Original Article

Is adherence to the Chinese Dietary Guidelines associated with better self-reported health? The Chinese Dietary Guidelines Adherence Score

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Background and Objectives: Poor adherence to dietary guidelines is related to physical and mental disorders, as reflected in self-reported health statuses. This study evaluates the association between diet quality and self-reported health within the Shanghai Diet and Health Study. **Methods and Study Design:** We used Chinese Dietary Guidelines Adherence scores to assess diet quality in a cross-sectional study of 4487 subjects above 15 years of age, who completed three-day 24h diet recalls and responded to self-reported health questionnaires. A composite health score was calculated based on Item Response Theory, using the Rasch model. Multiple linear-regression models were evaluated to assess the relationship between self-reported health status and diet quality. **Results:** Based on the various adherence scores, we divided our sample into fifths. Based on these divisions and with the exception of a single instance, our results show a significant trend: self-reported health declines with declining adherence to official dietary guidelines. This trend was even significant when controlling for a large number of potential confounders. **Conclusions:** This study shows that consumption of a healthy and balanced diet, as reflected in adherence to the Chinese Dietary Guidelines, is related to increased levels of overall health among Shanghai residents.

Key Words: diet quality, self-reported health, China, Item Response Theory, Dietary-Guideline Adherence

INTRODUCTION

Adherence to a whole healthy diet pattern rather than analysing the individual components of a diet is increasingly becoming the state-of-the-art method for estimating the health status of a given population.[1] Indeed, assessment of single nutrients ignores important interactions between diet components; more importantly, however, is that individuals never consume isolated nutrients. Observing a diet, which adheres to some official dietary guideline, is closely related to improved nutritional quality and closely associated with an adequate intake of proteins, carbohydrates, vitamins, and minerals.[2,3]

Conversely, poor adherence to dietary recommendations may cause nutrient imbalance.[4-6] An unreasonable diet structure is an important factor that may lead to increasingly unhealthy conditions such as obesity, high blood pressure, high cholesterol, diabetes, cancer, chronic obstructive pulmonary disease, and even premature death.[7-9] According to the WHO, dietary factors contribute to human health by 14%; this is second only to genetic factors (16%), and far more than medical factors (7%).[10] In addition, poor diets are associated with increased incidence rates of anxiety, depression, and other problems of mental health. Studies have shown that the high fat and protein contents and the lack of essential fatty acids, characteristic of typical Western diets, may be causative of mental disorders.[10] Unsurprisingly, the relationship between diet and overall quality of health is re-

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ceiving ever-increasing amounts of attention.

Given that dietary intake plays a role in energy balance, with potential effects on obesity and several non-communicable diseases (NCDs),[11,12] there is a growing interest in using indices of overall dietary quality to evaluate adherence to healthy and recommended balanced diets.[10,13-19] Scores reflecting overall diet quality can help assess nutrient- and food-specific variables, providing diet assessments that incorporate nutrient and food interactions assumed to be biologically important.[1,20-22] Diet-quality indices provide a new tool for diet evaluation and are more advantageous in resolving diet complexity than traditional assessments of a single nutrients or food groups.[23] In China exists an index for diet-quality assessment relative to the Chinese Dietary Guidelines, i.e., based on consumption recommendations within the main food groups. In the present study, we refer to this index as the Chinese Dietary Guidelines Adherence (CDGA) score. The CDGA score was designed to assess under- and over-nutrition as well as overall dietary balance, all of which constitute risk factors for NCDs in the Chinese population, which is currently witnessing rapid economic change.[24]

With the concept of health evaluation, more focus is placed on combining internal and external—subjective and objective—perspectives, rather than on a single aspect of the evaluation. Self-reported health (SRH) is a method employed in the assessment of self-evaluated health and is an important means for evaluating health statuses.[24-27] The SRH status may be multi-dimensional and reflects respondents' own view on their physical and psychological health.[10] It is an important supplement to objective health observations or examinations, and it provides health data that traditional survey methods cannot access.

Poor adherence to dietary guidelines has been associated with physical as well as mental disorders. However, no studies have assessed the association of adherence to CDGA with SRH. Thus, the purpose of this study was to evaluate the relationship between SRH status and CDGA score in the Shanghai Diet and Health Study (SDHS).

METHODS

Study design and recruitment

The SDHS is an ongoing open cohort that has existed since 2012. The SDHS was designed and implemented by the Chinese government to examine the nutritional status and food contaminants in Shanghai, and to assess how they affect human health. The aforementioned rapid economic growth in Shanghai has introduced remarkable variations in diets and eating habits that may influence health outcomes. Cohort participants were recruited in a multistage, stratified random sampling process aimed to secure a representative sample of Shanghai inhabitants aged 15 years or older. The megacity was stratified into urban, fringe, and rural areas based on the ratio of non-agricultural registered residents in sub-districts to those in townships. Villages and townships within urban, fringe, and rural areas were selected using the probability-proportional-to-size sampling method. Neighbourhoods were randomly selected in each village and town. Finally, 54 sites (villages and towns), including 162 neighbourhoods, were randomly selected from 229 sites. A total of 1944 subjects and their family members were recruited. Data were collected in May–June 2012 (spring), August–September 2013 (summer), November–December 2012 (fall), and January–February 2013 (winter).

The SDHS was approved by the Ethical Review Committee of Shanghai Municipal Center for Disease Control and Prevention, with ethical approval number 2012-15. All participants were fully informed of the study's purpose and procedures before enrolling, and they all signed written consent forms.

Dietary data collection

In the SDHS, dietary assessment was based on a combination of data collected at the individual level, with food inventory obtained at the household level. To collect individual dietary data, every household member was asked to report all food consumed over the previous 24h for three days (two working days and one weekend day) whether at home or not. This was defined as the three-day 24h recall. Household consumption of condiments (e.g. edible oils, salt, and sauces) was determined by weighing all food consumed by the household over three consecutive days. Three-day 24h recalls were performed on three consecutive days to match the weighing. All purchases and wasted condiments were also recorded. At the end of the survey, all remaining condiments were weighed again.

Trained field interviewers recorded the types and amounts of food consumed at each meal, using picture aids and food location on the previous day. The amount of food in each dish was estimated from the household inventory; the proportion of each dish consumed was reported by each participant.

Data quality control was ensured by field interviewers, who were trained for at least three days in collecting dietary data. In case of outliers, the household and individuals in question were revisited to assess food consumption and resolve discrepancies.

The food codes in the SDHS correspond to food names in the Chinese Food Composition Table, and were used for food-group classification.[20,27,28] Total intake for each food group was determined. Cooking oil and salt intake from household food consumption data were used to supplement individual dietary data. Individual cooking oil and salt consumption was calculated according to the total amounts of oil and salt consumed in the household divided by the proportions of energy consumed by each of its members.[29]

CDGA score

The CDGA scoring system (from Chinese DBI-07 (revised from the DBI-2002)) assesses the overall dietary quality in the Chinese population. The CDGA scores contains seven components from the Chinese Dietary Guidelines and Chinese Food Pagoda, including: (1) cereals; (2) vegetables and fruits; (3) dairy products, and soybean and related products; (4) animal source food; (5) condiments and alcoholic beverages; (6) dietary variety; and (7) drinking water.[10,29]

An overall score of zero reflects reaching or just exceeding the lowest recommended intake of all food groups. Positive scores indicate over-intake relative to the recommended level and are particularly important in the evaluation of condiments and alcoholic beverages, which should be consumed in “reduced” or “limited” amounts, as recommended by Chinese dietary guidelines. Negative scores indicate deficient food intake and are particularly important in the evaluation of vegetable, fruit, dairy-product, soybean-product, and drinking-water intake, all of which should be consumed in “abundant” or “sufficient” amounts. Both ends of the scale are important in assessing the intake of cereals and animal source foods, both of which should be consumed in “appropriate” amounts.

The CDGA scores can be further categorised into 12 food sub-groups and diet varieties, including: (1) rice and related products; (2) wheat and related products; (3) corn, coarse grains and related products, starchy roots and products; 4) dark-colored vegetables; (5) light-colored vegetables; (6) fruits; (7) soybean and related products; (8) milk and dairy products; (9) red meat and meat products; (10) poultry and game; (11) eggs; (12) fish and shellfish; and (13) diet variety.

Sub-group scores of zero indicate having reached the lowest recommended intake, and positive and negative scores follow the same pattern as reported above for the seven main food groups. The suggested lowest intake is 5 g/d for soybean and related products, and 25 g/d for the other 11 food subgroups, based on Chinese Diet-Quality Index (DQI) guidelines.[10,29] Other CDGA components have been described in detail elsewhere,[24,30,31] and scoring details are found in Supplementary table 1.

By adding scores of all CDGA components, we calculated three indicators of dietary quality. Higher bound score (HBS) assesses excessive food intake by adding all positive scores. Lower bound score (LBS) assesses deficit food intake by adding the absolute values of all negative scores. Dietary quality distance (DQD) evaluates unbalanced food intake by adding the absolute values of both positive and negative scores. The possible ranges of HBS, LBS, and DQD are thus 0-32, 0-72, and 0-84, respectively.10 The larger the HBS, LBS, or DQD values, the poorer diet quality; a score of 0 reflects optimal diet quality.10 Average HBS, LBS, and DQD scores were calculated in the four different seasons to reflect diet quality all-year round.

For each parameter the following scale was used: score of 0, “excellent” dietary intake (no problem); score ≤20% of maximum score, “good” dietary intake (almost no problem); between 20% and 40% of maximum score, “acceptable” dietary intake (low level); between 40% and 60% of maximum score, “poor” dietary intake (moderate level); >60% of maximum score, “very poor” dietary intake (high level).[10]

Self-reported health

Self-reported general-health statuses is frequently used in epidemiological surveys and constitutes an important indicator for many health issues. The SDHS asked respondents for their own overall assessment of their general health using a single question (SQ health) as well as a set of questions about health states in specific domains (IRT health). The single question was answered using a five-point Likert-type scale (very good, good, moderate, bad, and very bad). Eight self-related health domains (affection, mobility, sleep/energy, cognition, interpersonal activities, vision, self-care, and pain) were assessed.

The composite health score was calculated based on Item Response Theory, using the Rasch model.[1,13] IRT health ranges from zero to 100; the higher the score, the better the health status.

Assessment of other variables

Height and weight were measured directly by trained health workers, as recommended by the WHO.[14] Age groups were divided into three categories (15–44, 45–59, and >60 years). Marital status was divided into two categories (married and other marital status), based on five categories in the questionnaire. Occupation status was grouped into three levels (professional job, labour job, and other). Years of education level was distributed into four categories (≤6 years, 7–9 years, 10–12 years, and >12 years). Smoking and drinking statuses were categorised dichotomously (No/Yes). BMI was divided into four categorical levels, based on recommendations from the Working Group on Obesity in China: normal (18.5–23.9 kg/m^2); overweight (24.0–27.9 kg/m^2); obese (>28.0 kg/m^2); and underweight (<18.5 kg/m^2). Participants were divided into three residency groups according to location (urban, suburban, and rural). Family income was divided into four levels (<20,000 RMB/person, 20,000–50,000 RMB/person, >50,000 RMB/person, and not reported income).

Statistical analyses

Means and standard deviations (SDs) were used to assess CDGA scores for each food group, as these data were normally distributed. Medians and ranges were used for non-normally distributed parameters. The Chi-square test was used to assess the distribution of self-reported health for different diet-quality levels. Three multiple linear regression models were employed to evaluate the relationship between diet quality and self-reported health. Model 1 adjusted age and sex, Model 2 additionally adjusted for marriage status, occupation, income, residency, and disease status, and Model 3 was a full model, adding smoking and drinking statuses to Model 2. Tests for linear trends (p for trend) were determined by treating quintiles as continuous variables (i.e., 1–5), with the same model analyses conducted. A significance level of 5% (α=0.05) was employed throughout the study, and data were analysed using SAS 9.3 (SAS, Cary, NC, USA) (Figure 1).

RESULTS

Characteristic of study participants

Table 1 shows the characteristics of residents according to CDGA scores fifths. The DQD in the lowest (healthiest diet) was 26.8 in median, ranging from 2.0 to 31.0; in the second, third, fourth, and highest (less healthy diet) fifths, median values of 34.0 (31.3 to 36.7), 39.0 (36.8 to 41.0), 43.3 (41.3 to 45.8) and 49.5 (46.0 to 68.0). The medians and ranges of LBS in the lowest (healthiest diet) and highest fifths were 21.3 (2.0 to 30.3) and 40.5 (26.8 to 66.0), respectively. The median HBS in the lowest (healthiest diet) and highest fifths were 5.0 (0.0 to 14.0) and 9.5 (0.0 to 23.0), respectively. Ages (mean±SD) from lowest to highest fifth were 50.5±16.9, 49.6±16.9,

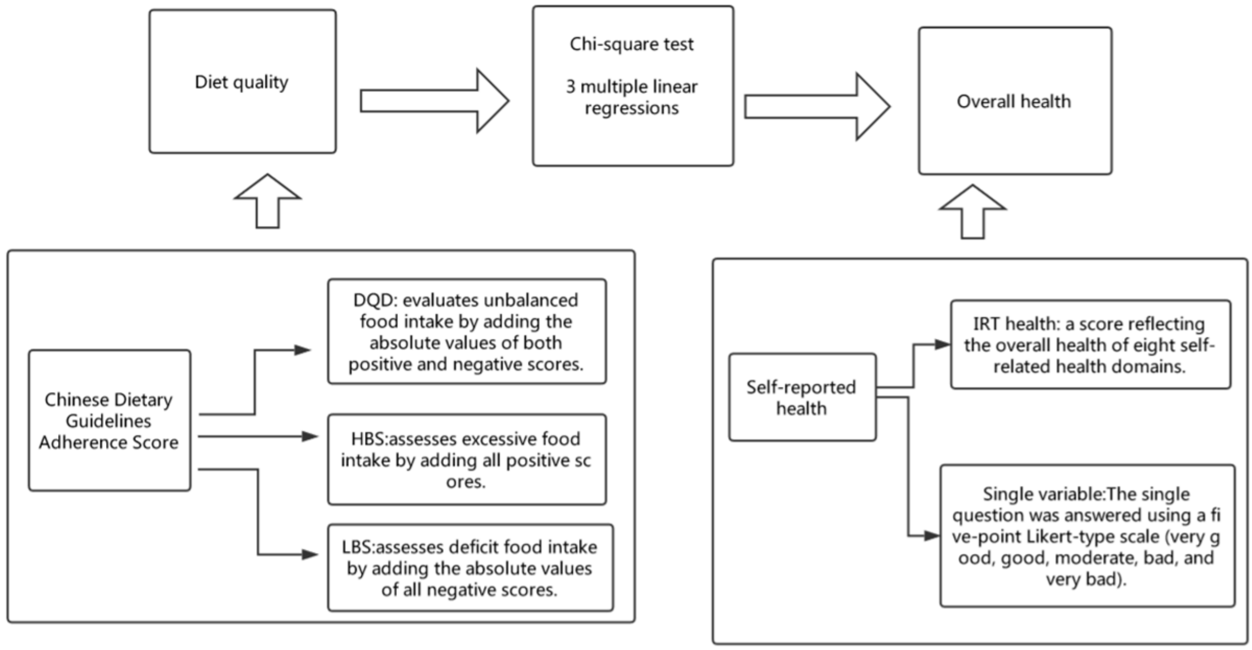

Figure 1. Conceptual diagram for study design (HBS, Higher bound score, LBS, Lower bound score; DQD, Dietary quality distance; IRT, Item Response Theory)

48.2±17.5, 51.5±17.4, and 53.4±17.2, respectively. Mean IRT health score declined with increasing DBI score, from lowest to highest fifth (80.0±18.3, 78.6±SD18.4, 77.7±18.6, 76.0±19.6 and 74.0±20.1, respectively. The percentage of self-reported bad and very bad health among the participants increased with the CDGA scores. BMI values from lowest to highest fifth were 23.3±2.8, 23.4±2.9, 23.4±3.1, 23.8±3.0 and 23.7±3.0, respectively. As for gender, percentages of male in the lowest and highest fifths were 41.4% and 59.1%, respectively. The distributions of the marital status, education level, occupation, family income, smoking and drinking, residency and disease conditions across different diet groups are presented in Table 1.

CDGA scores and self-reported health (IRT-health)

The self-reported health (IRT-health) status was inversely associated with the CDGA scores in Model 1 after adjustment with age and sex. The standard coefficient for the second fifth compared with the lowest fifth of DQD scores was -2.24 (95% confidence interval [CI] -3.76 to -0.73); the values for the third, fourth and highest fifths compared with the lowest fifth of DQD scores were -4.17 (95% CI -5.68 to -2.65), -3.99 (95% CI -5.52 to -2.47) and -5.65 (95% CI -7.15 to -4.14), respectively (all p for trend <0.0001). According to the LBS index, the coefficient for the highest fifth of CDGA scores compared with the lowest fifth was -5.75 (95% CI -7.25 to -4.26; p for trend <0.001) in Model 1. As for the HBS index, the coefficient for the highest fifth of CDGA scores compared with the lowest fifth was -0.84 (95% CI -2.54 to 0.87, p for trend=0.3202). After adjustment for age, sex, marital status, occupation, income, residency and disease status (Model 2, Table 2), the ratio was more than two times higher in participants who ate the least healthy diet according to DQD scores (highest fifth) compared with those consuming the healthiest diet (lowest fifth). The multivariable ratios were -2.37 (-4.10 to -0.63, p for trend=0.0103) in DQD, -2.95 (-4.58 to -1.31, p for trend <0.001) in LBS and -2.98 (-4.72 to -1.25, p for trend <0.001) in Model 2. After subsequent adjustment for smoking and drinking statuses, the coefficient for the highest fifth of DQD scores compared with the lowest fifth was -2.88 (-4.67 to-1.09, p for trend=0.0036). According to the LBS index, the coefficient for the highest fifth of LBS scores compared with the lowest fifth was -3.18 (-4.87 to-1.49; p for trend <0.0001). As for the HBS index, the coefficient for the highest fifth of DQD scores compared with the lowest fifth was -2.49 (4.28 to 0.70; p for trend=0.0014).

Subgroups analyses

According to subgroups analysis of IRT score differences, in various age groups, the trend was apparent among participants aged >60 years. The coefficient for the highest fifth of CDGA scores compared with the lowest fifth was -8.1 (95% CI -11.20 to -4.98; p for trend <0.0001). When stratified by gender, the correlation was statistically significant in females, but not in males. By disease status, a statistically significant correlation was found in diseased individuals, but not in the healthy population (Figure 2).

CDGA scores and self-reported health (single variable)

As is showing in the Table 3, a statistically significant relationship was obtained between diet quality and single variable self-reported health (p=0.02 for DQD, p=0.0984 for LBS and p=0.0011 for HBS).

Discussion

In this cross-sectional analysis of 4487 residents in Shanghai, China, we found that lower CDGA scores, reflecting closer adherence to official public dietary guidelines, were associated with higher self-reported health, as measured using a compound as well as a single-

Table 1. Characteristics of study participants grouped by CDGA-scores

Characteristic	Lowest fifth (healthiest diet) (*n*=888)	Second fifth (*n*=890)	Third fifth (*n*=902)	Fourth fifth (*n*=880)	Highest fifth (least healthy diet) (*n*=927)
Diet scores					
DQD, median (range)	26.75 (2.00-31.00)	34.00 (31.25-36.67)	39.00 (36.75-41.00)	43.25 (41.25-45.75)	49.50 (46.00-68.00)
LBS, median (range)	21.25 (2.00-30.25)	27.75 (13.50-36.00)	32.00 (14.00-40.00)	35.75 (24.25-44.75)	40.50 (26.75-66.00)
HBS, median (range)	5.00 (0.00-14.00)	6.00 (0.00-22.00)	7.00 (0.00-25.50)	7.50 (0.00-21.50)	9.50 (0.00-23.00)
Years of age, mean (SD)	50.5 (16.9)	49.6 (16.9)	48.2 (17.5)	51.5 (17.4)	53.4 (17.2)
IRT health, mean (SD)	80.0 (18.3)	78.6 (18.4)	77.7 (18.6)	76.0 (19.6)	74.0 (20.1)
SQ health, n (%)					
Very good	281 (31.6)	260 (29.2)	301 (33.4)	283 (32.2)	325 (35.1)
Good	346 (39.0)	343 (38.5)	335 (37.1)	337 (38.3)	295 (31.8)
Moderate	234 (26.4)	258 (29.0)	226 (25.1)	213 (24.2)	254 (27.4)
Bad	27 (3.0)	28 (3.1)	36 (4.0)	39 (4.4)	49 (5.3)
Very bad	0 (0.0)	1 (0.1)	4 (0.4)	8 (0.9)	4 (0.4)
BMI, kg/m^2, mean (SD)	23.3(2.8)	23.4 (2.9)	23.4 (3.1)	23.8 (3.0)	23.7 (3.0)
Sex, n (%)					
Men	368 (41.4)	392 (44.0)	447 (49.6)	450 (51.1)	548 (59.1)
Women	520 (58.6)	498 (56.0)	455 (50.4)	430 (48.9)	379 (40.9)
Marital Status, n (%)					
Married	676 (76.1)	712 (80.0)	698 (77.4)	719 (81.7)	761 (82.1)
Other marital status	212 (23.9)	178 (20.0)	204 (22.6)	161 (18.3)	166 (17.9)
Years of education, n (%)					
≤6	75 (8.4)	115 (12.9)	159 (17.6)	245 (27.8)	371 (40.0)
7-9	219 (24.7)	256 (28.8)	282 (31.3)	297 (33.8)	304 (32.8)
10-12	274 (30.9)	257 (28.9)	227 (25.2)	187 (21.3)	148 (16.0)
>12	320 (36.0)	262 (29.4)	234 (25.9)	151 (17.2)	104 (11.2)
Occupation, n (%)					
Professional job	262 (29.5)	212 (23.8)	230 (25.5)	186 (21.1)	132 (14.2)
Labor job	17 (1.9)	65 (7.3)	79 (8.8)	103 (11.7)	226 (24.4)
Others	609 (68.6)	613 (68.9)	593 (65.7)	591 (67.2)	569 (61.4)
Family income, n (%)					
<20000 RMB/person	88 (9.9)	64 (7.2)	43 (4.8)	45 (5.1)	43 (4.6)
20000-50000 RMB/person	181 (20.4)	192 (21.6)	273 (30.3)	340 (38.6)	440 (47.5)
>50000 RMB/person	170 (19.1)	223 (25.1)	209 (23.2)	216 (24.5)	228 (24.6)
Non-reported		411 (46.2)	377 (41.8)	279 (31.7)	216 (23.3)
Smoker, n (%)					
No	748 (84.2)	731 (82.1)	690 (76.5)	634 (72.0)	597 (64.4)
Yes	140 (15.8)	159 (17.9)	212 (23.5)	246 (28.0)	330 (35.6)
Drinker, n (%)					
No	61 (6.9)	57 (6.4)	50 (5.5)	45 (5.1)	33 (3.6)
Yes	702 (79.1)	702 (78.9)	695 (77.1)	683 (77.6)	637 (68.7)
Non-reported	125 (14.1)	131 (14.7)	157 (17.4)	152 (17.3)	257 (27.7)
Region, n (%)					
Urban	760 (85.6)	568 (63.8)	404 (44.8)	263 (29.9)	179 (19.3)
Suburban	102 (11.5)	246 (27.6)	328 (36.4)	332 (37.7)	186 (20.1)
Rural	26 (2.9)	76 (8.5)	170 (18.8)	285 (32.4)	562 (60.6)
Disease, n (%)					
No	577 (65.0)	560 (62.9)	604 (67.0)	539 (61.3)	562 (60.6)
Yes	311 (35.0)	330 (37.1)	298 (33.0)	341 (38.8)	365 (39.4)

CDGA-scores: the Chinese Dietary Guidelines Adherence (CDGA) score, CDGA score was designed to assess under-and over-nutrition as well as overall dietary balance, all of which constitute risk factors for NCDs in the Chinese population; DQD: Dietary quality distance, DQD evaluates unbalanced food intake by adding the absolute values of both positive and negative scores; LBS: Lower bound score, LBS assesses deficit food intake by adding the absolute values of all negative scores; SQ: single question, which collects the data of respondents for their own overall assessment of their general health; IRT: In specific domains, which collects the data of respondents about health states in specific domains; BMI: Body Mass Index; SD: Standard deviation

Table 2. Association of CDGA scores with self-reported heath

CDGA scores	Model 1†		Model 2‡		Model 3§	
	Coef. (95% CI)	*p*-value	Coef. (95% CI)	*p*-value	Coef. (95% CI)	*p*-value
DQD						
Lowest fifth¶	0.00 (referent)		0.00 (referent)		0.00 (referent)	
Second fifth	-2.24 (-3.76, -0.73)	0.0037	-1.42 (-2.92, 0.07)	0.0618	-1.79 (-3.34, -0.24)	0.0234
Third fifth	-4.17 (-5.68, -2.65)	<0.0001	-2.81 (-4.35, -1.27)	0.0003	-3.04 (-4.63, -1.45)	0.0002
Fourth fifth	-3.99 (-5.52, -2.47)	<0.0001	-1.85 (-3.46, -0.23)	0.0250	-2.14 (-3.81, -0.47)	0.0119
Highest fifth¶	-5.65 (-7.15, -4.14)	<0.0001	-2.37 (-4.10, -0.63)	0.0075	-2.88 (-4.67, -1.09)	0.0016
p for Trend	<0.0001		0.0103		0.0036	
LBS						
Lowest fifth¶	0.00 (referent)		0.00 (referent)		0.00 (referent)	
Second fifth	-2.71 (-4.22, -1.21)	0.0004	-1.91 (-3.39, -0.42)	0.0118	-1.90 (-3.43, -0.36)	0.0158
Third fifth	-2.43 (-3.93, -0.93)	0.0015	-0.91 (-2.43, 0.61)	0.2423	-0.93 (-2.50, 0.65)	0.2482
Fourth fifth	-5.41 (-6.93, -3.88)	<0.0001	-3.52 (-5.11, -1.93)	<0.0001	-3.48 (-5.13, -1.84)	<0.0001
Highest fifth¶	-5.75 (-7.25, -4.26)	<0.0001	-2.95 (-4.58, -1.31)	0.0004	-3.18 (-4.87, -1.49)	0.0002
p for Trend	<0.0001		0.0001		<0.0001	
HBS						
Lowest fifth¶	0.00 (referent)		0.00 (referent)		0.00 (referent)	
Second fifth	-1.26 (-2.88, 0.35)	0.1257	-1.14 (-2.71, 0.42)	0.1511	-0.88 (-2.49, 0.72)	0.281
Third fifth	-1.42 (-3.09, 0.25)	0.0959	-1.79 (-3.41, -0.17)	0.0301	-1.42 (-3.08, 0.25)	0.0949
Fourth fifth	-1.89 (-3.53, -0.24)	0.0244	-2.74 (-4.35, -1.13)	0.0009	-2.33 (-3.99, -0.67)	0.0059
Highest fifth¶	-0.84 (-2.54, 0.87)	0.3374	-2.98 (-4.72, -1.25)	0.0008	-2.49 (-4.28, -0.70)	0.0063
p for Trend	0.3202		0.0001		0.0014	

CDGA-scores: the Chinese Dietary Guidelines Adherence (CDGA) score, The CDGA score was designed to assess under-and over-nutrition as well as overall dietary balance, all of which constitute risk factors for NCDs in the Chinese population; DQD: Dietary quality distance , DQD evaluates unbalanced food intake by adding the absolute values of both positive and negative scores; LBS: Lower bound score, LBS assesses deficit food intake by adding the absolute values of all negative scores; HBS: Higher bound score , HBS assesses excessive food intake by adding all positive scores.

†Model 1 adjusted for age and sex.

‡Model 2 adjusted for age, sex, marital status, occupation, income, residency, and disease status.

§Model 3 adjusted for age, sex, marital status, occupation, income, residency, disease status, smoking status, and drinking status.

¶Lowest fifth corresponds to the healthiest diet; highest fifth corresponds to the least healthy diet according to CDGA scores.

question approach. This association was consistent among individuals above 60 years of age, females, and sick people, after adjustment for several potential confounders. These basic findings extend the relevance dietary scoring to overall health assessment rather than considering it assessing a single aspect of health only, and they also support the importance of diet in health.

The Chinese Dietary Guidelines were proclaimed by the Chinese Nutrition Society and Ministry of Health in 2007 and again in 2016. The guidelines aim to help the population keep a balanced diet and have been especially relevant during recent nutritional transitions to more westernised diets.[32,33] Similarly to Dietary Approaches to Stop Hypertension, they recommend consumption of plenty of grains, vegetables, fruits, dairy products, and soy foods, appropriate amounts of fish, poultry, eggs, and lean meats, and limited amounts of fat and salt.[10] Dietary habits constitute a potential risk factor, affecting physical and psychosocial health, which, in turn, may influence overall health status.

Currently, a rise in the diet-related burden due to NCDs is happening nearly worldwide.[34] High-quality diet reduces mortality and disability.[35] It has been reported that greater adherence to a Mediterranean diet, which is widely considered a model of healthy eating for its contribution to a favourable health status and a better quality of life, is associated with significantly improved health. Mediterranean diets are associated with significant reductions in overall mortality, mortality from cardiovascular disease (CVD), cancer incidence and mortality, and incidence of Parkinson's and Alzheimer's disease.[10] Closer adherence to Japanese dietary guidelines is also associated with reduced risk of total mortality, mortality from CVD, particularly from cerebrovascular disease, in Japanese adults.[36] Likewise, greater compliance with Chinese or US dietary guidelines is associated with lower overall mortality in Chinese adults. Favourable associations are more evident in men than in women and more consistent in relation to cardiometabolic than to cancer mortality.[37]

Adherence to recommended diets is also associated with better mental health. Indeed, high-quality diets are associated with reduced verbal-memory decline compared with their lower-quality equals; adherence to Mediterranean diet is similarly associated with relatively slower memory decline. These associations remain significant after adjustment for a number of covariates.[10] Adherence to the Mediterranean diet is related to better self-perceived mental and physical health functions, after controlling for confounding factors such as age, smoking, BMI, alcohol consumption, educational level, leisure-time physical activity, and the presence of chronic conditions.[38] Following a healthy diet is significantly associated with better emotional health, and following an unhealthy with greater emotional distress, after controlling for age, ethnicity, and gender. In addition and independently of each other, healthy and unhealthy eating scales have been associated with mental health in socially disadvantaged New Zealand adolescents.[39] Poor nutrition may also contributes to the pathogenesis of depression, with data supporting a relationship between the disorder

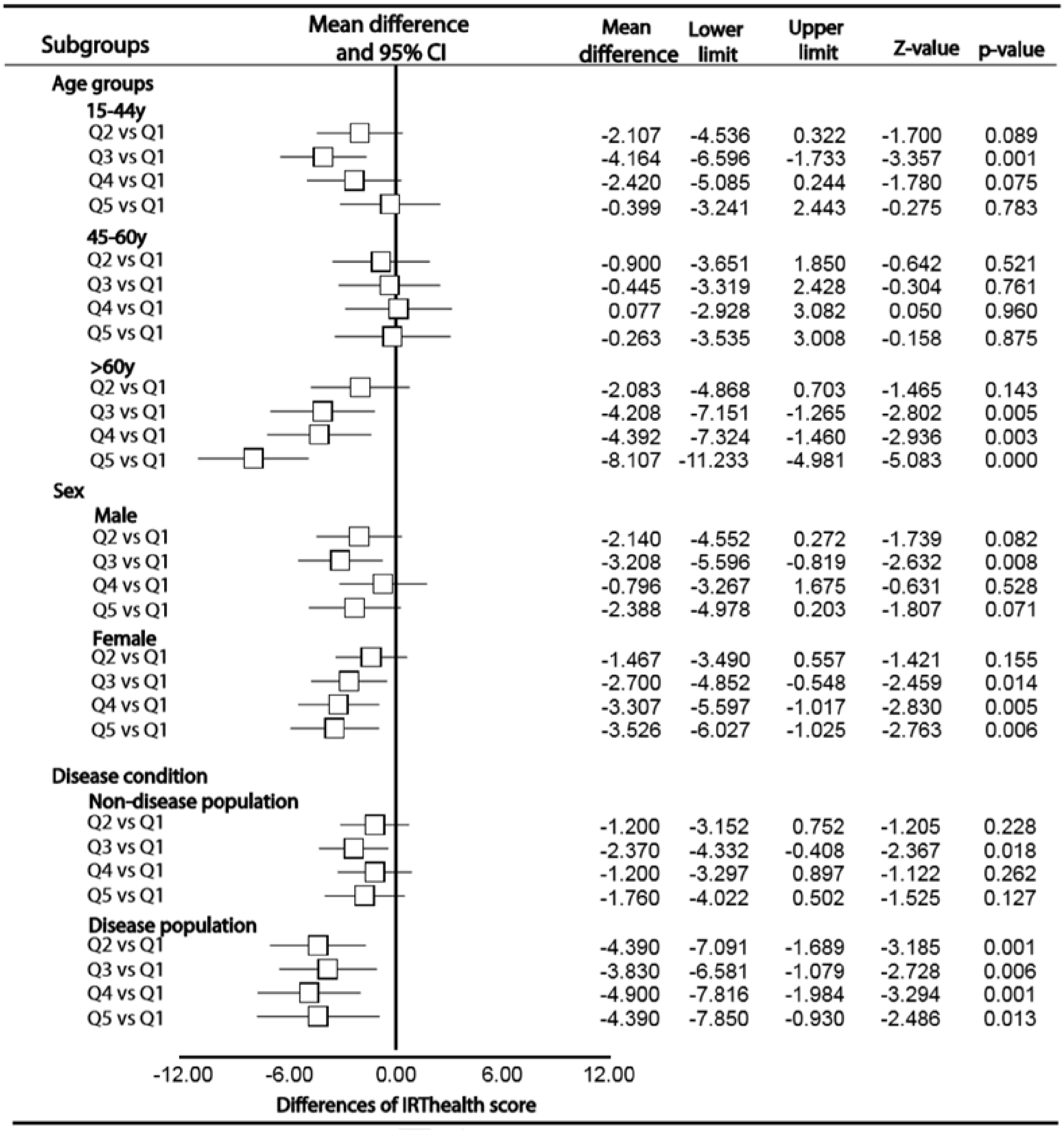

Figure 2. Subgroup analysis for the IRT-health scores.

and poor essential fatty acid and folic acid statuses; there is even a high likelihood that these nutrients may be used for depression treatment or boosting of existing or ongoing treatments. Other nutrients, including dietary antioxidants and certain trace elements, have not undergone the same rigorous scrutiny, but several have strong biological potentials in affecting brain function and thus modulating emotions. Results from the Australian National Nutrition and Health Surveys have indicated that food groups as well as fatty acids are associated with mood or emotions.[40] In individuals consuming typical western diets, deficiency in discrete nutrients with known effects on mental health is relatively common.[10]

The findings of the present study support previous conclusions that adherence to recommended dietary patterns may significantly improve overall health and that diet-quality evaluation may constitute an important means for assessing health, physically as well as psychologically.

Results of our subgroup analyses showed a significantly decreasing trend of overall health with elevated DBI in women, people above the age of 60, and sick individuals, but not in men, individuals below 60 years old or healthy. We speculate that men and young people may adhere less to recommended diets or pay less attention to their guidelines.[41] Additionally, middle-aged men are the primary providers in Chinese families, which puts them under relatively more pressure, among other things due to severe competition for promotions and high dependence from their children and parents. Such individuals tend to have an unhealthy lifestyle.

Strengths and limitations

This study is significant in that it is the first of its kind to assess associations between indicators of dietary adherence and overall health in a large Chinese sample. We used three compound CDGA-related scores to assess the dietary quality of participants. Unlike previous studies, we evaluated the relationship between diet quality and overall health, underlining the CDGA scores as important indices in assessing physical as well as mental health. The

Table 3. Association of CDGA scores with self reported health

CDGA scores	SQ health					CMH chi-square	*p*-value
	Very good	Good	Moderate	Bad	Very bad		
DQD							
Lowest fifth†	281 (19.4)	346 (20.9)	234 (19.7)	27 (15.1)	0 (0.0)	4.944	0.0262
Second fifth	260 (17.9)	343 (20.7)	258 (21.8)	28 (15.6)	1 (5.9)		
Third fifth	301 (20.8)	335 (20.2)	226 (19.1)	36 (20.1)	4 (23.5)		
Fourth fifth	283 (19.5)	337 (20.4)	213 (18.0)	39 (21.8)	8 (47.1)		
Highest fifth†	325 (22.4)	295 (17.8)	254 (21.4)	49 (27.4)	4 (23.5)		
LBS							
Lowest fifth†	287 (19.8)	353 (21.3)	230 (19.4)	28 (15.6)	0 (0.0)	2.732	0.0984
Second fifth	279 (19.2)	338 (20.4)	249 (21.0)	26 (14.5)	0 (0.0)		
Third fifth	290 (20.0)	351 (21.2)	232 (19.6)	30 (16.8)	5 (29.4)		
Fourth fifth	279 (19.2)	302 (18.2)	234 (19.7)	35 (19.6)	6 (35.3)		
Highest fifth†	315 (21.7)	312 (18.8)	240 (20.3)	60 (33.5)	6 (35.3)		
HBS							
Lowest fifth†	219 (15.1)	193 (11.7)	193 (16.3)	50 (27.9)	5 (29.4)	10.606	0.0011
Second fifth	295 (20.3)	392 (23.7)	278 (23.5)	36 (20.1)	5 (29.4)		
Third fifth	269 (18.6)	349 (21.1)	225 (19.0)	27 (15.1)	2 (11.8)		
Fourth fifth	321 (22.1)	394 (23.8)	257 (21.7)	35 (19.6)	2 (11.8)		
Highest fifth†	346 (23.9)	328 (19.8)	232 (19.6)	31 (17.3)	3 (17.6)		

CDGA-scores: the Chinese Dietary Guidelines Adherence (CDGA) score, The CDGA score was designed to assess under-and over-nutrition as well as overall dietary balance, all of which constitute risk factors for NCDs in the Chinese population; DQD: Dietary quality distance, DQD evaluates unbalanced food intake by adding the absolute values of both positive and negative scores; LBS: Lower bound score, LBS assesses deficit food intake by adding the absolute values of all negative scores; HBS: Higher bound score , HBS assesses excessive food intake by adding all positive scores; SQ: single question, which collects the data of respondents for their own overall assessment of their general health; CMH: Cochran–Mantel–Haenszel statistics, CMH is a test used in the analysis of stratified or matched categorical data.

†Lowest fifth corresponds to the healthiest diet; highest fifth corresponds to the least healthy diet according to CDGA scores.

current findings provide more evidence in favour of the benefits of adhering to the Chinese Dietary Guidelines to overall health. The size, stability, and representativeness of our sample makes us confident in our findings.

The present study also had several limitations, however, primarily because of its cross-sectional design. We also recognize that our findings should be generalized to the Chinese population as a whole with caution; differences in health awareness, socioeconomic status, and lifestyle might differ significantly between the general population and the study sample. Future studies should employ a longitudinal approach to assess actual causal relationships between diet quality and overall health.

AUTHOR DISCLOSURES

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Supplementary table 1. Components of the CDGA index

Components	Score	Subgroup	Score	Intake range by intake level(kJ)					
				6700	7550	8350	9200	10050	10900
C1-Cereals	(-12)—12	Cereals	(-12)—12[‡]	0~49=-8 200-250 g=0 >500 g=12	0~25 g=-10 225~275 g=0 >525 g=12	<25 g=-12 275~325 g=0 >575 g=12	<25 g=-12 275~325 g=0 >575 g=12	<75 g=-12 325~375 g=0 >625 g=12	-12<125 g=-12 375~425 g=0 >675 g=12
C2-Vegetables and Fruits	(-12)—0	Vegetable	(-6)—0	≥300 g=0 150~299 g=-2 1~149 g=-4 0 g=-6		≥350 g=0 175~249 g=-2 1~175 g=-4 0 g=-6	≥400 g=0 200~399 g=-2 1~199 g=-4 0 g=-6	≥450 g=0 225~449 g=-2 1~225 g=-4 0 g=-6	≥500 g=0 250~499 g=-2 1~249 g=-4 0 g=-6
		Fruits	(-6)—0	≥200 g=0 100~199 g=-2 1~99 g=-4 0 g=-6		≥300 g=0 150~299 g=-2 1~149 g=-4 0 g=-6		≥400 g=0 200~399 g=-2 1~199 g=-4 0 g=-6	
C3-Milk and dairy products,Soybean and soybean products	(-12)—0	Dairy	(-6)—0	≥ 300 g=0, score decreased 1 with intake amount decreased 50 g					
		Soybean	(-6)—0	≥30 g=0, 15~29 g=-2 1~14 g=-4, 0 g=-6		≥40 g=0, 20~39 g=-2 1~19 g =-4, 0 g=-6			≥50 g=0, 2 5~49 g=-2 1~24 g=-4, 0 g=-6
C4-Animal food	(-12)—(-8)	Red meat, products, Poultry and game	(-4)—4	0 g=-4, 1~25 g=-2 25-75 g=0 75~125 g=2 >125 g over=4			0 g=-4 1~50 g=-2 50~100 g=0 101~150 g=2 >150 g=4		
		Fish,and shrimp	(-4)—0	<20 g=-4 20~29 g=-3 30~39 g=-2 40~49 g=-1 ≥50 g=0		<30 g=-4 30~44 g=-3 45~59 g=-2 60~74 g=-1 ≥75 g=0			<40 g=-4 40~59 g=-3 60~79 g=-2 80~99 g=-1 ≥100 g=0
		Egg	-4—4	>75 g=4 51~75 g=2 25~50 g=0 1~24 g=-2 0 g=-4					

[†]Cereal include rice, wheat, dried legumes (exclude soybean) and tubers. Intake amount means fresh amount. Sweet potato: intake amount divided by 3; potato: intake amount divided by 4; yam and yambean: divided by 6.
[‡]Score increased (decreased) 2 with 50g intake increased (decreased) from 0 to maximal (minimal) score.

Supplementary table 1. Components of the CDGA index (cont.)

Components	Score	Subgroup	Score	Intake range by intake level(kJ)						
				6700	7550	8350	9200	10050	10900	11700
C5-Condiments and alcoholic beverage	0－12	Cooking oil	0－4	≤25 g=0 26~50 g=2 >50 g=4				≤30 g=0 30~60 g=2 >60 g=4		
		Salt	0－4	≤6 g=0 7~12 g=2 >12 g=4						
		Alcohol Beverage	0－4	Male: ≤25 g=0, 26~50 g=1, 51~75 g=2, 76-100 g=3, >100 g=4 (25 g alcohol=750 ml beer or 250 ml wine or 75 g liquor (<38°) or 50 g liquor (> 38°)						
				Female: ≤15 g=0,15~30 g=1, 31~45 g=2, 46~60 g=3, >60 g=4 (15 g alcohol=450ml beer or 150 ml wine or 50 g liquor(38°) or 30 g liquor (> 38°)						
C6-Diet variety	(-12)－0	Diet variety	(-12)－0	For consumption of greater than 25 g of foods (soybean is 5 g), otherwise score is -1						
C7-Drinking water	(-12)－0	Drinking water	(-12)－0	> 1200 ml=0, <100 ml=-12; score decreased 1 with intake amount decreased 100ml from 0 to 12						

†Cereal include rice, wheat, dried legumes (exclude soybean) and tubers. Intake amount means fresh amount. Sweet potato: intake amount divided by 3; potato: intake amount divided by 4; yam and yambean: divided by 6.

‡Score increased (decreased) 2 with 50g intake increased (decreased) from 0 to maximal (minimal) score.