	4·1	55	3·2	61	3·6	68	4·4	68	5·2	91	4·3	
	Overweight	3028	36·1	656	38·0	590	34·9	540	35·3	478	36·3	764	36·1	
	Obesity	1215	14·5	276	16·0	253	15·0	219	14·3	176	13·4	291	13·7	
WHO waist circumference categories**,††														0·370
	Moderate abdominal obesity	1971	23·5	418	24·2	404	23·9	369	24·1	307	23·3	473	22·3	
	Abdominal obesity	1608	19·2	357	20·7	323	19·1	298	19·5	239	18·2	391	18·5	
Chinese-specific waist circumference categories‡‡														0·013
	Moderate abdominal obesity	1603	19·1	331	19·2	321	19·0	292	19·1	226	17·2	433	20·4	
	Abdominal obesity	3575	42·6	786	45·5	723	42·8	656	42·9	574	43·6	836	39·5	

*Cut-points for categorical perceived stress: quintile 1: 0–17; quintile 2: 18–22; quintile 3: 23–25; quintile 4: 26–27 and quintile 5: 28–52.
†*P* value is for ANOVA of continuous BMI, for chi-square test of categorical BMI and for chi2 test of categorical waist circumference.
‡Mean (SD) was reported for continuous BMI.
§WHO cut-points for BMI: underweight, <18·5 kg/m²; normal weight, 18·5–24·9 kg/m²; overweight but not obese, 25·0–29·9 kg/m² and obese, ≥30·0 kg/m².
‖Per cent of normal weight category is omitted for it can be calculated by: 100 %–underweight %–overweight but not obese %–obese %.
¶Chinese-specific cut-points for BMI: underweight, <18·5 kg/m²; normal weight, 18·5–23·9 kg/m²; overweight but not obese, 24·0–27·9 kg/m² and obese, ≥28·0 kg/m²
**Per cent of normal waist circumference is omitted for it can be calculated by: 100 % minus the per cents of two kinds of elevated waist circumference.
††WHO cut-points for waist circumference: moderate abdominal obesity is defined as >94 cm and ≤102 cm for male and >80 cm and ≤88 cm for female, while abdominal obesity is defined as >102 cm for male and >88 cm for female.
‡‡Chinese-specific cut-points for waist circumference: moderate abdominal obesity is defined as ≥85 cm and <90 cm for male and ≥80 cm and <85 m for female, while abdominal obesity is defined as ≥90 cm for male and ≥85 for female.

Using the WHO cut-points for waist circumference, 23·5 % of the adults had moderate abdominal obesity and 19·2 % had abdominal obesity. Using the Chinese-specific cut-points for waist circumference, 19·1 % of the adults had moderate abdominal obesity and 42·6 % had abdominal obesity. Adults in the lower quintiles of perceived stress ($P = 0·013$) were more likely to have abdominal obesity using Chinese-specific cut-points.

Associations between perceived stress and adiposity

Table 3 presents the associations between perceived stress quintiles and BMI and waist circumference. In the multivariate linear models for perceived stress quintiles and continuous BMI, higher perceived stress quintiles were significantly associated with lower continuous BMI (overall P value <0·001). Compared to adults in the lowest quintile of perceived stress, adults in the second quintile of perceived stress had a 0·35 kg/m^2 lower BMI (95 % CI: −0·59, −0·11), adults in the third quintile of perceived stress had a 0·44 kg/m^2 lower BMI (95 % CI: −0·69, −0·19), adults in the fourth quintile of perceived stress had a 0·48 kg/m^2 lower BMI (95 % CI: −0·74, −0·21) and adults in the top quintile of perceived stress had a 0·44 kg/m^2 lower BMI (95 % CI: −0·67, −0·21), after adjusting for sociodemographic characteristics. Supplemental Figure 1 shows the association between continuous perceived stress and continuous BMI using restricted cubic spline analyses, adjusted for sociodemographic characteristics. Similar to the analysis using perceived stress quintiles, continuous perceived stress scores were negatively correlated with continuous BMI, which plateaued at higher levels of perceived stress. A test of non-linearity showed that a linear relationship could not be rejected ($P = 0·265$).

In multinomial logistic regression models for perceived stress quintiles and the WHO cut-points for BMI categories, higher perceived stress quintiles were significantly associated with lower relative prevalence of being obese (BMI ≥ 30 kg/m^2) (overall P value = 0·015). Compared to adults in the lowest quintile of perceived stress, adults in the third quintile of perceived stress had 0·65 times the prevalence of obesity (95 % CI: 0·48, 0·87), adults in the fourth quintile of perceived stress had 0·62 times the prevalence of obesity (95 % CI: 0·45, 0·85) and adults in the top quintile of perceived stress had 0·72 times the prevalence of obesity (95 % CI: 0·55, 0·94). No overall significant associations between perceived stress quintiles and BMI categories were observed when using Chinese-specific cut-points (overall P value = 0·098), but some individual comparisons between perceived stress quintiles and obesity (BMI ≥ 28 kg/m^2) were significant. Compared to adults in the lowest quintile of perceived stress, adults in the fourth quintile of perceived stress had 0·77 times the prevalence of obesity (95 % CI: 0·62, 0·96) and adults in the top quintile of perceived stress had 0·79 times the prevalence of obesity (95 % CI: 0·65, 0·96).

Multinomial logistic regression models for perceived stress quintiles and waist circumference showed that adults in the top quintile of perceived stress had a lower relative prevalence of abdominal obesity compared to adults in the lowest quintile (relative prevalence ratio = 0·73, 95 % CI: 0·61, 0·88; overall P value = 0·047). Associations were similar when using Chinese-specific cut-points for waist circumference: adults in the highest quintile of perceived stress had a lower relative prevalence of abdominal obesity (comparing top to bottom quintile, relative prevalence ratio = 0·77, 95 % CI: 0·67, 0·89; overall P value = 0·017).

No significant effect modification was found by residential area on the associations between perceived stress quintiles and the outcomes of BMI and waist circumference.

Discussion

To our knowledge, this was the first study to examine the associations between perceived stress and BMI and waist circumference in a large and national sample of Chinese adults. Results showed that adults in the higher quintiles of perceived stress had, on average, lower continuous BMI, and lower relative prevalence of obesity and abdominal adiposity using both WHO and Chinese-specific cut-points. These associations were independent of adults' sex, age, education level, marital status, residential area, employment status and personal income level and did not differ by adults' residential areas.

Contrary to our findings, prior studies conducted in predominantly Western countries have found that perceived stress is associated with higher obesity and greater weight gain[12–14]. In a 5-year longitudinal study in Australia, respondents' perceived stress and negative life events at baseline were associated with greater weight gain[27]. A cross-sectional study of Hispanic/Latino adults in the USA also showed that adults with higher chronic stress had higher odds of being overweight and having elevated waist circumference[12]. A 3-year follow-up study of Australian women showed that higher perceived stress was associated with higher odds of obesity both in baseline cross-sectional and longitudinal analyses, in part due to more frequent fast food consumption, less leisure-time physical activity and more television time[17]. However, other studies have shown that stress may also be associated with lower appetite and weight loss[18,28–30].

There are several possible explanations for the differential relationships between perceived stress and obesity between Western and Asian countries. The first explanation is the difference in the role of dietary intake and eating behaviours in response to perceived stress. Previous studies in Western countries have found that perceived stress was associated with uncontrolled eating and emotional eating, resulting in weight gain[12,14,31]. However, a study

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Table 3 Associations between perceived stress quintiles and BMI and waist circumference among adults in the China Health and Nutrition Survey 2015 (*n* 8385)*,†,‡

Outcomes			Perceived Stress§ (Quintile 1 as the reference)					
			Quintile 1 (*n* 1728)	Quintile 2 (*n* 1690)	Quintile 3 (*n* 1531)	Quintile 4 (*n* 1317)	Quintile 5 (*n* 2119)	Overall *P* value‖
BMI (continuous)		β¶	Ref.	−0·35**	−0·44***	−0·48***	−0·44***	<0·001
		95 %CI**		−0·59, −0·11	−0·69, −0·19	−0·74, −0·21	−0·67, −0·21	
BMI categories using WHO cut-points‡‡ (Ref.: normal weight)	Underweight	RPR††	Ref.	1·01	1·27	1·53*	1·18	0·015
		95 % CI		0·69,1·47	0·88,1·84	1·05,2·22	0·83,1·67	
	Overweight	RPR	Ref.	0·89	0·89	0·98	0·88	
		95 % CI		0·77,1·03	0·77,1·04	0·83,1·14	0·76,1·01	
	Obese	RPR	Ref.	0·79	0·65**	0·62**	0·72*	
		95 % CI		0·60,1·04	0·48,0·87	0·45,0·85	0·55,0·94	
BMI categories using Chinese-specific cut-points§§ (Ref: normal weight)	Underweight	RPR	Ref.	0·99	1·27	1·49*	1·17	0·098
		95 % CI		0·68,1·45	0·87,1·84	1·02,2·17	0·82,1·67	
	Overweight	RPR	Ref.	0·87	0·88	0·93	0·91	
		95 % CI		0·75,1·01	0·76,1·03	0·79,1·09	0·79,1·06	
	Obese	RPR	Ref.	0·86	0·83	0·77*	0·79*	
		95 % CI		0·71,1·05	0·67,1·02	0·62,0·96	0·65,0·96	
Waist circumference categories using WHO cut-points‖‖ (Ref: normal)	Moderate abdominal obesity	RPR	Ref.	0·99	0·97	0·93	0·83*	0·047
		95 % CI		0·84,1·17	0·82,1·16	0·77,1·11	0·70,0·97	
	Abdominal obesity	RPR	Ref.	0·93	0·9	0·84	0·73***	
		95 % CI		0·77,1·12	0·74,1·09	0·68,1·03	0·61,0·88	
Waist circumference categories using Chinese-specific cut-points¶¶ (Ref: normal)	Moderate abdominal obesity	RPR	Ref.	0·96	0·96	0·84	0·97	0·017
		95 % CI		0·79,1·16	0·78,1·16	0·68,1·04	0·81,1·16	
	Abdominal obesity	RPR	Ref.	0·91	0·91	0·90	0·77***	
		95 % CI		0·78,1·06	0·77,1·06	0·76,1·06	0·67,0·89	

*Linear regression models were used for perceived stress quintiles and continuous BMI; multinomial logistic regression models were used for perceived stress quintiles and categorical BMI and categorical waist circumference.
†Models adjusted for age, sex, education level, marital status, residential area, employment status and personal income level.
‡*$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.
§Cut-points for categorical perceived stress: quintile 1: 0–17; quintile 2: 18–22; quintile 3: 23–25; quintile 4: 26–27 and quintile 5: 28–52.
‖Overall *P* value is for the overall association between perceived stress quintiles and adiposity, calculated from likelihood-ratio test.
¶Coefficient of multiple linear regression.8
**95 % CI
††RPR: relative prevalence ratios
‡‡WHO cut-points for BMI: underweight, <18·5 kg/m^2; normal weight, 18·5–24·9 kg/m^2; overweight but not obese, 25·0–29·9 kg/m^2 and obese, ≥30·0 kg/m^2.
§§Chinese-specific cut-points for BMI: underweight, <18·5 kg/m^2; normal weight, 18·5–23·9 kg/m^2; overweight but not obese, 24·0–27·9 kg/m^2 and obese, ≥28·0 kg/m^2.
‖‖WHO cut-points for waist circumference: moderate abdominal obesity is defined as >94 cm and ≤102 cm for male and >80 cm and ≤88 cm for female; abdominal obesity is defined as >102 cm for male and >88 cm for female.
¶¶Chinese-specific cut-points for waist circumference: moderate of abdominal obesity is defined as ≥85 cm and <90 cm for male and ≥80 cm and <85 cm for female; abdominal obesity is defined as ≥90 cm for male and ≥85 for female.

of women in urban South Asia showed that women reported a loss of appetite in response to the stress of marital fights[32]. Another study of immigrant women in Korea showed that respondents with the highest stress scores were less likely to consume meals regularly and skipped breakfast more often. In the same study, higher stress scores were also associated with lower intakes of total energy, carbohydrates, protein and fat, and women with higher stress were more likely to be underweight[33]. In a study among female Chinese immigrants, results showed that positive life events were associated with higher energy intake, while migration-related stress was negatively associated with food intake[34]. Similarly, among Chinese female students residing in America, perceived stressful conditions were associated with decreased dietary intake eaten[35]. These different dietary habits as a consequence of stress may lead to differential relationships between stress and obesity in Western countries compared to Asian countries.

Changes in eating behaviour in response may also be mediated by the food environment. While many Asian countries are undergoing nutrition transformations of the local food environments, individuals in Asian countries generally consumed less processed foods than individuals in Western countries[36–38]. In 2015, China was in the early stages of this nutrition transformation, processed food represented less than 1/3 of food purchases during that period[21,38,39], and most processed foods were sold in supermarkets[40]. Individuals in less urbanised areas may have lower access to large-sized supermarkets nearby[20], and thus lower exposure to processed foods. Besides, fast food restaurants were mainly located in a few metropolitan cities and were just starting to emerge slowly in smaller cities of China before 2015[41], people had more limited options of highly processed foods during stressful times. Thus, differences in food environments may also explain the different associations between perceived stress and adiposity observed in Western countries and the present study.

Another explanation is differences in other lifestyle behaviours as a response to stress between individuals in Western and Asian countries. Cultural values and norms can influence individual stress-coping strategies. Research suggests that adults in Western countries exhibit greater unconscious eating behaviours in response to stress[12,14,31], while research among Chinese populations suggest adults may smoke more[42] or consume more alcohol[43] in response to stress, both of which could lead to weight loss[44,45].

Finally, there may be differences in cultural attitudes towards obesity between Western countries and in China. In Chinese culture, 'happy mind and fat body' is a well-known idiom describing the relationship between mood and obesity, where being 'fat' is a symbol of wealth and life satisfaction. This belief is still very popular in China. For example, one study found that Chinese people with obesity were less likely to suffer from psychological problems[46], which is consistent with the jolly 'fat' hypothesis proposed by Crisp and McGuiness[47]. Another study examined the relationship between subjective well-being and adult BMI using the Chinese General Social Survey; their results showed that those with higher levels of happiness tended to have higher BMI[48]. Conversely, another well-known idiom in China is 'No desire for eating foods or drinking tea', which means feelings of anxiety or unhappiness are related to loss of appetite[48]. These cultural factors demonstrate how wealth or positive affection is connected with body weight and may explain why high levels of perceived stress are associated with lower levels of adiposity observed in the present study.

The study had some limitations. First, this study was cross-sectional, so a causal relationship between perceived stress and adiposity cannot be determined. Previous studies have shown that stress can be a cause of obesity through higher levels of emotional eating and lower physical activity[14]. On the other hand, greater adiposity could also increase perceived stress through weight stigma, forming a 'vicious cycle' where weight stigma increases psychological stress, leading to increased eating, weight gain and subsequently greater weight stigma[49,50]. Longitudinal data can help to better examine the effects of perceived stress on weight gain over time and account for potential reverse causation. Second, we were unable to incorporate sampling weights or variables related to sample design as this information was not provided in the CHNS data set. Although consistent with previous studies using CHNS data[51–54], the lack of data on sample design and sampling weights may have impacted some of the effect estimates and standard errors and the results are not generalisable to the national Chinese population. Third, although the measurement of perceived stress in this study has been validated, it cannot identify different types of objective stressors, which may have different cognitive and physical effects[55,56]. Moreover, the duration of stress may also moderate the effects of stress on obesity[57]. Future research should consider incorporating perceived and objective measures of stress, as well as more detailed assessments on the type, severity and duration of individual stressors, to better understand how stress can differentially influence BMI and waist circumference. Lastly, the associations between perceived stress quintiles and adiposity showed a probable non-linear relationship, namely that the associations between perceived stress quintiles and BMI tended to plateau at the highest quintile of perceived stress. Future research should analyse the precise non-linear relationship between perceived stress and adiposity.

Despite these limitations, this study is the first research to examine the relationship between perceived stress and adiposity in Chinese adults, which is critical when obesity and mental health disorders are both increasing in China[2,19]. Other strengths of this study include the large study population, measured anthropometric outcomes by

Public Health Nutrition

trained research staff, and the use of a widely used and validated measure of perceived stress adapted for the Chinese population. The present study contributes to the literature on stress and adiposity, which have mainly focused on individuals in Western countries.

Conclusion

In the present study, we found that perceived stress was inversely associated with adiposity among Chinese adults. Future studies should aim to better understand the directionality of observed associations and the potential biological and behavioural mechanisms underlying these associations. If causal, the results of this study may inform the development of health management and health intervention programmes to simultaneously promote healthy stress management and healthy body weight in the Chinese population.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020005054

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