Low dietary quality in patients with COPD and the association with disease severity: a cross-sectional study

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ABSTRACT

Background and Objectives: Dietary nutrition plays an essential role in the progression of chronic obstructive pulmonary disease (COPD). This study aimed to use Chinese Healthy Eating Index (CHEI) to evaluate dietary quality in COPD patients and investigate the relationship between dietary quality and COPD disease severity. **Methods and Study Design:** A total of 525 COPD inpatients were collected from December 1st, 2022, to December 1st, 2023. The dietary intake was collected through food frequency questionnaires (FFQ), and diet quality was assessed by the CHEI. Modified Medical Research Council Dyspnea Scale (mMRC), the COPD assessment test (CAT), and Global Initiative for Obstructive Lung Disease (GOLD) stage were used to assess disease severity. Multivariable logistic regression was used to analyze the association between the total CHEI score, and its component scores and COPD disease severity. **Results:** The CHEI score with COPD patients is 56.75±8.89. The CAT score of the low CHEI group was significantly higher than that of the high CHEI group (p<0.05). Ordinal logistic regression analysis indicated that the group with higher CHEI total scores was significantly associated with the low grade of mMRC (OR: 0.982, 95%CI: 0.964, 1.000, p<0.05). And the higher intake of tubers, whole grains and mixed beans, and fish and seafood were all associated with lower mMRC grades (p<0.05). **Conclusions:** COPD patients have poor dietary quality. High CHEI scores were associated with the low mMRC grades. Patients with COPD should be encouraged to maintain a good quality diet to reduce the risk of disease exacerbation.

Key Words: Chinese Healthy Eating Index, chronic obstructive pulmonary disease, dietary quality, FFQ, Disease severity

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a heterogeneous lung condition characterized by chronic respiratory symptoms (dyspnea, cough, expectoration) due to persistent abnormalities of the airways (bronchitis, bronchiolitis) and/or alveoli (emphysema) that often result in progressive airflow limitation.[1] It is estimated that about 3.5 million people die of COPD each year worldwide and have become the world's fourth leading cause of death.[2] Several studies have shown that the prevalence is significantly higher in patients > 40 years of age than in patients < 40 years of age, and that the prevalence of COPD increases significantly with age.[3, 4]

The current routine treatment of COPD includes drug therapy, smoking cessation counselling, and pulmonary rehabilitation therapy.[5] However, along with clinical treatment, dietary and nutritional management has also entered the minds of researchers.[6, 7] In recent years, there has been increasing evidence that diet and nutrition can be a variable factor in the development and progression of COPD.[8, 9] High consumption of vegetables, fruits, and whole grains reduces the risk of developing COPD.[10, 11] Meanwhile, excessive intake of alcohol and refined grains is associated with an increased risk of developing COPD.[12, 13] Dietary intake is not only associated with the risk of developing COPD, but at the same time, enhancing the quality of a patient's diet may also improve the patient's nutritional status, reduce the number of acute exacerbations, and decrease the economic burden.[14, 15] Therefore, we will use a complete and comprehensive dietary quality score to assess the dietary intake of COPD patients more comprehensively and to make an overall judgement on their dietary quality.

Currently, dietary quality scores that have been used include the Healthy Eating Index (HEI), the Healthy Diet Indicator (HDI), the Diet Quality Index (DQI), and others. The HEI was developed by the US Department of Agriculture (USDA) in 1995 and designed to assess Americans' dietary intake and dietary quality.[16] Canada, Brazil, Australia and Thailand have adapted HEI for their populations based on local dietary guidelines.[17-19] Following the revision of the Dietary Guidelines for Chinese Residents (DGC) in 2016, the Chinese Healthy Eating Index (CHEI) was developed based on the HEI for a more effective assessment of the dietary quality of Chinese people.[19]

The CHEI not only evaluates the dietary quality of healthy people,20 but also can be used to study the relationship between diet and diseases, such as metabolic syndrome of pregnancy,[21] diabetes,[22] and tumors.[23, 24] However, CHEI has not been applied to patients with respiratory diseases, especially COPD. Dietary quality assessment of patients with COPD can help us to understand the dietary characteristics of patients and effectively guide them to make rational food choices and nutritional adjustments. Therefore, the aim of this study was to apply CHEI to evaluate dietary quality in patients with chronic obstructive pulmonary disease and to investigate the relationship between dietary quality and COPD disease severity in order to better guide the dietary intake of patients in the clinic and to help the recovery of the disease.

MATERIALS AND METHODS

Study design and population

This is a cross-sectional study. The sample size was calculated a priori using N=. Based on previous studies, the proportion of COPD patients with moderate disease severity was 56%.25 The significance level (α) was 0.05 and the statistical power (1-β) was 0.90. To account for data exclusion, the final sample size was increased by 20%. A minimum of 377 subjects was therefore required.

This study has been conducted including 536 patients with diagnoses of AECOPD from December 1st, 2022, to December 1st, 2023, in Weifang No.2 People's Hospital, Shandong Province, China. All the AECOPD patients were investigated, and those who did not meet the inclusion and exclusion criteria were excluded from the study, resulting in the inclusion of 525 patients (Figure 1). This study was reviewed and approved by the Ethics Committee of the Medical Department of Qingdao University (QDU-HEC-2022277) and the Ethics Committee of Weifang NO.2 People's Hospital (KY2023-030-01) and complied with the Declaration of Ethical Principles for Medical Research in Helsinki. The study was registered with the Chinese Clinical Trial Registry (No. ChiCTR2300069658). All patients provided informed written consent.

All COPD patients received standard clinical treatment. Participants were eligible to be included if they: 1) were aged 45 years or older; 2) had a COPD diagnosis, according to GOLD-2025; 3) were in hospital; and 4) signed informed consent. The exclusion criteria were: 1) history of oncological disease or tuberculosis disease in the previous five years; 2) history of severe cardiovascular diseases such as myocardial infarction, angina pectoris and heart failure; 3)poor control of blood pressure (systolic blood pressure >170mmHg or diastolic blood pressure >100 mmHg) or blood glucose (fasting blood glucose >7.0mmol/L or postprandial blood glucose >10.0 mmol/L); 4) history of liver diseases, coagulation disorders, etc. in the previous two years; 5) history of alcohol, drug abuse or other dependence within 2 years; 6) incomplete dietary data or energy intake below 500 kcal/day or above 5000 kcal/day.

Data collection

Demographic characteristics of the participants such as age, gender, place of residence, educational level and lifestyle habits (such as smoking) were collected through a questionnaire. The physical examination was performed by professionally trained staff and included measurements of height, weight, waist and hip circumferences. Body mass index (BMI) was calculated as follows: BMI = weight (kg)/height (m).[26] Waist Hip Ratio (WHR)

was calculated by dividing waist circumference by hip circumference. The modified Medical Research Council Dyspnea Scale (mMRC) grades and the COPD assessment test (CAT) were assessed by questionnaire. The mMRC is divided into five grades, 0-4. CAT scores range from 0-40, with ≤20 being mild to moderate and >20 being severe and very severe.[7] Information on the patient's clinical case was collected, including comorbidities (hypertension and diabetes) and lung function index, including forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC), the ratio of forced expiratory volume in 1 s and forced vital capacity (FEV1/FVC), and the ratio of actual to predicted value of FEV1(FEV1%pred). The degree of airflow obstruction was graded using the 2024 edition of the Global Initiative for Obstructive Lung Disease (GOLD) guidelines.[7]

Dietary questionnaire and calculation of CHEI

The dietary questionnaire was used to conduct a dietary review. The food frequency questionnaire (FFQ) was used to investigate the diet of the study population in the last year, which included the frequency of eating 92 foods (times/year, times/month, times/week, times/day) and the average amount of food consumed per serving (g). The questionnaire is quoted from the simplified version of FFQ25.[27] Before the commencement of the study, a preliminary survey was conducted to familiarize us with the interview process and to understand the local dialect. To standardize data collection procedures, our team conducted mock interviews with 10 individuals (not included in the final sample) to refine question delivery and timing. As the study region has unique linguistic characteristics, we verified that all participants could fully understand the questions through this pilot phase. And the dietary questionnaire was adapted in small parts to suit the area. We increased the types of wheat flour-based foods in the region, increased the variety of clams and carp in aquatic products, and decreased the variety of silver carp and perch. The daily intake of edible oil, edible salt and added sugar was included in the survey. Subjects were excluded if their dietary questionnaires were incomplete or if they reported energy intake below 500 kcal/day or above 5000 kcal/day due to possible errors in questionnaire responses or survey bias.[21, 28]

The CHEI was built on the Dietary Guidelines for Chinese (DGC-2016), and its reliability and validity were evaluated.[29] To ensure uniform energy and similar carbohydrates, proteins, and fats, the standard portion sizes for each food group were calculated according to DGC-2016. CHEI contains 17 food components, including 12 adequacy components: total grains, whole grains and mixed beans, tubers, total vegetables, dark vegetables, fruits, dairy, soybeans, fish and seafood, poultry, eggs, seeds and nuts, and five moderation/limitation

components: red meat, cooking oils, sodium, added sugars and alcohol. The sodium content calculated in this study is only the sodium content in table salt, excluding sodium in other foods and condiments. With the exception of fruit, cooking oils, and sodium, which had a maximum score of 10, all the other components had a maximum score of 5. The scores for the 17 components of the CHEI are divided into four sections. Fruits, sodium and edible oils were scored as 0, (0-5), (5-10) and 10 and scores for other food components were scored as 0, (0-2.5), (2.5-5) and 5. The specific criteria and corresponding scores are delineated in Supplementary table1. The CHEI total score was the sum of scores for all 17 components, ranging from 0 to 100 (highest diet quality).

Statistical analysis

Data analysis was performed using SPSS (IBM, version 22.0), and $p < 0.05$ was considered statistically significant. Figures were performed using GraphPad Prism (GraphPad Software, version 9). The data were first tested for normality for the Kolmogorov-Smirnov test. Quantitative data that conformed to a normal distribution were described as mean ± standard deviation (SD), and non-normal data were described by media and quartile descriptions. Categorical data were expressed as absolute numbers and percentages. Multiple group comparisons of quantitative data were made using the One-way analysis of variance (ANOVA). The Kruskal -Wallis H test was used to test multiple groups of categorical data. Stratified analyses of gender and place of residence compared differences among the four subgroups of CHEI. And a Trend test was added for differences between the three CHEI groups and pulmonary function indices (FEV1, FVC, FEV1/FVC, FEV1%), CAT, mMRC, and GOLD stage. Ordinal logistic regression was used to assess the association between the total CHEI score or its component scores and mMRC and GOLD stage. Binary logistic regression was used to examine the relationship between the CHEI total score and its component scores and the CAT groups (the 2 categories of CAT score). Potential confounders incorporated into the adjusted models included age, gender, BMI, education level, place of residence, smoking index, physical activity level and alcohol intake status.

RESULTS

Characteristics of the participants

Analyses were performed on 525 participants. The mean age of the enrolled population was 69.64±7.83 years. A total of 429(81.7%) were male. The BMI was 22.37±3.84 kg/m^2. In this study, former smokers were 49.0%, and current smokers were 22.8%. The study population

was characterized by moderate airflow limitation (FEV1 52.51 ± 23.69% pred). The FEV1 was 1.31 ± 0.66 L, and the FVC was 2.68 ± 0.83 L. According to the GOLD stage, 38% of COPD patients were level III, and 30.5% were level II. In this study, 43.2% of COPD patients had a mMRC score of level 3. The CAT score greater than 20 was 64% (Supplementary Table 2).

The CHEI scores of the participants

The total CHEI score for 525 patients with COPD was 56.75±8.89. The CHEI score ranged from 31.56 to 87.64. Table 1 showed the fraction of each food component of CHEI and the proportion of people in each component. In general, except for added sugars and alcohol, most people did not meet the recommended values (receive the highest ingredient scores) for the food categories in DGC-2016. The percentage of participants scoring zero on the seeds and nuts section was 52.95%. Tubers, total vegetables, dark vegetables, fruits, soybeans, fish and seafood, and poultry were the components with relatively insufficient intake. The proportion of participants receiving 0 to half total score for each of the seven components was 59.81%, 73.33%, 82.48%, 52.95%, 55.81%, 68.57%, 55.62%. At the same time, red meat was the most serious component of overconsumption, with only 2.29% of patients getting a perfect score. Furthermore, more than half of the participants were also consuming more than the recommended amount of cooking oil and sodium. The vast majority of people scored high on alcohol and added sugar intake.

Stratification analyzed by gender and residence showed that females scored higher than males on whole grain and mixed beans, fruits, cooking oils, and alcohol components (p all<0.01). Meanwhile, patients residing in rural areas scored higher than those residing in towns for whole grains and mixed beans (p<0.05), poultry (p<0.01), sodium (p<0.001), and alcohol (p<0.01), with opposite results obtained for seeds and nuts (p<0.01) (Figure2).

The characteristics, lung function and disease state of the participants

The CHEI score was divided into three groups: low, middle, and high CHEI group. Table 2 indicated that compared to the low CHEI scores group, patients in the group with a high CHEI score had higher body weight, higher BMI, higher hip circumference, lower waist-to-hip ratio, and fewer current smokers and fewer people with hypertension (p<0.05). However, there were no significant differences between the three groups in terms of age, gender and place of residence, whether they lived alone or not, and Education level (p>0.05).

Table 3 indicated the CAT score of the low CHEI group was significantly higher than that of the high CHEI group (p<0.05), but after grouping, there was no significant difference among the three CHEI groups (p>0.05). No difference in lung function index FEV1, FVC, FEV1/FVC, FEV1 (%pred), GOLD stage and mMRC were observed between the three groups (p all >0.05).

CHEI scores and disease severity

Ordinal logistic regression analysis indicated that the group with higher CHEI total scores was significantly associated with the low grade of mMRC (OR: 0.982, 95%CI: 0.964, 1.000, p<0.05). The results in Figure3B and Supplementary Table 3 showed a negative correlation between whole grains and mixed beans (OR: 0.826, 95%CI: 0.753, 0.906, p<0.001), tubers (OR: 0.896, 95%CI: 0.818, 0.981, p<0.05), fish and seafood (OR: 0.862, 95% CI: 0.785, 0.947, p<0.01), red meat (OR: 0.892, 95%CI: 0.804, 0.990, p<0.05) and mMRC grades. However, sodium scores were positively correlated with mMRC grades (OR: 1.074, 95% CI: 1.022, 1.127, p<0.05).

Binary logistic regression showed no significant associations with CHEI scores and CAT grades. Figure 3 D and Supplementary Table 4 revealed that higher intake of total vegetables (OR: 0.765, 95%CI: 0.624, 0.933, p<0.01), dark vegetables (OR: 0.754, 95%CI: 0.601, 0.946, p<0.05) were associated with lower CAT grades. As shown in Figure3E, F and Supplementary Table 5, no significant association was found between CHEI score and GOLD stage (p>0.05).

DISCUSSION

A total of 525 participants were included in this cross-sectional study. In this study, the dietary quality of patients with COPD was comprehensively assessed using the CHEI, with a mean of 56.75±8.89. Nuts and seeds, tubers, vegetables, fruits, soybeans, fish and seafood, and poultry are the components with insufficient intake. Overall, the nutritional quality of diets was poor in patients with COPD. Compared to the low CHEI scores group, patients in the group with a high CHEI score had higher body weight, higher BMI, higher hip circumference, lower waist-to-hip ratio, fewer current smokers, fewer people with hypertension, and lower CAT scores. After adjusting for confounders, there was an association between high CHEI score and low mMRC grades.

In this study, the age of patients with COPD was 69.64±7.83 years, and poor dietary quality was found in this population assessed with the CHEI. This was similar to the results

assessed by the Alternative Healthy Eating Index (AHEI-2010).[30] Among the 17 components of the CHEI, seeds and nuts were the most deficient components. And tubers, vegetables, fruits, soybeans, fish and seafood, and poultry are insufficient intake. The population included in this study was middle-aged and older adults >45 years of age, and the mean age of COPD patients was 69.64 ± 7.83 years. Seeds and nuts, vegetables, and fruits may be related to oral health problems in older adults, thereby affecting the choice of food, such as the reduced function of chewing muscles due to decreased muscle strength, gum recession, and loose, lost, and missing teeth.[31-33] Moreover, inadequate intake of fruits and vegetables may be related to older age as a function of declining gastrointestinal function as well as an individual's socioeconomic circumstances.[34, 35] And seeds and nuts are rich in fat, which may activate inflammatory pathways, such as nuclear factor kappa-B (NF-κB) and toll-like receptor 4 (TLR4), leading to the triggering of increased respiratory symptoms.[36, 37]

At the same time, several studies have shown that a high intake of vegetables, fish and seafood is inversely associated with increased risk of COPD.[38, 39] And studies in China have shown that intake of tubers, dairy products, and soya products is already low in the elderly population.[40-42] This may be related to decreased digestive function and food intolerance due to gastrointestinal dysmotility in the elderly.[43] The majority of patients with COPD in our study were also found to consume more than the recommended intake of red meat and sodium. The evidence showed a positive association between increased intake of red meat and sodium and the risk of developing COPD.[44, 45] So further research is needed regarding dietary recommendations for red meat in COPD patients. This study found high sodium intake in COPD patients, which may be related to a high-salt diet. Traditional Chinese dietary patterns, which often emphasize salty flavors, combined with the age-related decline in taste sensitivity among older adults, may collectively contribute to elevated salt consumption levels.[46-48] And the results of this study found that only 41.33% of the patients who received a full score in the cooking oil group. This may be due to the increased intake of cooking oil and salt in the elderly due to their diminished sense of taste.[49]

Differences in scores for certain food components by gender and place of residence were also found in our study. High intake of whole grains and mixed beans, and fruits and low intake of cooking oils and alcohol among female patients may be due to the differences in lifestyle habits and food choices.[50] The observed variations in consumption of whole grains, mixed beans, poultry, and alcohol across different residential settings, as identified through stratified analysis. This may be due to the influence of the living environment and economic

conditions.[51] For example, people in rural areas with lower economic levels prefer less expensive meat, e.g. poultry.

The results of the study showed that the CAT scores of the low CHEI group were significantly higher than the high CHEI group. And based on logistic regression analyses, the results illustrated that high CHEI scores reduce the probability of high mMRC grades. The CAT and mMRC are important indicators for assessing the degree of disease and the quality of life of patients with COPD.[52, 53] Therefore, we have inferred from the findings that a healthy diet quality may reduce the risk of dyspnoea and disease exacerbation in patients with COPD. Although the association between overall diet score and severity of chronic obstructive pulmonary disease has been less well studied, evidence from epidemiological studies suggests a relationship between dietary factors and lung function.[54] A Mediterranean-like dietary pattern, characterized by a high intake of fruit, vegetables, oily fish and whole grains, is associated with preserved lung function.[55] Moreover, in cross-sectional analyses of the general population, an overall healthy diet as assessed by the HEI-2005 was positively associated with the FEV1/FVC.[56]

Several mechanisms could explain the observed association between dietary quality scores and the severity of COPD. On the one hand, COPD is a chronic progressive disease characterized by airflow limitation, which is closely related to oxidative stress and inflammation in the lungs.[57] A higher diet-quality score, such as the Recommended Food Score (RFS), alternate Mediterranean Diet Score (aMDS), and Alternate Healthy Eating Index (AHEI), was associated with lower levels of oxidative stress and inflammation biomarkers.[58, 59] Thus, diets with higher CHEI scores may reduce COPD disease severity by reducing oxidative stress and inflammation. On the other hand, the results of CHEI food fractions also suggested that food groups may contribute to the association with COPD. Tubers, whole grains and mixed beans and vegetables are high in a variety of nutrients, including vitamins, minerals, and dietary fiber, which can reduce the level of inflammation in the body, thus improving the condition of the disease.[60, 61] For example, vitamin C and vitamin E, which are rich in vegetables and fruits and are common antioxidants, can increase serum glutathione (GSH) levels and decrease superoxide dismutase (SOD) and malondialdehyde (MDA) levels, thus exerting beneficial effects on COPD patients.[62, 63] Dietary fiber from whole grains and mixed beans and tubers reduces serum levels of inflammatory markers such as C-reactive protein (CRP), and interleukin-6 (IL-6).[64] Fish and seafood are rich in protein, which improves the nutritional status of the patient, and contain omega-3 polyunsaturated fatty acids (n-3 PUFAs) and minerals that can play a role in reducing inflammation and

immunomodulation in the body.[65-67] For example, n-3 PUFAs can have beneficial effects on COPD through the production of the pro-resolving mediators with anti-inflammatory actions, such as resolvins and protectins.[68] Therefore, patients with COPD should increase their intake of whole grains and mixed beans, tubers, and aquatic products, consume red meat in moderation, and reduce the intake of alcohol.

This study embodies several strengths and innovations. First, for the first time, the CHEI, which is consistent with the recommendations of the DGC-2016, was used to investigate the relationship between dietary quality and COPD progression and exacerbations in patients with COPD. Second, a significant strength of this study is the timeliness of the dataset, which covers dietary records collected between 2022 and 2023. Finally, the results of analyses of the food components of the CHEI may also reflect the quality of dietary patterns and provide clues for guiding patients to eat properly. However, this study has some limitations. Firstly, this study used a cross-sectional design, which is statistically less efficient compared to cohort studies, and does not allow for direct and definite causal conclusions to be drawn. Second, the FFQ may be affected by regional and seasonal variations. Recall bias may exist in dietary surveys. Thirdly, although we have controlled for a large number of confounders in our analysis, there are still other unincluded confounders that may have affected the results of this study. And the data presented in this paper came from only a limited number of patients in one center. Therefore, these findings can only reflect the dietary quality of COPD patients in the region. A nationwide analysis of patients' dietary quality would require full integration of data from multiple centers to continue to expand the sample size.

Conclusion

In conclusion, COPD patients have poor dietary quality within our study area. We recommend that male patients increase their intake of coarse cereals and fruits, and that patients living in urban areas reduce their intake of alcohol and cooking oils. Good dietary quality plays an important role in the progress of COPD. CHEI total score and scores of each food component showed that the inclusion of tubers, whole grains and mixed beans, fruits, vegetables, and fish and seafoods in the diet of COPD patients may have a beneficial effect on reducing disease severity in COPD. The patients with COPD should be encouraged to follow DGC-2016 to optimize their diet. Efforts should also be made to maintain a good quality of overall diet to realize the potential of dietary factors in reducing the risk of disease exacerbation.

SUPPLEMENTARY MATERIALS

All supplementary materials are available upon request to the editorial office.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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Table 1. The CHEI components intakes for COPD patients (n=525)

CHEI component	COPD (n=525)	0	0-2.5 or 0-5	2.5-5 or 5-10	5 or 10
Total grains	3.35 (1.38,5.00)	1 (0.19)	81 (15.43)	209 (39.81)	234 (44.57)
Whole grains and mixed beans	4.64 (3.24,5.00)	35 (6.67)	151 (28.76)	179 (34.1)	160 (30.48)
Tubers	1.89 (0.64,3.70)	78 (14.86)	236 (44.95)	130 (24.76)	81 (15.43)
Total vegetables	1.84 (1.14,2.57)	0 (0.00)	385 (73.33)	126 (24.00)	14 (2.67)
Dark vegetables	1.61 (1.00,2.23)	0 (0.00)	433 (82.48)	87 (16.57)	5 (0.95)
Fruits	4.76 (2.04,7.50)	28 (5.33)	250 (47.62)	200 (38.10)	47 (8.95)
Dairy	1.76 (0.00,5.00)	192 (36.57)	93 (17.71)	71 (13.52)	169 (32.19)
Soybeans	2.23 (0.85,3.96)	53 (10.10)	240 (45.71)	154 (29.33)	78 (14.86)
Fish and seafood	1.36 (0.39,3.21)	91 (17.33)	269 (51.24)	90 (17.14)	75 (14.29)
Poultry	2.03 (0.65,5.00)	85 (16.19)	207 (39.43)	95 (18.10)	138 (26.29)
Eggs	5.00 (3.80,5.00)	7 (1.33)	48 (9.14)	180 (34.29)	290 (55.24)
Seeds and nuts	0.00 (0.00,1.62)	278 (52.95)	143 (27.24)	27 (5.14)	77 (14.67)
Red meat	2.57 (1.16,3.76)	73 (13.90)	183 (34.86)	257 (48.95)	12 (2.29)
Cooking oils	8.00 (4.00,8.00)	72 (13.71)	71 (13.52)	165 (31.43)	217 (41.33)
Sodium	7.00 (4.00,9.00)	47 (8.95)	111 (21.14)	283 (53.90)	84 (16.00)
Added sugars	5.00 (4.00,5.00)	63 (12.01)	22 (4.19)	47 (8.95)	393 (74.89)
Alcohol	5.00 (5.00,5.00)	27 (5.14)	16 (3.05)	15 (2.86)	467 (88.95)
Total scores	56.75 ± 8.89	-	-	-	-

CHEI: Chinese healthy eating index; COPD: chronic obstructive pulmonary disease.
Categorical data are presented as n (%); Quantitative data that conformed to a normal distribution mean ± SD and non-normal data are described by median (Q25, Q75).

Table 2. Comparison of the characteristics of COPD patients among three CHEI score groups (n = 525)

Demographic characteristics	CHEI			F/χ^2	*p*
	T1 (N=175)	T2 (N=175)	T3 (N=175)		
Age(y)				3.601	0.463
40-	27(15.4)	23(13.1)	17(9.7)		
60-	132(75.4)	137(78.3)	146(83.4)		
80-	16(9.1)	15(8.6)	12(6.9)		
Gender				0.994	0.608
Male	147(84.0)	140(80.0)	142(81.1)		
Female	28(16.0)	35(20.0)	33(18.9)		
Living alone				5.308	0.070
Yes	25(14.3)	22(12.6)	12(6.9)		
No	150(85.7)	153(87.4)	163(93.1)		
Place of residence				0.681	0.711
Urban	66(37.7)	72(41.1)	73(41.7)		
Rural	109(62.3)	103(58.9)	102(58.3)		
Education level				7.133	0.309
Illiteracy	13(7.4)	17(9.7)	15(8.6)		
Low	137(78.3)	131(74.9)	126(72.0)		
Middle	23(13.1)	27(15.4)	29(16.6)		
High	2(1.1)	0(0.0)	5(2.9)		
Smoking				22.609	<0.001**
Non-smoker	35(20.0)	59(33.7)	54(30.9)		
Former smoker	83(47.4)	77(44.0)	97(55.4)		
Current smoker	57(32.6)	39(22.3) †	24(13.7) †‡		
Weight (kg)	60.79±12.27	59.76±11.42	63.19±11.72 ‡	3.89	0.021*
BMI (kg/m^2)	22.16±3.83	21.92±3.66 †	23.03±3.94 ‡	4.112	0.017*
Waistline (cm)	88.15±11.28	86.97±10.53	89.18±11.28	1.759	0.173
Hipline (cm)	95.97±11.08	96.19±10.32 †	98.54±10.58 ‡	3.119	0.045*
WHR	0.92±0.07	0.90±0.06 †	0.91±0.06 †	3.229	0.040*
SBP (mmHg)	136.45±18.72	132.25±19.87 †	136.85±18.48 ‡	3.125	0.045*
DBP (mmHg)	82.20±10.83	81.27±11.80	83.02±11.69	1.028	0.358
Comorbidity					
Hypertension	95(54.3)	69(39.4) †	85(48.6)	7.884	0.019*
Diabetes	26(14.9)	28(16.0)	21(12.0)	1.213	0.545

COPD: chronic obstructive pulmonary disease; CHEI: Chinese healthy eating index; BMI: body mass index; WHR: waist to hip ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; T1: Low CHEI scores group (47.06±4.61); T2: Middle CHEI scores group (56.70±2.27); T3: High CHEI scores group (66.50±4.66).
Categorical data are presented as n (%); Quantitative data that conformed to a normal distribution mean ± SD
†p<0.05 compared to T1 group
‡p <0.05 compared to T2 group
*: p<0.05, **: p<0.001.

Table 3. Lung function of COPD patients among three CHEI score groups (n = 525)

Demographic characteristics	CHEI			F/χ^2	*P*	P_{trend}
	T1(N=175)	T2(N=175)	T3(N=175)			
Lung function†						
FEV1(L)	1.31±0.59	1.29±0.72	1.26±0.63	0.108	0.897	0.649
FVC(L)	2.62±0.81	2.54±0.94	2.68±0.84	0.615	0.541	0.651
FEV1/FVC	48.70±13.43	48.48±14.28	46.26±12.93	1.025	0.360	0.201
FEV1(%pred)	51.35±23.37	50.57±24.61	50.04±24.66	0.073	0.929	0.703
GOLD Stage†				2.489	0.870	0.544
I	11(11.3)	14(13.9)	10(9.5)			
II	33(32.0)	27(26.7)	33(31.4)			
III	38(39.2)	37(36.6)	41(39.0)			
IV	17(17.5)	23(22.8)	21(20.0)			
CAT score	19.75±4.58	19.42±4.55	18.44±4.50 ‡§	3.925	0.020*	0.007**
CAT group				4.514	0.105	0.059
≤ 20	106(60.6)	107(61.6)	123(70.3)			
> 20	69(39.4)	68(38.9)	52(29.7)			
mMRC grade				7.998	0.434	0.070
0	10(5.7)	13(7.4)	15(8.6)			
1	16(9.1)	24(13.7)	26(14.9)			
2	36(20.6)	38(21.7)	37(21.1)			
3	87(49.7)	67(38.3)	73(41.7)			
4	26(14.9)	33(18.9)	24(13.7)			

CHEI: Chinese healthy eating index; COPD: chronic obstructive pulmonary disease; FEV1: forced expiratory volume in 1 s; FVC: forced vital capacity; FEV1/FVC: the ratio of forced expiratory volume in 1 s and forced vital capacity; FEV1%pred: the ratio of actual to predicted value of FEV1; GOLD: Global Initiative for chronic obstructive pulmonary disease; CAT: COPD assessment test; mMRC: the modified medical research council dyspnea scale; T1: Low CHEI scores group (47.06±4.61); T2: Middle CHEI scores group (56.70±2.27); T3: High CHEI scores group (66.50±4.66).
Categorical data are presented as n (%); Quantitative data that conformed to a normal distribution mean ± SD
†305 of 525 patients had lung function indicators.
‡p<0.05 compared to T1 group
§p <0.05 compared to T2 group
*: p<0.05. **: p<0.01.
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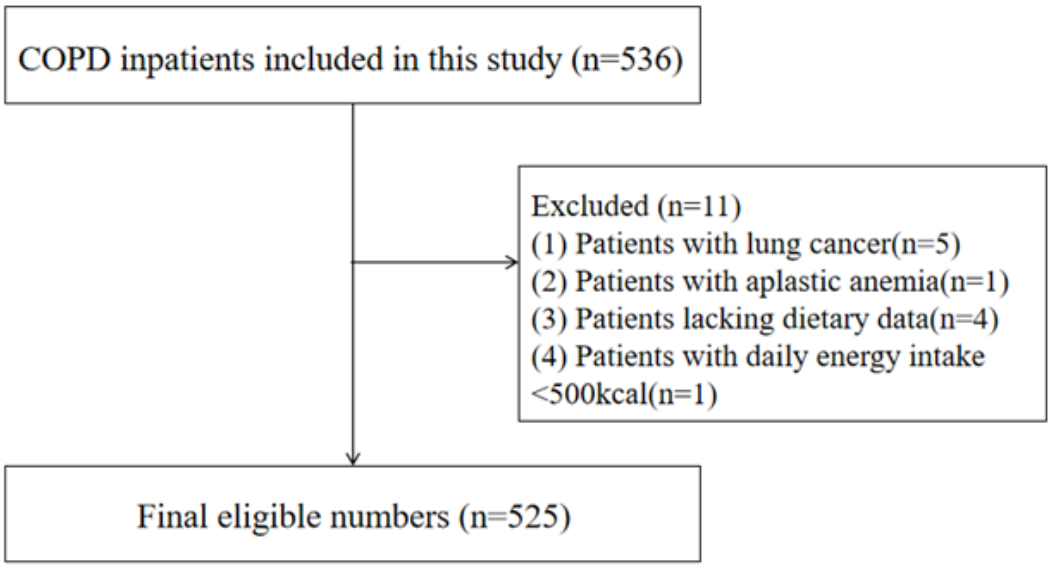

Figure 1. Flow chart of the study population

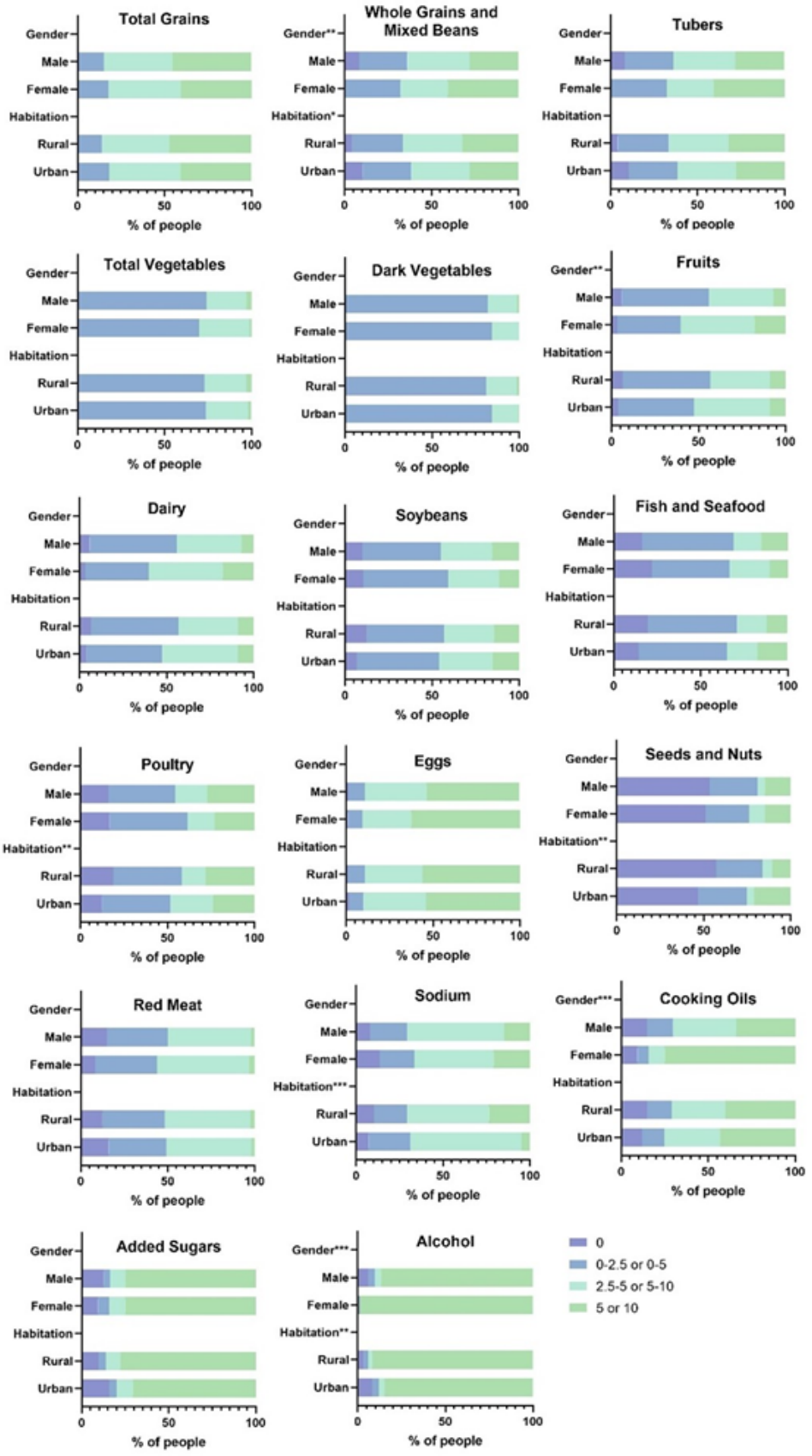

Figure 2. The CHEI components by gender and residence stratification. *: p<0.05, **: p <0.01, ***: p <0.001.

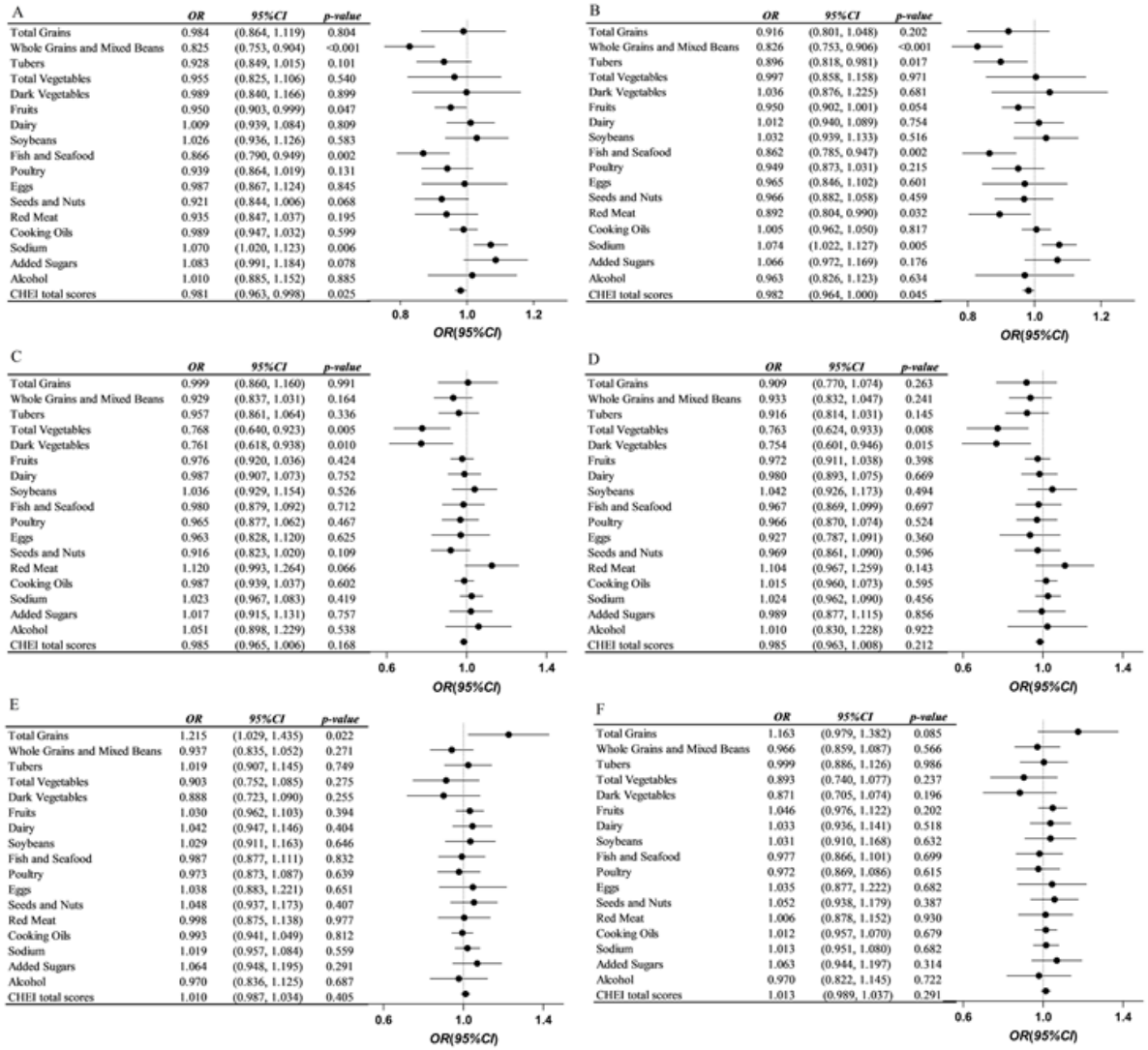

Figure 3. Odds ratio and confidence interval of association between CHEI score and mMRC, CAT, and GOLD. CHEI: Chinese healthy eating index; mMRC: the modified medical research council dyspnea scale; CAT: chronic obstructive pulmonary disease assessment test; GOLD: Global Initiative for chronic obstructive pulmonary disease. A: between CHEI score and mMRC (Model 1); B: between CHEI score and mMRC (Model 2); C: between CHEI score and CAT (Model 1); D: between CHEI score and CAT (Model 2); E: between CHEI score and GOLD (Model 1); F: between CHEI score and GOLD (Model 2). Model 1: adjusted for age, gender and BMI; Model 2: adjusted for age, gender, BMI, smoking index, education level, place of residence, physical activity level and alcohol consumption status