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Adherence to Dietary Guidelines and Nutritional Awareness Among a Population of Chinese University Students: Comparative Analysis Across Sex, Ethnicity, and BMI Groups

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ABSTRACT: University students, transitioning from adolescence to adulthood, are at a critical stage where dietary habits and health behaviors are established, influencing long-term health outcomes. This study aimed to assess the dietary intake and nutritional awareness of a population of Chinese university students (n=833), comparing their consumption with national dietary guidelines and reference intakes, while exploring subgroup differences. Results indicated that males had significantly higher amounts of most food categories compared to females. Except for whole grains and legumes, ethnic minorities had lower compliance with the recommended intakes for several food categories compared to Han Chinese. Han males consumed more energy, protein, and fat than their ethnic minority counterparts. Obese participants showed higher protein and fat intake compared to those with normal body mass index (BMI). Additionally, BMI-related trends in macronutrient contributions showed that protein and fat contributed more to the total energy intake of individuals with higher BMI. Han individuals also had higher energy contributions from protein and fat and lower carbohydrate contributions compared to ethnic minorities. Nutrient intake was generally below recommended levels, with low proportions of participants meeting the recommended intake for Vitamin A, C, calcium and dietary fiber. High proportions of participants exceeded the tolerable upper intake levels for iron and manganese. Nutritional awareness scores were also significantly higher among Han students, as well as those with higher BMIs and higher income levels. This study highlights significant disparities in dietary intake and nutritional awareness among Chinese university students, with variations across sex, ethnicity, BMI, and income categories.

1. Introduction

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University students are at a critical stage of transitioning from adolescence to adulthood, during which dietary habits and health behaviors are often established, influencing long-term health outcomes(1). This life phase is also marked by unique challenges, such as increased autonomy over food choices, exposure to new social environments and food cultures, and limited financial resources, all of which can significantly impact dietary patterns(2). Research suggests that university students often fail to meet dietary recommendations, with unhealthy behaviors such as low intake of fruits and vegetables and excessive consumption of fast foods and sugary products becoming increasingly prevalent(3, 4). These habits not only compromise immediate health but may also contribute to chronic disease risks later in life(5).

In China, rapid economic development and changing lifestyles have further transformed dietary consumption patterns among young adults, including university students(6, 7). The shift from structured high school routines to the relative freedom of university life has been linked to poor adherence to dietary guidelines and suboptimal nutritional practices(1, 8-10). For instance, a nationwide survey across 30 provinces has shown that university students aged 18-25 exhibit the lowest compliance with the Dietary Guidelines for Chinese Residents, reflecting insufficient knowledge and implementation of balanced eating principles(11).

The 2022 Chinese Dietary Guidelines (CDG) and the Dietary Reference Intakes (DRIs) for China (2023 edition) serve as foundational documents for public health education and policy, supporting national initiatives such as the Healthy China Action Plan (2019–2030) and the National Nutrition Plan (2017–2030)(7, 12-14). These guidelines, developed through rigorous scientific principles and extensive research, provide evidence-based recommendations tailored to China's population. They aim to promote healthy eating habits, improve nutritional awareness, and address key health challenges, including the prevention of chronic diseases and nutrition-related conditions among Chinese populations including students(7). Understanding university students' dietary intake and nutritional awareness in the context of these national strategies is essential. Research on university students' adherence to these dietary recommendations can provide potential insights into their eating behaviors and the factors influencing them.

Given these considerations, this study investigated the dietary intake and nutritional awareness among a population of Chinese university students, comparing their nutritional intake to the latest CDG (2022) and the DRIs for China (2023 edition). Moreover, subgroup analyses by sex, ethnicity and body mass index (BMI) were conducted to identify disparities among different groups and provide insights for tailoring interventions to specific population needs. By aligning the analysis with national public health initiatives, this research aims to contribute to the ongoing efforts to promote healthier eating habits and improve long-term health outcomes in this key population group.

2. Materials and Methods

2.1 Study design and participants

From October 2022 to January 2024, this study was carried out involving 845 volunteer university students. Data collection was conducted through an anonymous online questionnaire hosted on the platform

(<https://www.wjx.cn/>). Participants could consult researchers if needed when the survey was administered in virtual meeting rooms. The questionnaire gathered information on socio-demographic factors, lifestyle habits, dietary intake, and nutritional awareness. Following quality checks, 9 questionnaires were excluded due to incomplete identification data, and 3 were determined to be non-genuine responders, leaving 833 valid questionnaires for analysis (Supplementary Figure S1). The study adhered to the principles of the Declaration of Helsinki and received approval from the Ethics Committee of Nanjing Municipal Center for Disease Control and Prevention (NJCDCLL. No. 2023012).

2.2 Socio-demographic characteristics and lifestyles

Socio-demographic characteristics included sex, age, ethnicity, annual per capita family income (<10,000, 10,000-59,999, 60,000-99,999, $\geq 100,000$ RMB), height, and weight. BMI was calculated as weight (kg) divided by height squared (m^2) and categorized as underweight ($<18.5 \text{ kg/m}^2$), normal weight ($18.5\text{--}23.9 \text{ kg/m}^2$), overweight ($24.0\text{--}27.9 \text{ kg/m}^2$), and obesity ($\geq 28.0 \text{ kg/m}^2$) based on Chinese standards(15). Information on current smoking and drinking status was collected, with alcohol intake estimated in units (1 unit = 8 g or 10 mL pure alcohol(16)) using standard ethanol contents per 100 mL of common Chinese alcoholic beverages. Physical activity data included the average daily outdoor activity duration and energy expenditure from exercise (kcal/d), which was calculated using metabolic equivalents (METs) of 9 for vigorous activities and 5 for moderate activities, along with body weight.

2.3 Estimation of dietary intake, nutrient intake and nutritional awareness

Dietary data for the past year were collected using a detailed, validated food frequency questionnaire (FFQ) tailored for Chinese residents(17-19). The FFQ included 86 specific food items categorized into 11 major groups: staple foods, legumes, vegetables, fungi and algae, fruits, dairy products, meats, seafood, eggs, snacks and sweets, and beverages and condiments. Food consumption frequencies were recorded as occurrences per day, week, month, or year and standardized to weekly occurrences for analysis. The average portion size for each food item, reported in grams, was used to calculate the average daily intake. To ensure accuracy, the FFQ provided detailed completion guidelines, such as recording food weights (e.g., raw, dry, fresh, or edible portions), instructions for seasonal foods (e.g., reporting occurrences per month or year), and portion size examples based on standard adult servings. If participants had questions during the survey, they could consult researchers either in person or through virtual meeting platforms. The total daily energy and nutrient intakes for each participant—including macronutrients (protein, fat, carbohydrates) and micronutrients (e.g., vitamins A, C, E, thiamin, riboflavin, niacin, calcium, phosphorus, potassium, sodium, magnesium, iron, zinc, selenium, copper, and manganese)—were calculated using nutrient composition data from China Food Composition 2002(20). These intake data were then compared with the recommendations in the latest CDG (2022), specifically its Food Based Dietary Guidelines (FBDG), as well as the DRIs for China (2023 edition), to assess compliance and identify potential nutritional gaps.

The questionnaire on dietary and nutritional awareness consisted of four dimensions: dietary recommendations, food characteristics, nutrition and disease, and general nutrition knowledge. Each correct

answer was awarded 1 point, while incorrect answers received no points. The maximum scores for these sections were 18, 13, 13, and 11, respectively, resulting in a total possible score of 55 points. Higher total scores indicated potentially better nutritional awareness.

2.4 Statistical analysis

Depending on the data's normality, continuous variables were presented as either mean $\pm$ standard deviation (SD) or median $\pm$ interquartile range (IQR). Comparisons between groups were conducted using appropriate statistical tests based on the distribution and characteristics of the data. For continuous variables, the Shapiro-Wilk test was used to assess normality. When data were normally distributed and exhibited homogeneity of variance (as assessed by Levene's test), comparisons between two groups were performed using the two independent samples t-test, and comparisons among more than two groups were conducted using one-way ANOVA. In cases where the data were not normally distributed or variances were unequal, the non-parametric Mann-Whitney U-test was applied for two-group comparisons, and the Kruskal-Wallis test was used for comparisons involving multiple groups. For categorical data, the Chi-square (χ^2) test was used when the total sample size exceeded 40 and the expected frequency was ≥ 5 , while Fisher's exact test was applied when the total sample size was less than 40 and the expected frequency was < 5 . Statistical analyses were carried out using IBM SPSS Statistics version 22.0 (SPSS Inc., Chicago, IL, USA), and a P -value < 0.05 was considered statistically significant. Figures were generated using OriginPro 2021 and BioRender (BioRender.com).

3. Results

3.1 Characteristics of the participants

Table 1 summarizes the demographic and lifestyle characteristics of the participants. The study population included 390 males (46.8%) and 443 females (53.2%), with ages ranging from 17 to 27 years. The mean age was comparable between males (20.76 ± 1.59) years and females (20.77 ± 1.63) years, showing no significant difference ($P > 0.05$). In terms of BMI, males had a higher average value of (22.39 ± 3.29) compared to (20.75 ± 2.65) for females ($P < 0.001$). More males were categorized as overweight or obese, while a greater percentage of females fell into the normal and underweight categories. The study also included 583 participants of Han ethnic group (70.0%) and 250 from various ethnic minority groups (30.0%), comprising 150 Uyghur, 29 Tibetan, 11 Hui, 6 Zhuang, 5 Manchu, 4 Miao, 4 Yi, 4 Tujia, 4 Mongolian, and 33 from other minority groups. The proportion of Han ethnic group was significantly higher among males compared to females in this study ($P < 0.001$). Smoking prevalence was relatively low at 3.4%, but males had a significantly higher rate of smoking (5.9%) than females (1.1%). Additionally, the proportion of non-drinkers was significantly lower in males than in females (50.0% vs. 72.5%), whereas males were more likely to consume over 30 alcohol units per year (24.9% vs. 7.7%). Average daily outdoor activity duration was (2.73 ± 2.19) hours for males and (2.83 ± 2.28) hours for females, with no significant difference ($P >$

0.05). However, males had a significantly higher median energy expenditure from exercise, recorded at 253.34 (86.67-522.04) kcal/d, compared to 111.35 (7.53-274.71) kcal/d for females ($P < 0.001$).

Table 1. Characteristics of Participants[#]

Category	Total (n=833)	Male (n=390)	Female (n=443)	P
Age (years)	20.76 ± 1.61	20.76 ± 1.59	20.77 ± 1.63	0.889 [*]
BMI (kg/m²)	21.52 ± 3.08	22.39 ± 3.29	20.75 ± 2.65	<0.001 [*]
18.5-23.9 (normal)	607 (72.9%)	269 (69.0%)	338 (76.3%)	<0.001 [†]
<18.5 (underweight)	100 (12.0%)	31 (7.9%)	69 (15.6%)	-
24.0-27.9 (overweight)	89 (10.7%)	64 (16.4%)	25 (5.6%)	-
≥28.0 (obesity)	37 (4.4%)	26 (6.7%)	11 (2.5%)	-
Annual per capita household income (RMB)				
<10,000	189 (22.7%)	90 (23.1%)	99 (22.3%)	0.425 [†]
10,000-59,999	472 (56.7%)	216 (55.4%)	256 (57.8%)	-
60,000-99,999	74 (8.9%)	41 (10.5%)	33 (7.4%)	-
≥100,000	98 (11.8%)	43 (11.0%)	55 (12.4%)	-
Ethnic group				
The Han ethnic group	583 (70.0%)	296 (75.9%)	287 (64.8%)	<0.001 [†]
Ethnic minority	250 (30.0%)	94 (24.1%)	156 (35.2%)	-
Current smoking status				
Non-smoker	805 (96.6%)	367 (94.1%)	438 (98.9%)	<0.001 [†]
Current smoker	28 (3.4%)	23 (5.9%)	5 (1.1%)	-
Current drinking status (alcohol units consumed/year, 1 unit is 8 g or 10 mL of pure alcohol)				
Non-drinker	516 (61.9%)	195 (50.0%)	321 (72.5%)	<0.001 [†]
≤5	91 (10.9%)	46 (11.8%)	45 (10.2%)	-
5.1-30	95 (11.4%)	52 (13.3%)	43 (9.7%)	-
>30	131 (15.7%)	97 (24.9%)	34 (7.7%)	-
Energy expenditure from exercise (kcal/d)	162.79 (36.90-385.71)	253.34 (86.67-522.04)	111.35 (7.53-274.71)	<0.001 [§]
Outdoor activity duration (h/d)	2.79 ± 2.23	2.73 ± 2.19	2.83 ± 2.28	0.510 [*]

[#] Values are means ± SDs, medians (IQRs), or n (percentages).

^{*} P value of two independent samples *t*-test.

[†] P value of Chi-square (χ^2) test (theoretical frequency ≥ 5).

[§] P value of Mann-Whitney-U-test.

3.2 Intake of food categories

Table 2 presents the intake of various food categories and the proportion of individuals meeting the minimum recommended intake for adults as specified by the FBDG. Compared to females, males exhibited significantly higher consumption of cereals, fresh vegetables, dairy products, soybeans and soy products, poultry and red meat, eggs, and sugar-sweetened or carbonated beverages, while their intake of starchy roots and tubers was significantly lower ($P < 0.05$). Additionally, a significantly larger proportion of males met the minimum recommended intake for cereals, whole grains and legumes, dairy products, soybeans and soy products, poultry and red meat, aquatic products, fish, and eggs ($P < 0.05$). Among these foods, the proportion meeting the recommended intake for cereals, soybeans and soy products, and poultry and red meat was relatively high, with both males and females exceeding 60%. In contrast, the proportion meeting the recommended intake for eggs was lower, with both genders below 50%, while the proportions for other foods were very low, all below 30%. Among these, fish had the lowest compliance, with only 15.9% of males and 9.5% of females meeting the recommended intake. In addition, Supplementary Tables S1 and S2 present the intake of food categories and the proportion meeting the minimum recommended intake among males and females, respectively, across different BMI groups. Among males, compared to the normal weight group, the overweight and obesity groups had significantly higher intakes of vegetables, fruits, dairy products, soybeans

and soy products, poultry and red meat, aquatic products, eggs, sugar-sweetened or carbonated beverages, and coffee or tea beverages ($P < 0.05$). Among females, compared to the normal weight group, the obesity group had significantly higher intakes of nuts and poultry and red meat ($P < 0.05$).

Table 2. Intake of Food Category and Proportion of Individuals Meeting the Minimum Recommended Intake for Adults of the Food Based Dietary Guidelines in The Chinese Dietary Guidelines (2022)[#]

Food category	Recommended intake	Male (n=390)	Female (n=443)	P
Cereals (g/d)	200~300 g/d	377.78 (243.81, 657.14) 325 (83.3%)	248.10 (144.03, 410.71) 271 (61.2%)	<0.001* <0.001†
Whole grains and legumes (g/d)	50~150 g/d	4.23 (0.00, 30.00) 77 (19.7%)	3.33 (0.00, 21.00) 59 (13.3%)	0.599* 0.012†
Starchy roots and tubers (g/d)	50~100 g/d	0.14 (0.00, 17.32) 65 (16.7%)	3.33 (0.00, 28.57) 67 (15.1%)	0.034* 0.543†
Fresh vegetables (g/d)	300~500 g/d	154.40 (59.67, 342.95) 107 (27.4%)	111.80 (42.60, 290.29) 108 (24.4%)	0.017* 0.314†
Fresh fruit (g/d)	200~350 g/d	61.23 (13.51, 178.66) 89 (22.8%)	60.14 (15.71, 200.00) 111 (25.1%)	0.447* 0.451†
Dairy products (g/d)	300~500 g/d	92.77 (20.00, 250.46) 81 (20.8%)	71.43 (14.67, 204.70) 61 (13.8%)	0.038* 0.007†
Soybeans and soy products (g/w)	105~175 g/w	401.93 (83.00, 1068.50) 281 (72.1%)	233.00 (50.00, 732.38) 280 (63.2%)	0.001* 0.007†
Nuts (g/w)	50~70 g/w	0.00 (0.00, 53.22) 104 (26.7%)	1.92 (0.00, 50.50) 118 (26.6%)	0.283* 0.992†
Poultry and red meat (g/w)	280~525 g/w	1046.83 (383.75, 2762.50) 321 (82.3%)	613.33 (244.67, 1250.00) 324 (73.1%)	<0.001* 0.002†
Aquatic products (g/w)	280~525 g/w	70.00 (3.84, 300.00) 105 (26.9%)	46.67 (2.33, 186.92) 82 (18.5%)	0.142* 0.004†
Fish (g/w)	300~500 g/w	23.33 (0.00, 147.50) 62 (15.9%)	17.26 (0.00, 93.33) 42 (9.5%)	0.124* 0.005†
Eggs (g/w)	300~350 g/w	276.67 (77.88, 500.00) 192 (49.2%)	155.80 (35.00, 351.92) 165 (37.2%)	<0.001* <0.001†
Sugar-sweetened or carbonated beverages (g/d)	-	83.57 (12.81, 242.75) -	28.57 (1.67, 88.10) -	<0.001* -
Coffee or tea beverages (g/d)	-	13.52 (0.00, 108.69) -	15.00 (0.00, 93.33) -	0.849* -

[#] Values are medians (IQRs) and n (proportion of individuals meeting the minimum recommended intake).

* P value of Mann-Whitney-U-test.

† P value of Chi-square (χ^2) test (theoretical frequency ≥ 5).

The results in Table 3 compare the differences in the intake of various food categories between Han and ethnic minority groups, as well as the proportion of individuals meeting the minimum recommended intake for each food category. Among males, the intake of starchy roots and tubers, fresh vegetables, dairy products, soybeans and soy products, poultry and red meat, aquatic products, fish, eggs, and sugar-sweetened or carbonated beverages was significantly higher in the Han group compared to the ethnic minority group ($P < 0.05$). Additionally, the proportion of Han individuals meeting the recommended intake for cereals, dairy products, soybeans and soy products, poultry and red meat, aquatic products, fish, and eggs was significantly higher than that of ethnic minority individuals ($P < 0.05$). Among females, the intake of fresh fruit, dairy products, soybeans and soy products, poultry and red meat, aquatic products, and fish was significantly higher in the Han group compared to the ethnic minority group ($P < 0.05$). The proportion of Han females meeting the recommended intake for soybeans and soy products and poultry and red meat was also significantly higher than that of ethnic minority females ($P < 0.05$). However, regardless of sex, the proportion of Han individuals meeting the recommended intake for whole grains and legumes was significantly lower than that of the ethnic minority group ($P < 0.05$).

Table 3. Intake of Food Category and Proportion of Han and Ethnic Minority Meeting the Minimum Recommended Intake for Adults of the Food Based Dietary Guidelines in The Chinese Dietary Guidelines (2022)[#]

Food category	Recommended intake	Male			Female		
		The Han ethnic group (n=296)	Ethnic minority (n=94)	P	The Han ethnic group (n=287)	Ethnic minority (n=156)	P
Cereals (g/d)	200~300 g/d	379.48 (250.17, 655.36) 256 (86.5%)	369.40 (185.54, 703.57) 69 (73.4%)	0.358* 0.003 [†]	242.86 (150.00, 400.00) 175 (61.0%)	250.00 (137.32, 456.61) 96 (61.5%)	0.843* 0.908 [†]
Whole grains and legumes (g/d)	50~150 g/d	3.94 (0.00, 25.16) 51 (17.2%)	6.90 (0.00, 52.86) 26 (27.7%)	0.311* 0.027 [†]	3.60 (0.00, 17.64) 31 (10.8%)	2.86 (0.00, 29.78) 28 (17.9%)	0.828* 0.034 [†]
Starchy roots and tubers (g/d)	50~100 g/d	1.55 (0.00, 20.00) 52 (17.6%)	0.00 (0.00, 14.88) 13 (13.8%)	0.042 * 0.397 [†]	3.33 (0.00, 21.43) 37 (12.9%)	2.74 (0.00, 30.00) 30 (19.2%)	0.582* 0.075 [†]
Fresh vegetables (g/d)	300~500 g/d	173.92 (65.81, 389.24) 87 (29.4%)	107.50 (32.49, 253.57) 20 (21.3%)	0.012 * 0.124 [†]	114.29 (48.41, 307.14) 72 (25.1%)	92.43 (26.20, 256.35) 36 (23.1%)	0.159* 0.638 [†]
Fresh fruit (g/d)	200~350 g/d	61.64 (16.67, 185.03) 69 (23.3%)	58.57 (6.79, 160.60) 20 (21.3%)	0.435* 0.682 [†]	75.19 (19.18, 209.00) 76 (26.5%)	43.29 (11.57, 173.21) 35 (22.4%)	0.027 * 0.348 [†]
Dairy products (g/d)	300~500 g/d	114.25 (30.54, 273.78) 68 (23.0%)	44.07 (3.51, 171.43) 13 (13.8%)	<0.001 * 0.057 [†]	90.78 (18.57, 224.76) 41 (14.3%)	42.86 (5.39, 167.86) 20 (12.8%)	0.006 * 0.669 [†]
Soybeans and soy products (g/w)	105~175 g/w	500.00 (120.24, 1100.87) 227 (76.7%)	194.50 (12.50, 836.95) 54 (57.4%)	0.001 * <0.001 [†]	280.00 (63.94, 774.67) 193 (67.2%)	155.00 (7.00, 630.00) 87 (55.8%)	0.009 * 0.017 [†]
Nuts (g/w)	50~70 g/w	0.00 (0.00, 50.00) 78 (26.4%)	0.00 (0.00, 70.00) 26 (27.7%)	0.492* 0.803 [†]	5.27 (0.00, 50.00) 75 (26.1%)	0.00 (0.00, 65.63) 43 (27.6%)	0.622* 0.745 [†]
Poultry and red meat (g/w)	280~525 g/w	1353.08 (514.67, 2998.65) 255 (86.1%)	700.00 (182.04, 1548.75) 66 (70.2%)	<0.001 * <0.001 [†]	650.00 (300.00, 1413.33) 219 (76.3%)	550.00 (90.33, 1050.00) 105 (67.3%)	0.033 * 0.041 [†]
Aquatic products (g/w)	280~525 g/w	90.39 (7.17, 331.67) 90 (30.4%)	26.69 (0.49, 126.48) 15 (16.0%)	0.007 * 0.006 [†]	67.67 (9.33, 200.00) 53 (18.5%)	28.00 (0.00, 160.00) 29 (18.6%)	0.008 * 0.975 [†]
Fish (g/w)	300~500 g/w	28.00 (0.00, 199.38) 54 (18.2%)	3.84 (0.00, 93.97) 8 (8.5%)	0.004 * 0.025 [†]	30.00 (0.00, 100.00) 26 (9.1%)	0.00 (0.00, 90.00) 16 (10.3%)	<0.001 * 0.681 [†]
Eggs (g/w)	300~350 g/w	320.63 (109.39, 556.67) 158 (53.4%)	150.00 (13.53, 350.00) 34 (36.2%)	<0.001 * 0.004 [†]	168.00 (55.00, 367.50) 116 (40.4%)	150.00 (14.00, 350.00) 49 (31.4%)	0.060* 0.061 [†]
Sugar-sweetened or carbonated beverages (g/d)	-	90.19 (18.15, 266.41) -	39.29 (0.68, 203.57) -	0.010 * -	30.00 (2.86, 91.55) -	19.00 (0.27, 87.50) -	0.305* -
Coffee or tea beverages (g/d)	-	16.67 (0.00, 114.29) -	3.17 (0.00, 83.93) -	0.157* -	16.67 (0.00, 100.00) -	8.33 (0.00, 77.45) -	0.154* -

[#] Values are medians (IQRs) and n (proportion of individuals meeting the minimum recommended intake).

* P value of Mann-Whitney-U-test.

[†] P value of Chi-square (χ^2) test (theoretical frequency ≥ 5).

3.3 Intake of energy and macronutrients

Table 4 presents the energy and macronutrient intake of participants and comparisons between the Han and ethnic minority groups. The results indicate that among males, energy, protein, and fat intake were significantly higher in the Han group compared to the ethnic minority group ($P < 0.05$). However, among females, no statistically significant differences were observed. Supplementary Table S3 further compares the results with the DRIs for China (2023 edition), including Acceptable Macronutrient Distribution Ranges (AMDR) and Recommended Nutrient Intake (RNI). The results indicate that a higher proportion of males met the RNI for protein compared to females, whereas females were generally more likely to meet the AMDR for fat and carbohydrates. Compared to ethnic minority groups, the Han ethnic group had a significantly higher proportion of participants whose protein intake met the RNI ($P < 0.05$). Although the proportions meeting the AMDR for fat and carbohydrates were also higher among the Han group, these differences were not statistically significant ($P > 0.05$).

Table 4. The Energy and Macronutrient Intake of Participants and Comparison Between Han ethnic group and Ethnic Minority Groups[#]

Category	Total (n=833)	The Han ethnic group (n=583)	Ethnic minority (n=250)	<i>P</i> [*]
Energy intake (kcal/d)				
Males	3108.98 (1983.19, 4979.74)	3144.20 (2088.81, 5088.53)	2921.22 (1461.27, 4567.28)	0.039
Females	2041.71 (1168.50, 3284.91)	2090.88 (1285.34, 3284.91)	1956.18 (1000.92, 3321.14)	0.447
Protein intake (g/d)				
Males	141.01 (84.40, 235.36)	150.23 (89.12, 259.30)	113.67 (59.73, 194.09)	0.001
Females	90.34 (49.31, 155.17)	94.55 (53.06, 161.79)	85.96 (40.31, 150.00)	0.124
Fat intake (g/d)				
Males	71.29 (40.46, 124.23)	77.41 (46.18, 139.52)	54.94 (24.65, 100.08)	<0.001
Females	47.40 (23.11, 84.23)	49.36 (26.27, 84.23)	42.81 (18.79, 84.14)	0.108
Carbohydrate intake (g/d)				
Males	470.26 (304.48, 714.15)	474.22 (314.99, 697.35)	439.12 (245.70, 769.46)	0.487
Females	312.63 (196.51, 496.30)	316.92 (204.66, 471.19)	303.41 (172.14, 546.35)	0.924

[#] Values are medians (IQRs).

^{*} *P* value of Mann-Whitney-U-test used to assess differences between the Han ethnic group and ethnic minority groups.

Table 5 presents a comparison of energy and macronutrient intake across different BMI categories. The Kruskal-Wallis H test revealed significant differences in protein and fat intake among males with different BMI classifications ($P < 0.05$). Further analysis using the Mann-Whitney U test indicated that obese males had significantly higher protein and fat intake compared to normal-weight males ($P < 0.05$). Similarly, obese females demonstrated significantly higher fat intake compared to normal-weight females ($P < 0.05$). Supplementary Table S4 further compares the proportion of participants across different BMI groups whose macronutrient intake met the DRIs. The results indicate that within the normal weight group, a significantly higher proportion of males met the RNI for protein, whereas the proportion meeting the AMDR was significantly lower in males than in females ($P < 0.05$). No statistically significant sex differences were observed in the other BMI groups ($P > 0.05$). Regardless of sex, there were no significant differences in the proportion of participants meeting the DRIs for macronutrient intake across different BMI groups ($P > 0.05$).

Table 5. Energy and Macronutrient Intake of Participants with Different BMI Categories[#]

Category	Normal weight (n=607)	Underweight (n=100)	Overweight (n=89)	Obesity (n=37)	P*
Energy intake (kcal/d)					
Males	3013.28 (1864.11, 5114.43)	3125.14 (2386.70, 4557.00)	3336.04 (2362.31, 4893.98)	3634.04 (2881.60, 5976.77) [†]	0.200
Females	2034.96 (1143.42, 3232.16)	2087.31 (1213.30, 3558.87)	1914.65 (1160.33, 4117.06)	2772.13 (2278.74, 4183.31)	0.418
Protein intake (g/d)					
Males	133.73 (76.08, 231.37)	151.78 (85.84, 235.37)	160.96 (101.76, 274.29)	211.41 (126.30, 333.31) [†]	0.046
Females	91.03 (48.50, 152.85)	87.96 (50.60, 154.69)	74.12 (51.14, 151.56)	147.65 (102.20, 193.66)	0.273
Fat intake (g/d)					
Males	65.71 (31.28, 119.57)	77.22 (35.70, 140.24)	83.84 (53.97, 147.45)	122.19 (58.95, 186.25) [†]	0.018
Females	48.98 (23.20, 81.20)	42.97 (21.60, 88.24)	45.00 (22.71, 79.21)	111.79 (43.78, 133.93) [†]	0.256
Carbohydrate intake (g/d)					
Males	469.18 (290.93, 760.99)	478.52 (301.20, 683.22)	474.21 (335.85, 695.60)	541.99 (420.51, 791.07)	0.582
Females	309.00 (182.72, 492.57)	313.24 (222.06, 497.96)	300.86 (171.37, 515.89)	364.96 (302.48, 507.98)	0.704

[#] Values are medians (IQRs).

* P value of Kruskal-Wallis H test used to assess differences among different BMI categories.

[†] P < 0.05 when compared with normal weight group (Mann-Whitney-U-test).

Figure 1 illustrates the contribution of protein, fat, and carbohydrate to total energy intake across different groups under various classifications. Figure 1A shows that the proportion of energy derived from protein was significantly lower in females compared to males ($P < 0.05$). Figure 1B highlights significant differences in macronutrient energy contributions among males with different BMI categories; as BMI increased, the energy contribution from protein and fat significantly rose, while that from carbohydrates significantly declined ($P < 0.05$). Similarly, Figure 1C demonstrates a comparable trend in females across BMI categories, but these differences were not statistically significant ($P > 0.05$). Figures 1D and 1E reveal that, regardless of sex, Han individuals had significantly higher energy contributions from protein and fat and significantly lower contributions from carbohydrates compared to the ethnic minority group ($P < 0.05$).

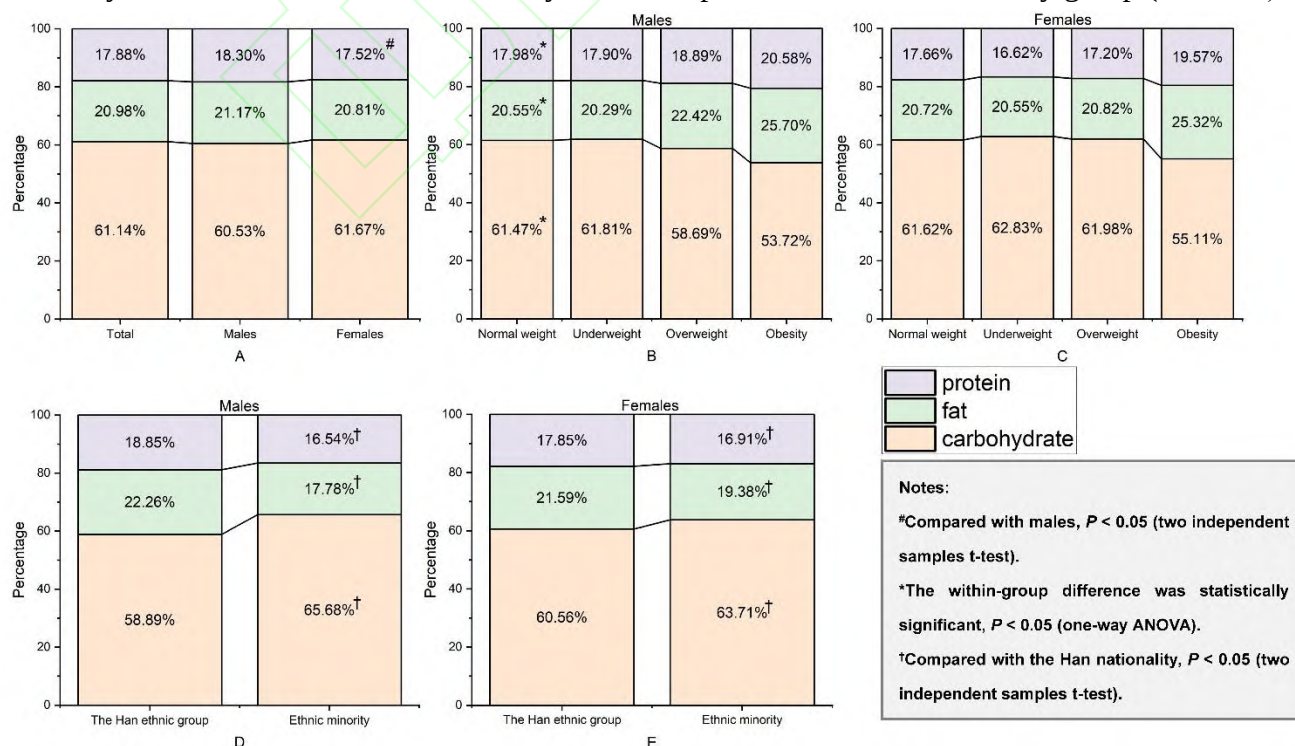


Fig. 1 Energy contribution of protein, fat, and carbohydrate across different groups under various classifications. Estimation basis: 1 gram of fat provides 9.0 kcal, 1 gram of protein provides 4 kcal, and 1 gram of carbohydrate provides 4 kcal.

3.4 Intake of micronutrients and dietary fiber

Table 6 presents the calculated intake of micronutrients and dietary fiber among participants, comparing the results with the DRIs for China (2023 edition), including the Estimated Average Requirement (EAR), RNI, Adequate Intake (AI), and Tolerable Upper Intake Level (UL). In the vitamin results, the proportion of individuals meeting the RNI for Vitamin A and Vitamin C was the lowest, with both males and females below 50%. In contrast, the highest proportion meeting the RNI was observed for niacin, with 80.3% of males and 72.0% of females achieving the recommended intake. In the mineral results, the proportion of individuals meeting the RNI or AI for calcium and sodium was relatively low, with both males and females below 50%. For other minerals, the RNI achievement rates were higher; however, a considerable proportion of participants exceeded the UL values. For example, among males, 44.1%, 19.0%, 51.5%, 15.4%, and 37.2% exceeded the UL for niacin, phosphorus, iron, zinc, and manganese, respectively. Among females, 27.1%, 37.5% and 22.6% exceeded the UL for niacin, iron and manganese, respectively. The dietary fiber data showed that 38.7% of males and 33.0% of females met the AI. Additionally, for vitamins, minerals, and dietary fiber, the proportion of males meeting the RNI or AI was consistently higher than that of females, while the proportion of males failing to meet the EAR was lower. However, the proportion of males exceeding the UL was also higher than that of females.

Table 6. Participants' Intake of Vitamins, Minerals, and Dietary Fiber

Category	Intake [#]	DRIs for China [*]			Intake Situation of the Target Population [†]		
		EAR	RNI/AI	UL	<EAR	≥RNI/AI	>UL
Vitamin A (μgRAE/d)							
Males	622.74 (267.90, 1145.84)	550	770	3000	178 (45.6%)	152 (39.0%)	24 (6.2%)
Females	427.35 (184.26, 839.58)	470	660	3000	232 (52.4%)	157 (35.4%)	15 (3.4%)
Vitamin C (mg/d)							
Males	76.77 (32.95, 153.83)	85	100	2000	185 (47.4%)	163 (41.8%)	0 (0.0%)
Females	65.04 (23.45, 152.37)	85	100	2000	253 (57.1%)	163 (36.8%)	0 (0.0%)
Vitamin E (mg α-TE/d)							
Males	18.59 (10.75, 31.27)	-	14 (AI)	700	-	248 (63.6%)	0 (0.0%)
Females	13.50 (6.99, 24.19)	-	14 (AI)	700	-	215 (48.5%)	0 (0.0%)
Thiamin (mg/d)							
Males	1.88 (1.09, 3.11)	1.2	1.4	-	114 (29.2%)	251 (64.4%)	-
Females	1.22 (0.65, 2.16)	1.0	1.2	-	183 (41.3%)	225 (50.8%)	-
Riboflavin (mg/d)							
Males	1.64 (0.94, 2.94)	1.2	1.4	-	138 (35.4%)	227 (58.2%)	-
Females	1.18 (0.56, 2.01)	1.0	1.2	-	187 (42.2%)	217 (49.0%)	-
Niacin (mgNE/d)							
Males	30.95 (18.60, 54.31)	12	15	35	48 (12.3%)	313 (80.3%)	172 (44.1%)

Females	20.99 (11.03, 36.06)	10	12	35	99 (22.4%)	319 (72.0%)	120 (27.1%)
Calcium (mg/d)							
Males	656.22 (365.76, 1108.80)	650	800	2000	193 (49.5%)	156 (40.0%)	33 (8.5%)
Females	469.36 (214.24, 905.20)	650	800	2000	282 (63.7%)	132 (29.8%)	22 (5.0%)
Phosphorus (mg/d)							
Males	1756.04 (1059.27, 2823.42)	600	720	3500	33 (8.5%)	342 (87.7%)	74 (19%)
Females	1194.58 (616.16, 1996.56)	600	720	3500	104 (23.5%)	313 (70.7%)	34 (7.7%)
Potassium (mg/d)							
Males	2940.36 (1719.90, 5223.88)	-	2000 (AI)	-	-	275 (70.5%)	-
Females	2129.82 (1093.23, 3792.88)	-	2000 (AI)	-	-	242 (54.6%)	-
Sodium (mg/d)							
Males	1360.11 (774.54, 2476.97)	-	1500 (AI)	-	-	175 (44.9%)	-
Females	964.05 (443.97, 1879.01)	-	1500 (AI)	-	-	138 (31.2%)	-
Magnesium (mg/d)							
Males	485.41 (295.91, 773.53)	270	330	-	86 (22.1%)	275 (70.5%)	-
Females	326.29 (179.93, 578.66)	270	330	-	179 (40.4%)	221 (49.9%)	-
Iron (mg/d)							
Males	43.52 (22.33, 81.54)	9	12	42	23 (5.9%)	361 (92.6%)	201 (51.5%)
Females	30.35 (14.60, 58.30)	12	18	42	86 (19.4%)	303 (68.4%)	166 (37.5%)
Zinc (mg/d)							
Males	17.25 (10.56, 31.83)	10.1	12.5	40	88 (22.6%)	265 (67.9%)	60 (15.4%)
Females	11.78 (6.50, 19.86)	6.9	8.5	40	124 (28.0%)	284 (64.1%)	29 (6.6%)
Selenium (mg/d)							
Males	78.27 (46.07, 133.23)	50	60	400	114 (29.2%)	243 (62.3%)	10 (2.6%)
Females	49.77 (24.91, 86.17)	50	60	400	223 (50.3%)	186 (42.0%)	2 (0.5%)
Copper mg/d)							
Males	3.14 (2.01, 5.25)	0.62	0.8	8.0	8 (2.1%)	371 (95.1%)	38 (9.7%)
Females	2.18 (1.23, 3.80)	0.62	0.8	8.0	39 (8.8%)	387 (87.4%)	23 (5.2%)
Manganese (mg/d)							
Males	8.48 (5.39, 13.82)	-	4.5 (AI)	11	-	319 (81.8%)	145 (37.2%)
Females	5.81 (3.24, 10.30)	-	4.0 (AI)	11	-	293 (66.1%)	100 (22.6%)
Dietary fiber (g/d)							
Males	19.83 (10.03, 37.72)	-	25~30 (AI)	-	-	151 (38.7%)	-
Females	14.40 (6.87, 32.69)	-	25~30 (AI)	-	-	146 (33.0%)	-

Values are medians (IQRs).

* EAR: Estimated Average Requirement; RNI: Recommended Nutrient Intake; AI: Adequate Intake; UL: Tolerable Upper Intake Level. The EAR, RNI/AI, and UL were based on the DRIs for China (2023 edition) for individuals aged 18-29.

† Values are n (percentages).

3.5 Nutritional awareness among participants

Table 7 presents the nutritional awareness scores among participants and compares differences across various groups. No significant differences were observed between males and females in the total score or the scores for the four subcategories: dietary recommendations, food characteristics, nutrition and disease, and general nutrition knowledge ($P > 0.05$). In contrast, the Han group showed significantly higher total scores and subcategory scores than the ethnic minority group ($P < 0.001$). Significant differences were also found in total scores, nutrition and disease, and general nutrition knowledge among individuals with different BMI categories, with overweight and obese participants scoring higher on average, and obese participants achieving the highest mean scores ($P < 0.05$). Additionally, significant differences in total scores and all four subcategories were observed across groups with varying economic levels ($P < 0.05$). Participants with an annual per capita household income $< 10,000$ RMB had the lowest scores, while those in the 60,000–99,999 RMB income group achieved the highest scores in all categories.

Table 7. Scores of Different Components of Nutritional Awareness Among Participants[#]

Category	Total score (Maximum score: 55)	Dietary recommendations (Maximum score: 18)	Food characteristics (Maximum score: 13)	Nutrition and disease (Maximum score: 13)	General nutrition knowledge (Maximum score: 11)
Sex					
Males	34.93 ± 9.49	11.09 ± 3.20	6.81 ± 2.58	9.54 ± 3.31	7.50 ± 2.51
Females	35.65 ± 8.18	11.20 ± 2.82	7.06 ± 2.45	9.96 ± 3.02	7.43 ± 2.14
<i>P</i>[*]	0.242	0.594	0.147	0.058	0.693
Ethnic group					
The Han ethnic group	37.22 ± 7.38	11.66 ± 2.78	7.21 ± 2.37	10.41 ± 2.58	7.94 ± 1.94
Ethnic minority	30.88 ± 10.21	9.96 ± 3.17	6.31 ± 2.74	8.26 ± 3.81	6.35 ± 2.72
<i>P</i>[*]	<0.001	<0.001	<0.001	<0.001	<0.001
BMI					
Normal weight	34.99 ± 8.80	11.06 ± 2.98	6.90 ± 2.49	9.64 ± 3.18	7.38 ± 2.35
Underweight	34.26 ± 10.44	11.10 ± 3.56	6.66 ± 2.91	9.36 ± 3.61	7.14 ± 2.51
Overweight	37.33 ± 7.79	11.45 ± 2.78	7.35 ± 2.47	10.57 ± 2.74	7.96 ± 2.11
Obesity	38.65 ± 4.08	11.97 ± 2.13	7.35 ± 1.58	10.87 ± 1.55	8.46 ± 1.07
<i>P</i>[†]	0.007	0.241	0.196	0.005	0.003
Annual per capita household income (RMB)					
<10,000	33.10 ± 9.75	10.37 ± 3.43	6.79 ± 2.62	8.95 ± 3.30	6.98 ± 2.49
10,000-59,999	35.20 ± 8.92	11.17 ± 2.98	6.89 ± 2.49	9.73 ± 3.30	7.42 ± 2.36
60,000-99,999	39.16 ± 6.54	12.04 ± 2.47	7.84 ± 2.54	11.01 ± 2.13	8.27 ± 1.59
≥100,000	37.22 ± 6.27	11.90 ± 2.14	6.81 ± 2.29	10.55 ± 2.30	7.97 ± 1.98
<i>P</i>[†]	<0.001	<0.001	0.014	<0.001	<0.001

[#] Values are means ± SDs.

^{*} *P* value of two independent samples *t*-test.

[†] *P* value of One-Way ANOVA.

4. Discussion

This study comprehensively evaluated the dietary intake, macronutrient and micronutrient consumption, and nutritional awareness among a population of Chinese university students. By comparing these findings with the latest 2022 CDG and DRIs for China (2023 edition), this research indicates the extent of adherence to

national dietary recommendations, highlights disparities across sex, ethnicity, and BMI classifications, and provides potential insights into the dietary habits and nutritional knowledge of this population.

Our results indicate significant sex-based differences in dietary and nutritional intake. Consistent with dietary data from the U.S., males consumed greater quantities of protein-rich foods such as dairy products, soy products, and meats, while females had a lower proportion meeting recommended intake thresholds for these categories(21, 22). These findings align with gender-specific dietary preferences and socio-cultural norms, where males typically prioritize protein-rich diets to support physical activity, whereas females often engage in restrictive eating behaviors for weight management(23-25). Although some studies suggest that these gender differences might stem from females having increased health awareness compared to males, our findings revealed no significant differences between sexes in any of the nutritional awareness scores(26). Additionally, such patterns have critical implications for nutritional adequacy and health risks, particularly the lower calcium intake observed in females, which may elevate the risk of osteoporosis later in life(27, 28).

Ethnic disparities were also evident in the dietary behaviors and nutritional awareness of Han and ethnic minority groups. Han participants demonstrated higher intake and compliance rates for most food categories, including dairy, soy products, poultry, vegetables and fruits, eggs, and aquatic products, as well as higher consumption of sugar-sweetened or carbonated beverages. This aligns with broader accessibility and cultural preferences for diverse food options among Han populations, but it may also be associated with economic disparities between ethnic groups(29-31). However, Han males consumed significantly more protein, fat, and energy compared to ethnic minority males in this study. Previous studies have also suggested that the Han population has a higher prevalence of overnutrition(32). A noteworthy exception was the higher compliance with whole grains and legumes observed in ethnic minority groups, which likely reflects traditional dietary practices emphasizing foods. These findings highlight the need for culturally tailored nutritional interventions that respect dietary preferences while promoting balanced intake across all population subgroups.

BMI classification further stratified dietary behaviors and nutritional awareness. Obese participants displayed significantly higher energy intake from protein and fat while exhibiting lower carbohydrate energy contributions. This trend, consistent across sexes, suggests an over-reliance on energy-dense foods. However, these findings do not suggest that the proportional contribution of macronutrients to energy intake directly influences BMI. Instead, the primary factor driving BMI increase appears to be an overall excess in total energy intake, with protein and fat contributing disproportionately to this surplus. In this study, obese males exhibited significantly higher intake levels across a wide range of food items, including vegetables, fruits, dairy products, soybeans and soy products, as well as poultry and red meat, aquatic products, eggs, and sugar-sweetened or carbonated beverages. This broad increase in consumption may contribute to excessive total energy intake, thereby promoting obesity. In contrast, obese females primarily consumed more nuts and poultry and red meat—foods rich in fat and protein. While moderate consumption of these items can be beneficial to health, excessive intake may still lead to an energy surplus. Additionally, the intake of nuts may be accompanied by the consumption of other snacks(33). Additionally, previous studies have consistently

shown that no single nutrient is inherently beneficial or harmful in the context of weight loss and its maintenance(34-37). Rather, guided by the principles of precision nutrition, dietary approaches tailored to an individual's eating habits and food preferences are more likely to enhance adherence, thereby facilitating sustainable long-term weight management(34). The effectiveness of such strategies ultimately hinges on achieving and maintaining a balance between energy intake and energy expenditure(38). Moreover, the higher nutritional awareness scores among overweight and obese individuals might indicate increased health consciousness following weight-related health concerns, as it is possible that overweight or obese individuals, driven by the need for weight management, began to enhance their knowledge of nutrition and health as part of their efforts to lose weight. However, this finding differs from the results of some previous studies. For instance, a cross-sectional study involving participants with an average age of 41.39 years found no significant association between BMI and levels of nutritional knowledge(39). A cross-sectional study of university students in Morocco reported that non-overweight students had significantly higher nutritional knowledge scores compared to their overweight or obese peers(40). These discrepancies highlight the need for further investigation into the causal relationship between nutritional knowledge, BMI, and dietary behavior, as the association may be influenced by potential factors in some cases.

Micronutrient analysis revealed substantial gaps in meeting recommended intakes, particularly for calcium, vitamin A, vitamin C and dietary fiber, with less than half of the participants achieving the RNI/AI. Furthermore, excess intake of certain micronutrients, such as niacin, phosphorus, iron, and manganese, highlights a dual burden of deficiency and overconsumption. These imbalances could stem from over-reliance on meat and processed foods while neglecting dairy products, fish, fresh fruits and vegetables, as evidenced by the low intake of these items. Interventions promoting whole-food-based dietary diversity are critical to addressing these dual nutritional challenges.

The study also reports differences in nutritional awareness among groups with varying economic levels. Students from higher-income households exhibited superior nutritional awareness scores, consistent with the hypothesis that economic resources facilitate access to healthier foods and nutritional education(41-44). Conversely, the poorest income group showed the lowest awareness, emphasizing the role of socioeconomic status as a determinant of dietary behaviors and access to knowledge. Policies targeting this demographic should prioritize affordable access to nutrient-dense foods and tailored education campaigns. In addition, an interesting observation in the study is that the group with the second-highest income level had the highest scores for all components of nutritional awareness, rather than the highest income group. The underlying reasons for this remain to be explored.

Despite its strengths, such as comprehensive dietary assessments and the inclusion of many ethnic minority students, addressing a gap in existing research that has predominantly focused on Han Chinese populations, this study has certain limitations. The dietary data were self-reported, which may introduce recall bias. Additionally, although the students came from diverse regions across China, with many minority students primarily hailing from the central and western provinces, they were primarily studying in Jiangsu

Province, thus the generalizability of the findings may be limited. Moreover, approximately 60% of the minority participants belonged to the Uighur ethnic group, which may have influenced group-level results. Furthermore, as the study population consisted of university students, who typically have higher levels of education and health literacy compared to the general population, the applicability of the findings to other demographic groups may be constrained.

In conclusion, this study highlights nutritional gaps and behavioral disparities among Chinese university students and provides actionable insights to guide public health initiatives under the Healthy China Action Plan and National Nutrition Plan. Tailored interventions addressing sex, ethnicity, BMI, and socioeconomic status are potential to promote healthier dietary habits.

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Declaration of interests

The authors declare none.

Ethical approval

This study was approved by the Ethics Committee of Nanjing Municipal Center for Disease Control and Prevention (NJCDCLL. No. 2023012), in accordance with the Declaration of Helsinki.

Data availability

All data generated or analysed during this study are included. The technical appendix and statistical procedure are available from the corresponding author upon reasonable request.

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