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Is there any relationship between dietary patterns and depression and anxiety in Chinese adolescents?

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Abstract

Objective: To determine the association between major dietary patterns characterized by factor analysis and risk of depression and anxiety symptoms among adolescents.

Design: Diet and symptoms of depression and anxiety were assessed in a cross-sectional survey among students attending junior high school. Dietary patterns were derived from a self-reported FFQ, which consisted of thirty-eight items. Anthropometric measurements were also performed.

Setting: Four junior high schools in Bengbu city, China.

Subjects: A random sample of 5003 adolescents, 11–16 years of age (mean 13·21 years).

Results: Three major dietary patterns were identified in the study based on factor analysis: 'snack', 'animal food' and 'traditional'. The prevalence of depression symptoms, anxiety disorders and the coexistence of both were 11·2% (560/5003), 14·6% (732/5003) and 12·6% (629/5003), respectively. After adjustment for potential confounders, adolescents in the highest tertile of snack dietary pattern scores had a higher odds for 'pure' psychological symptoms ('depression without anxiety', OR = 1·64; 95% CI 1·30, 2·06; and 'anxiety without depression', OR = 1·87; 95% CI 1·51, 2·31) compared with coexisting depression and anxiety (OR = 1·93; 95% CI 1·54, 2·43). Similar to snacks, high consumption of animal foods was associated with a higher risk of psychological symptoms. Compared with low consumption, adolescents in the highest tertile of traditional dietary pattern scores had lower odds for 'pure' depression (OR = 0·38; 95% CI 0·30, 0·49), 'pure' anxiety (OR = 0·85; 95% CI 0·69, 1·04) and coexisting anxiety and depression (OR = 0·50; 95% CI 0·39, 0·63).

Conclusions: Data from Chinese secondary-school adolescents validated findings from adult populations. Dietary patterns should be considered as important predictors of depression and anxiety among adolescents in further studies.

Keywords
Dietary patterns
Adolescent
Depression
Anxiety

Adolescence is a critical period for mental disorders, with a high percentage of all lifetime mental disorders detected for the first time by age 14 years[1]. Globally, approximately 20% of children and adolescents have mental disorders or mental health-related problems, and half of these cases are diagnosed before the age of 14 years[2]. During this period, mental health is strongly related to other developmental and health conditions. Investigations of clinic and community samples report that depression in adolescence can predict further problems by influencing quality of life, academic performance, social activities and even obesity in later life[3–6]. It has been reported that there is a high co-occurrence of depression and general anxiety disorders in adolescents[7]. Brady and Kendall[8] performed a literature review regarding anxiety and depression in children and adolescents and estimated that 15·9–61·9% of children with anxiety or depression had co-morbid anxiety and depressive disorders. Because the prevalence of mental disorders is high and causes effects on the physiological and psychological development of adolescents, the prevalence of mental disorders has become a major health problem[2]. Therefore, it is necessary to understand potential risk factors for mental health disorders in young

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people in an effort to formulate appropriate measures for early prevention and intervention.

Diet is usually investigated in lifestyle-mediated diseases[9]. In recent years, dietary patterns have been the subject of increased attention in the field of adolescent mental health. Researchers noticed that inadequate nutrition and poor diet quality (fast food, confectionery items, animal foods) are more frequently associated with mental problems[10–15]. A cross-sectional relationship between diet quality and depression was verified in a large sample of adolescents from a diverse range of sociodemographic backgrounds[13]. The intakes of fruit, vegetables, meat, snacks and other healthy foods were also assessed and shown to be related with mental or physical disorders in adolescents[10,16,17]. Unlike other diet research methods, dietary pattern analysis is used for characterizing the whole diet in combination. The use of FFQ has been validated in adolescents, sometimes even better than the 24 h recall approach[18]. FFQ can capture complex behaviours and potentially interactive effects among special nutrients that might impact mental health[19]. However, there are only a limited number of studies evaluating the association between special dietary patterns and mental disorders in adolescents[10,20]. For example, in a recent study conducted in adolescents aged 13–15 years, Oddy *et al.*[20] suggested that an increased adherence to a Western dietary pattern was associated with higher scores on the Child Behavior Checklist (CBCL), resulting in poorer mental health.

Adolescence is a stage when independence is established. Certain dietary patterns may be adapted by adolescents and might be followed for a long period. Consequently, unhealthy dietary patterns during youth would have profound implications for well-being in adulthood. In China the lifestyle and dietary habits of adolescents have changed in recent decades. Specifically, a higher percentage of urban adolescents consume more fast foods and sweetened beverages[21]. There are few studies that have assessed the role of dietary patterns with respect to adolescent mental health in China. Therefore, we determined the associations between major dietary patterns and the prevalence of depression and anxiety among Chinese adolescents.

Methods

Sample and procedures

The aerobic exercise intervention study is a school-based study investigating the effect of aerobic exercise on adolescent mental health which was conducted from September 2010 to October 2010 in Bengbu, Anhui Province, China.

The sampling scheme was a one-stage random cluster sample. The cluster sampling frame comprised all twenty-one junior schools in Bengbu city. We randomized four of twenty-one junior high schools (grades 7–9) on the basis of a computer-generated random number table that was in the hands of a person not involved in the study. All students and their parents in the four schools gave informed consent. A self-administered questionnaire survey was administered a week before anthropometric measurements were made. According to anonymous and voluntary participation, students completed questionnaires during one class period (45 min) without interruptions. The students' height, weight and waist circumference were measured and recorded by trained postgraduate students and school physicians. As of November 2010, 5340 students had completed the baseline questionnaire. There were 265 students who had incomplete anthropometric data and fifty-eight incomplete questionnaires (more than 15 % of information was missing). Fourteen students were excluded for receiving psychotropic medications or mental health treatment during the study period or had a history of substance abuse. A total of 5003 students were available at baseline for follow-up. For the present study we analysed data collected at baseline only.

Instruments

Dietary assessment

Habitual dietary patterns were assessed by a comprehensive and self-administered FFQ, which was designed to measure the dietary habits of the adolescents. The time of consumption for each food or food group per week was determined. According to the dietary features of the target population, the FFQ was modified on the basis of a previous questionnaire[22]. The FFQ included thirty-eight food items which are commonly consumed by Chinese adolescents. Each item represents a food group. Students were asked to indicate the consumption frequency during the previous 7 d that best described their intake. There were five frequency options, ranging from 'never' to '9 or more times' per 7 d, excluding alcoholic beverages. Each option was scored as follows: 'never eat' = 0; '1–3 times' = 1; '4–5 times' = 2; '6–8 times' = 3; and 'more than 8 times' = 4. The FFQ focused only on the frequency of each food item, and information on the portion size was not included.

Depression and anxiety assessment

Depression symptoms were measured by the Chinese version of the Depression Self-rating Scale for Children (DSRS), as developed by Birleson[23]. The DSRS was adapted to children 8–16 years of age and contained eighteen items, of which students self-reported the frequency of each item during the last week[23,24]. Each item response was rated on a 3-point scale from 'never' to 'more frequent'. A cut-off score of 15 was used to screen depression symptoms among children and adolescents. The scale has been validated, having content reliability in local children and young adolescents. The test–retest reliability, the split-half and Cronbach's α were in the

range 0·53–0·73. The total score of the scale also showed a significant correlation with the corresponding subscale of the CBCL ($r = 0·49$–$0·58$) and the subscale of the Paiers–Harris Children's Self-concept Scale ($r = 0·60$–$0·68$; P values both $<0·05$)[24].

The instrument used to screen anxiety symptoms of the students was the Chinese version of the Screen Scale for Child Anxiety Related Emotional Disorders (SCARED), as designed by Birmaher *et al.*[25], which contained forty-one items allocated to five dimensions: somatic/panic; generalized anxiety; separation anxiety; social phobia; and school phobia. Students were asked to answer the frequency with which they experienced each symptom using a 3-point scale (0 = 'almost never', 1 = 'sometimes' and 2 = 'often'). If the total score is more than 23, an anxiety disorder is screened. The validity and reliability of the SCARED (Chinese version) have been validated in a previous study[26]. The Chinese version of the scale also demonstrated good internal consistency, test–retest reliability (intra-class correlation coefficient = 0·46–0·77 over 2 weeks and 0·24–0·67 over 12 weeks) and good validity between anxiety and non-anxiety disorders[27].

Anthropometric measurements

Measurements were performed by a team of trained nurses and interviewers who used the same standard methods in the baseline study. Body height, weight and waist circumference were measured. Positioning of the body was standardized by asking the student to stand straight without shoes and with the heels placed together. Weight was measured to the nearest 0·1 kg using an electronic body weight meter. Students were asked to wear light clothing and empty their bladder. Height was measured to the nearest 0·1 cm with a manual height board. Waist circumference was measured 1 cm above the umbilicus with a standard tape measure to the nearest 0·1 cm. The height and waist circumference were measured twice, and the mean value was recorded. BMI (kg/m^2) and waist-to-height ratio (WHtR) were calculated to assess whether students were obese/overweight.

Covariate assessment

The sociodemographic information included age, gender, grade, family income, number of siblings, and maternal and paternal education. The family income was self-reported and classified in three levels ranging from 'low' (score = 1) to 'high' (score = 3). Maternal or paternal education was classified in four levels as follows: primary schooling or illiterate (score = 1); secondary schooling (score = 2); university or other tertiary qualification (score = 3); unknown (scored = 4). Physical activity was assessed based on the following question: 'How many days in the past week have you had at least one moderate physical activity (i.e. an activity that leaves you out of breath or feeling tired some of the time) for 60 min or more (never/1 d/2 d/ 3 d or more)?'[28].

Statistical analysis

We used factor analysis (principal components) to derive dietary patterns based on the FFQ. Thirty-eight food items were entered into the factor analysis, and rotated by orthogonal transformation (varimax rotation) to maintain uncorrelated factors and greater interpretability. Inter-item reliability for each factor was assessed by Cronbach's α coefficients (Cronbach's α for the FFQ was 0·895 in the present study). Items were excluded for the absolute value of factor loading $<0·2$ (Table 2). We determined to retain three factors according to the eigenvalues in the scree plot, which accounted for 34·78 % of the variance in the dietary information. The three factors were labelled as 'traditional', 'snack' and 'animal food', and scores were saved as variables in the data set. For further statistical analyses, factors were treated categorically (tertiles). Trend associations between categorically demographic variables and dietary patterns were assessed using χ^2 analysis. Means (and standard errors) of BMI, WHtR and age were calculated according to tertile of dietary pattern scores using ANOVA, and BMI and WHtR were adjusted for age and gender.

Bivariate logistic regression analysis was performed to estimate the odds of sociodemographic variables for mental disorders. Multinomial logistic regression models, with all three dietary patterns entered simultaneously as exposure variables, and categorical 'pure' depression (depression without anxiety), 'pure' anxiety (anxiety without depression) and coexisting depression and anxiety as dependent variables, were fitted to determine the confounder-controlled association of the three dietary patterns with self-reported mental problems. In each dietary pattern the lowest tertile was designated as the reference group. Statistical analyses were performed with the SPSS statistical software package version 10·0 (SPSS, Inc., Chicago, IL, USA). Differences were considered significant if $P < 0·05$.

Results

We assessed 2606 boys and 2397 girls in the present study. The mean age at recruitment was 13·21 (SD 0·99) years. Three dietary patterns were extracted from thirty-eight food groups (Table 1) in the FFQ using principal component analysis: snack, animal food and traditional. The factor-loading matrices for the three patterns are listed in Table 2. The snack dietary pattern was composed mainly of preserved fruit, a sweet course, frozen confection, yoghurt, chocolate, candy and carbonated drinks. The animal dietary pattern consisted of red meat, organ meat, processed meat, fried meat and other Chinese meat dishes. The traditional dietary pattern is a typically healthy and recommended diet, and included foods such as gruel, oatmeal, whole grains, fresh yellow or red vegetables, fruit and soya milk.

Table 1 The thirty-eight food items in the FFQ with examples

	Food item	Examples
1.	Staple food (for most Chinese)	Rice, noodles
2.	Bread	White bread, whole-wheat bread, toast
3.	Pancake	Chinese oil cake, batter cake
4.	Chinese traditional congee	Corn congee, millet congee
5.	Porridge	Porridge
6.	Whole grains	Corn, sweet potato (boiled or baked)
7.	Red meat	Beef, lamb, pork (not fried)
8.	Organ meat	Pig and other animals' bowels, blood (not fried)
9.	Poultry	Chicken, duck, goose (not fried)
10.	Fish and other fishery products	Fish, shrimp (not fried)
11.	Processed meat	Sausage, ham
12.	Preserved meat	Preserved pork, preserved beef
13.	Chinese traditional meat dishes	Meat balls
14.	Egg	Egg (including yolk)
15.	Western fast food	Hamburger, pizza
16.	Chinese fast food	Steamed stuffed-bun, Chinese hamburger
17.	Fried meat	Chicken, beef, pork (fried)
18.	Fried vegetables	Potato, sea tangle, soya products (fried)
19.	Roast meat	Shish kebab (Chinese traditional dish)
20.	Fried pasta	Twisted cruller (Chinese style), spring roll
21.	Fresh yellow or red vegetables	Carrot, tomato, big capsicums (all not fried)
22.	Fresh green leafy vegetables	Spinach, Chinese cabbage, leaf lettuce
23.	Fresh fruit	Apple, orange, banana
24.	Preserved fruit	Prune, raisin
25.	Soya products	Tofu, dried tofu
26.	Soya milk	Soya milk
27.	Milk	Raw milk, powdered milk (including whole, low-fat or fat-free milk)
28.	Yoghurt	Yoghurt (including frozen yoghurt)
29.	Sweet course	Cake, biscuit, cookie
30.	Ice cream	Ice cream, ice cream bars (including low-fat or fat-free)
31.	Chocolate	Chocolate, chocolate wafer
32.	Candy	Candy
33.	Nuts	Peanut, walnut, melon seed, cashew
34.	Tea	Tea, tea drink
35.	Carbonated beverages	Cola, sprite
36.	Flavoured milk drink	Flavoured milk drink
37.	Fruit/vegetable juice	Tomato juice, orange juice
38.	Sauerkraut	Pickle, salted egg

The distribution of students' sociodemographic and anthropometric characteristics across the three dietary patterns is shown in Table 3. A higher consumption of the snack dietary pattern was associated with female gender, being an only child in the family, higher level of maternal and paternal education, and age- and gender-adjusted lower BMI and WHtR. An increased frequency of consuming the animal dietary pattern was generally associated with male gender, being an only child in the family, lower level of maternal and paternal education, older age, and age- and gender-adjusted lower BMI and WHtR. Among those who followed a traditional dietary pattern, higher scores were associated with female gender, being an only child in the family, higher family income, higher maternal and paternal education level and younger age.

Table 4 contains data on the prevalence of depression and anxiety disorders and the associated sociodemographic and anthropometric characteristics. The prevalence of depression, anxiety and coexisting depression and anxiety was 11·2 %, 14·6 %, and 12·6 %, respectively. A high risk of depression or anxiety was associated with girls, being an only child in the family, low maternal and paternal educational level, low family income and lack of physical activity.

Table 5 shows that the prevalence of mental disorders, especially coexisting depression and anxiety, was associated with higher tertiles of the snack and animal food dietary pattern scores; however, an inverse correlation was observed between the traditional dietary pattern and depression and anxiety.

Results from multiple logistic regression analyses, with all three dietary patterns entered simultaneously as exposure variables, and categorical pure depression, pure anxiety and coexisting depression and anxiety as outcomes, demonstrated that the highest tertile scores in the snack dietary pattern were associated with higher odds for depression and anxiety disorders, associations which were strengthened by all adjustments for age, gender, maternal and paternal education, family income, BMI and physical activity in model 3 (Table 6). The traditional dietary pattern was associated with decreased odds for the three categories of mental disorders in the unadjusted and adjusted analyses.

Table 2 Factor-loading matrix for the major factors (diet patterns) identified using food consumption data from the FFQ*: adolescents (*n* 5003) aged 11–16 years, Bengbu, China, 2010

Food or food group	Snack	Animal food	Traditional
Pancake	–	0·39	0·24
Red meat	–	0·50	0·33
Organ meat	–	0·53	0·25
Poultry	–	0·60	0·24
Fish and other fishery products	–	0·45	0·32
Processed meat	–	0·61	–
Bacon	0·22	0·65	–
Meat balls	0·21	0·55	–
Steamed stuffed-bun	–	0·51	–
Fried meat	0·44	0·54	–
Fried vegetables	0·40	0·41	–
Roast meat	0·42	0·49	–
Sauerkraut	–	0·32	–
Fried pasta	0·26	0·43	–
Fast food	0·45	0·42	–
Preserved fruit	0·55	–	0·28
Yoghurt	0·45	–	0·38
Sweet course	0·54	0·20	0·22
Frozen confection	0·56	0·30	–
Chocolate	0·60	–	–
Candy	0·57	–	–
Nut	0·49	–	0·20
Tea or tea drink	0·52	0·28	–
Carbonated drinks	0·54	0·37	–
Flavoured milk drink	0·60	–	–
Fruit/vegetable juice	0·53	–	0·27
Staple food (for Chinese)	–	–	0·42
Gruel	–	–	0·52
Oatmeal	–	–	0·32
Whole grains	–	–	0·47
Egg	–	0·22	0·55
Fresh yellow or red vegetables	–	–	0·66
Fresh green leafy vegetables	–	–	0·73
Fresh fruit	0·25	–	0·63
Soya products	–	–	0·54
Soya milk	0·27	–	0·47
Milk	0·23	–	0·51

*Absolute values <0·20 were not listed in the table for simplicity. 'Bread' item was excluded.

Discussion

In the present cross-sectional study among Chinese students attending junior high school, we have demonstrated a relationship between major dietary patterns and mental disorders. We used factor analysis to identify three major dietary patterns, specifically snack, animal food and traditional dietary patterns, which explained 35 % of the variance. The value was low but similar to the outcomes in previous studies[29,30].

High intakes of snacks and animal foods were shown to be associated with mental disorders, and a high intake of a traditional diet was associated with a decreased likelihood of mental disorders. These findings provide a new viewpoint for a multi-focus intervention aiming to improve mental health in Chinese adolescents.

The results suggest that high consumption of unhealthy diets (animal food and snack patterns), rich in energy-dense but nutrient-poor foods and snacks, is associated with a higher risk of depression and anxiety. These findings are in agreement with two recent epidemiological studies[31,32]. Specifically, a positive correlation was shown between snack food intake and mental disorders among adults and older adolescents. Evidence from an observational study in Asian countries suggests that there is a correlation between sugar consumption and the annual rate of depression[33]. In a survey of 2579 Chinese college students, the relationship between food consumption frequency, perceived stress and depression was studied, and a higher intake of snack foods was shown to be significantly associated with depression[32]. Overconsumption of snacks may contribute to excessive energy, fat and sugar intakes in adolescents, and snacks provide few of the micronutrients which are essential for optimal neurotransmitter function and involved in the pathologies of various psychiatric disorders, such as depression, anxiety, panic disorder and personality disorders[34,35].

In the current study gender was an important determinant of intake with respect to snack diets. Girls consumed more snack foods than boys. The findings are also supported by previous conclusions that females were ambivalent towards eating snacks, perceiving snacks as unhealthy, but preferred to eat especially under stress[36,37]. However, other authors have reported in Australian children and adolescents that boys had more extra food intake compared with girls[38].

The traditional diet pattern, consisting of whole grains, fruits, vegetables, rice and some soya products, was inversely associated with the prevalence of psychological symptoms in our study. The findings herein are supported by findings from the Seguimiento Universidad de Navarra (SUN) prospective cohort study[39]. In the SUN study adherence to a Mediterranean diet, ensuring adequate intakes of fruits, nuts, vegetables, cereals, legumes and fish, was considered an important protector against depression in adolescents[39]. In addition to the aforementioned whole diet patterns, increased intakes of individual foods, such as vegetables, fruits, dairy and cereals, have also been linked with promoting or maintaining a healthy mental status[40–43]. In the 1970 British cohort study[44], children with higher mental abilities reported more frequent intakes of fruits, vegetables, wholegrain bread and low-fat meats, but lower intakes of chips, non-wholegrain bread and snacks as adults. In recent years, Western foods have become more available and popular among children and adolescents relative to traditional diet alternatives[23,45]. Therefore, we suggest that further research regarding the impact of a decreased intake of healthy foods on mental disorders is needed.

With respect to the validity of capturing complex behaviours and potentially interactive effects among special nutrients that might impact mental health, there is growing recognition that special dietary patterns and their effects on mental health should be of concern in adolescents. In a recent study in Australia, Robinson *et al.*[10] examined

Table 3 Distribution of demographic/anthropometric characteristics according to tertile of dietary pattern scores: adolescents (*n* 5003) aged 11–16 years, Bengbu, China, 2010

	Snack				Animal food				Traditional			
	T1 (*n* 1661)	T2 (*n* 1648)	T3 (*n* 1694)		T1 (*n* 1662)	T2 (*n* 1647)	T3 (*n* 1694)		T1 (*n* 1653)	T2 (*n* 1644)	T3 (*n* 1706)	
	%	%	%	*P**	%	%	%	*P**	%	%	%	*P**
Sex†												
Male	38·1	31·0	30·9	<0·001	24·2	32·5	43·3	<0·001	34·8	32·4	32·8	0·02
Female	27·9	35·0	37·0		43·0	33·4	23·6		31·2	33·4	35·5	
Only child†												
Yes	34·5	32·3	33·1	<0·001	34·1	31·9	33·9	0·01	30·3	33·1	36·6	<0·001
No	28·7	35·0	36·3		30·1	36·3	33·6		42·7	31·9	25·5	
Family income†												
Low	44·9	29·3	25·8	<0·001	32·0	32·0	35·9	0·40	35·2	34·0	30·9	<0·001
Middle	33·7	34·3	32·0		32·6	33·7	33·7		35·2	32·6	32·2	
High	30·0	30·6	39·4		34·9	31·2	33·9		27·8	33·1	39·0	
Maternal education†												
Primary schooling/illiterate	36·5	33·5	30·0	0·04	27·7	36·3	36·0	<0·001	46·7	31·4	21·9	<0·001
Secondary schooling	32·3	33·4	34·2		31·8	33·1	35·1		34·6	32·5	32·9	
University or more	34·6	32·9	32·6		36·6	32·2	31·3		23·4	34·4	42·2	
Unknown	33·2	32·9	33·9		36·4	31·0	32·6		44·0	31·0	24·9	
Paternal education†												
Primary schooling/illiterate	32·6	33·6	33·9	0·05	25·7	35·9	38·5	<0·001	50·7	29·3	20·1	<0·001
Secondary schooling	31·9	33·0	35·1		31·0	33·5	35·4		36·4	33·4	30·3	
University or more	35·6	33·0	31·3		37·5	31·7	30·8		23·3	33·6	43·1	
Unknown	29·9	31·6	38·5		33·0	32·1	34·9		45·5	28·5	26·0	

	Mean	SE	Mean	SE	Mean	SE	*P*	Mean	SE	Mean	SE	Mean	SE	*P*	Mean	SE	Mean	SE	Mean	SE	*P*
Age	13·21	0·02	13·14	0·02	13·20	0·02	0·11	13·11	0·02	13·21	0·99	13·26	0·02	<0·001	13·26	0·02	13·16	0·02	13·12	0·02	<0·001
BMI‡	20·73	0·09	20·44	0·09	20·22	0·09	<0·001	20·73	0·09	20·48	0·09	20·19	0·09	<0·001	20·39	0·09	20·51	0·09	20·49	0·09	0·61
WHtR‡	0·44	0·002	0·43	0·002	0·43	0·002	<0·001	0·44	0·002	0·44	0·002	0·43	0·002	0·86	0·44	0·002	0·44	0·002	0·43	0·002	0·11

T1, lowest tertile of dietary pattern's score; T2, intermediate tertile of dietary pattern's score; T3, highest tertile of dietary pattern's score; WHtR, waist-to-height ratio.
*ANOVA was used for continuous variables and the χ^2 test for categorical variables to calculate *P* for trend across categories of dietary pattern.
†Values were unadjusted.
‡*P* value adjusted for age and gender.

Table 4 Association between demographic/anthropometric characteristics and pure depression, pure anxiety and coexisting depression and anxiety: adolescents (*n* 5003) aged 11–16 years, Bengbu, China, 2010

	Pure depression* (*n* 560, 11·2 %)			Pure anxiety† (*n* 732, 14·6 %)			Coexisting depression and anxiety (*n* 629, 12·6 %)		
	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*
Gender									
Female	1·40	1·15, 1·71	<0·001	1·04	0·87, 1·26	0·65	1·47	1·22, 1·78	<0·001
Male	1·00			1·00			1·00		
Age (years)‡									
15~	1·24	0·89, 1·74	0·21	0·91	0·66, 1·24	0·54	2·10	1·53, 2·88	<0·001
13–14	1·16	0·94, 1·42	0·17	1·04	0·87, 1·25	0·64	1·73	1·40, 2·14	<0·001
12~	1·00			1·00			1·00		
Maternal education‡									
Unknown	0·93	0·63, 1·36	0·70	0·78	0·52, 1·16	0·22	0·88	0·61, 1·27	0·50
University or more	0·57	0·42, 0·78	<0·001	0·85	0·63, 1·15	0·30	0·49	0·36, 0·67	<0·001
Secondary schooling	0·67	0·51, 0·90	0·01	1·00	0·75, 1·32	0·98	0·70	0·54, 0·92	0·01
Primary schooling/illiterate	1·00			1·00			1·00		
Paternal education‡									
Unknown	0·64	0·42, 0·95	0·03	0·81	0·52, 1·25	0·33	0·74	0·49, 1·11	0·15
University or more	0·42	0·31, 0·58	<0·001	0·86	0·62, 1·21	0·39	0·49	0·35, 0·67	<0·001
Secondary schooling	0·45	0·33, 0·61	<0·001	0·96	0·69, 1·33	0·80	0·70	0·51, 0·95	0·02
Primary schooling/illiterate	1·00			1·00			1·00		
Family income‡									
Low	1·67	1·18, 2·36	<0·001	0·97	0·68, 1·40	0·89	1·90	1·39, 2·59	<0·001
Middle	1·00			1·00			1·00		
High	1·04	0·85, 1·26	0·71	0·96	0·81, 1·15	0·68	0·71	0·58, 0·86	<0·001
Physical activity (d/week)‡									
0	1·00			1·00			1·00		
1	0·78	0·62, 0·98	0·03	0·96	0·77, 1·20	0·74	0·75	0·60, 0·94	0·01
2	0·66	0·51, 0·84	<0·001	1·21	0·97, 1·51	0·10	0·64	0·50, 0·81	<0·001
3 or more	0·50	0·39, 0·65	<0·001	0·87	0·69, 1·09	0·21	0·55	0·44, 0·70	<0·001
BMI (kg/m^2)									
<18·5	1·02	0·84, 1·24	0·85	0·92	0·77, 1·09	0·34	0·82	0·68, 0·99	0·04
18·5–23·9	1·00			1·00			1·00		
24·0–27·9	1·19	0·91, 1·57	0·21	0·89	0·69, 1·16	0·40	0·79	0·60, 1·05	0·11
≥28·0	0·78	0·49, 1·25	0·31	0·81	0·54, 1·21	0·31	0·89	0·59, 1·34	0·58
WHtR									
<0·5	1·00			1·00			1·00		
≥0·5	1·13	0·88, 1·45	0·35	0·93	0·74, 1·18	0·57	0·85	0·66, 1·10	0·21
Weight stature									
Normal	1·00			1·00			1·00		
Lean	1·00	0·81, 1·23	1·00	1·03	0·85, 1·24	0·76	1·07	0·87, 1·31	0·54
Overweight/obese	0·95	0·77, 1·19	0·67	1·13	0·93, 1·37	0·22	1·35	1·11, 1·65	<0·001

WHtR, waist-to-height ratio.
*Depression self-rating scale score ≥15.
†Child anxiety related emotional disorders scale score ≥23.
‡Self-reported variables.

lifestyle and demographic factors to identify the associations with mental problems (withdrawal, anxiety and depression, somatic complaints, delinquency, aggression) among younger adolescents. Six food groups were derived from a 212-item FFQ. The authors concluded that a higher intake of a 'meat food' diet pattern and an 'extra food' diet pattern (such as takeaway and snack foods) were significantly associated with a higher score on the Child Behaviour Checklist for Ages 4–18.

Although many studies have indicated a relationship between diet and mental disorders, the mechanisms are still not well understood. Some researchers have attempted to explain how diet and nutrition modulate biological processes underpinning mental disorders[46,47]; individual nutrients are often highlighted. Nutrients such as vitamin C, vitamin B_{12}, folate, *n*-3 fatty acids and α-linolenic acid, flavonoids and Zn have been verified to maintain psychological well-being. A recent finding also suggested that *trans*-unsaturated fatty acids have a dose–response effect on clinical depression[48]. Therefore, the intake of special nutrients is often considered a mediator of the association between whole diet and mental problems[49–52].

In the current study the prevalence of depression, anxiety and coexisting depression and anxiety was 11·2 %, 14·6 %, and 12·6 %, respectively. The rates of depression, anxiety and coexisting depression and anxiety are in agreement with previous studies regarding psychological symptoms. For example, by using the self-rating scale of the DSM-IV (*Diagnostic and Statistical Manual of Mental Disorders*, 4th edition) for major depression symptoms, the prevalence of depression was 18·9 % and 17·0 %,

Table 5 Prevalence of mental symptoms by tertile of dietary pattern scores: adolescents (*n* 5003) aged 11–16 years, Bengbu, China, 2010

		Without depression and anxiety		Pure depression		Pure anxiety		Coexisting depression and anxiety			
Dietary pattern	*n*	*n*	%	*n*	%	*n*	%	*n*	%	χ^2	*P*
Snack											
T1	1661	1115	67·1	177	10·7	195	11·7	174	10·5	63·21	<0·001
T2	1648	1039	63·0	160	9·7	254	15·4	195	11·8		
T3	1694	928	54·8	223	13·2	283	16·7	260	15·3		
Animal food											
T1	1662	1065	64·1	183	11·0	215	12·9	199	12·0	19·93	0·003
T2	1647	1033	62·7	191	11·6	234	14·2	189	11·5		
T3	1694	984	58·1	186	11·0	283	16·7	241	14·2		
Traditional											
T1	1653	890	53·8	266	16·1	232	14·0	265	16·0	122·28	<0·001
T2	1644	1021	62·1	172	7·2	245	14·9	206	12·5		
T3	1706	1171	68·6	122	7·2	255	14·9	158	9·3		

T1, lowest tertile of dietary pattern's score; T2, intermediate tertile of dietary pattern's score; T3, highest tertile of dietary pattern's score.

Table 6 Odds ratios (95 % confidence intervals) from multiple logistic regression models for pure depression, pure anxiety and coexisting depression and anxiety according to tertile of dietary pattern scores adolescents (*n* 5003) aged 11–16 years, Bengbu, China, 2010

	Pure depression			Pure anxiety			Coexisting depression and anxiety		
	OR*	95 % CI	*P*	OR*	95 % CI	*P*	OR*	95 % CI	*P*
Model 1†									
Snack									
T2	0·92	0·73, 1·67	0·49	1·50	1·22, 1·85	<0·001	1·21	0·96, 1·52	0·10
T3	1·53	1·23, 1·91	<0·001	1·85	1·50, 2·27	<0·001	1·84	1·48, 2·28	<0·001
Animal food									
T2	1·06	0·84, 1·33	0·64	1·23	1·00, 1·51	0·05	1·02	0·82, 1·27	0·88
T3	1·09	0·87, 1·37	0·45	1·56	1·27, 1·91	<0·001	1·37	1·11, 1·70	<0·001
Traditional									
T2	0·57	0·46, 0·71	<0·001	0·96	0·78, 1·17	0·68	0·70	0·57, 0·86	<0·001
T3	0·34	0·27, 0·43	<0·001	0·84	0·69, 1·03	0·09	0·44	0·36, 0·55	<0·001
Model 2‡									
Snack									
T2	0·93	0·73, 1·19	0·58	1·49	1·20, 1·85	<0·001	1·24	0·98, 1·56	0·08
T3	1·56	1·24, 1·96	<0·001	1·83	1·48, 2·26	<0·001	1·86	1·48, 2·34	<0·001
Animal food									
T2	1·09	0·87, 1·38	0·46	1·35	1·09, 1·67	0·01	1·10	0·88, 1·40	0·38
T3	1·20	0·95, 1·53	0·13	1·88	1·52, 2·33	<0·001	1·71	1·36, 2·15	<0·001
Traditional									
T2	0·58	0·46, 0·72	<0·001	0·97	0·78, 1·19	0·75	0·72	0·58, 0·89	<0·001
T3	0·35	0·28, 0·45	<0·001	0·85	0·69, 1·05	0·13	0·47	0·37, 0·59	<0·001
Model 3§									
Snack									
T2	0·98	0·77, 1·25	0·86	1·38	1·08, 1·65	0·01	1·27	1·00, 1·61	0·05
T3	1·64	1·30, 2·06	<0·001	1·87	1·51, 2·31	<0·001	1·93	1·54, 2·43	<0·001
Animal food									
T2	1·08	0·86, 1·37	0·46	1·34	1·08, 1·65	0·01	1·10	0·88, 1·39	0·41
T3	1·21	0·95, 1·53	0·13	1·87	1·51, 2·32	<0·001	1·71	1·37, 2·15	<0·001
Traditional									
T2	0·61	0·49, 0·76	<0·001	0·98	0·79, 1·23	0·82	0·74	0·60, 0·92	0·01
T3	0·38	0·30, 0·49	<0·001	0·85	0·69, 1·04	0·12	0·50	0·39, 0·63	<0·001

T1, lowest tertile of dietary pattern's score; T2, intermediate tertile of dietary pattern's score; T3, highest tertile of dietary pattern's score.
*T1 as reference group in all models.
†Model 1: unadjusted.
‡Model 2: adjusted for age, gender, maternal education, paternal education, family income and BMI.
§Model 3: adjusted per model 2 plus physical activity.

respectively, among 15- and 17-year-old adolescents in Sweden[53]. In the present study we screened mental symptoms by using psychological scales rather than clinical diagnostic criteria. Thus, the observed prevalence of mental symptoms was indeed higher than that of major depression and anxiety[54]. As a result, the interpretation of the results should be made with caution. In recent decades, Chinese society has experienced a massive socio-economic change and culture shock. Added to intense competition in education, psychological and

behavioural problems are gradually increasing in the adolescent population. The high prevalence of depression and anxiety in the present findings also reveals that promoting adolescent mental health is needed in China.

There were several limitations in our study. The study had a cross-sectional design, which limited the conclusions to aetiological inferences that unhealthy dietary patterns may lead to mental conditions. Unhealthy food choices may be compensatory mechanisms for mental disorders, rather than a causative factor. It has been shown that depressed individuals report greater preferences for carbohydrates (especially high-carbohydrate foods), increased serotonin release and relief of stress[55], compared with individuals without depression. Therefore, in a further study, a longitudinal design would preclude reverse causality existing in the findings. Except for morphological indices, all other information was self-reported by adolescents and subject to social desirability bias. The rate of unhealthy diets or other risk behaviours may be underestimated. The study used psychological screening scales rather than clinical diagnostic criteria to evaluate depressive symptoms and anxiety, which might lead to an overestimate of the incidence of depression or anxiety in adolescents. The adolescents who participated in the study were mainly from urban areas with Han nationality and lived in the same city, thus affecting the sample representation and further generalization of the results. There are various kinds of foods in the Chinese diet such that it is difficult for younger adolescents to recall portion size of foods they have eaten several days before. The FFQ was designed so that interviewees could provide answers more easily, without information on the portion size of each food item. As a result, the FFQ is limited with respect to the variability of the food consumption. It is impossible to rule out residual confounding or information bias by family variables as a factor in these findings.

Conclusions

Our study was designed to determine the association between overall diet and depression and anxiety symptoms in a large sample of Chinese adolescents. It was found that the snack and animal food patterns were associated with a high risk of depression and anxiety, while the traditional diet pattern was associated with a low risk for them after adjustment for relevant confounders. The study provided epidemiological evidence of a robust association of traditional, snack and animal food diets with mental symptoms in Chinese urban adolescents. Additional cohort studies involving dietary patterns and mental disorders in Chinese children and adolescents are warranted to investigate the predictive effect of habitual dietary behaviours on mental health in adolescence, as well as adulthood.

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