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The relationship between different diet quality indices and severity of airflow obstruction among COPD patients

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) is a major public health problem worldwide. Smoking is the number one cause of COPD; however, genetic, environmental and dietary factors contribute to the etiology of this disease. In this study, we assessed the association between three diet quality indices -the Healthy Eating Index-2005 (HEI-2005), the Healthy Eating Index-2010 (HEI-2010), and Mediterranean Diet Score (MED)- and the severity of disease in COPD patients.

Methods: This cross-sectional study was performed at Rasul-e-Akram Hospital in Tehran on 121 COPD patients with the mean age of (SD) of 66.1(10.9) years. A pulmonary specialist diagnosed all participants based on a spirometry test. They were categorized into four groups (1, 2, 3, 4 stages of disease). Three diet quality indices, spirometry test and determination of disease severity were performed for all the participants. ANCOVA and Kruskal-Wallis test were used to assess the relationship between dietary quality indices and severity of the disease. The relationship between HEI-2010, HEI-2005, MED score, their components and lung function was assessed using a multiple linear regression analysis. All analyses were done using SPSS 18.

Results: Reduction of the Healthy Eating Index-2010 and MED score were observed along with the increase in disease severity, but they were not significant. The relationship between the three diet quality indices and lung function showed a significant association between MED score and Forced expiratory volume in one second (FEV1), The Forced Vital Capacity (FVC) (β=2.9, 95% CI (1.1, 4.8), p=0.002), (β=2.8, 95% CI (0.9, 4.8), p=0.007), respectively.

Conclusion: Mediterranean dietary pattern and obtaining a better score on HEI-2010 diet were associated with a better lung function test.

Keywords: COPD, Diet Quality Index, nutrition, Mediterranean Diet.

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Introduction

Chronic respiratory diseases constitute a public health problem worldwide (1). COPD is a debilitating condition that could end in morbidity and death. COPD patients suffer from limited airflow and systemic inflammation of the lungs and other organs and have an impaired quality of life (2). Several comorbidities such as hypertension, diabetes mellitus and cardiovascular disease (CVD) are common in COPD patients. COPD is a lengthy and costly disease to treat (3). According to the 2010 Global Burden of Disease report, COPD was the third most common cause of death in the world (4), with a global prevalence of 10% (5). Proportionally speaking, low- and middle-income countries presently have the highest number of chronic respiratory disease patients worldwide (5). Tobacco

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smoking is the greatest risk factor of COPD (6). However, COPD appears in only about 20% of smokers (7) and about one third of COPD patients are non-smokers, suggesting that other factors such as (4)genetic and environmental factors ; namely, (8) outdoor and indoor pollution, exposure to pollutants at the workplace may contribute to the development of this disease (4).

Disease management has focused mostly on smoking; hence, other modifiable factors, which could potentially alter the course of the disease, have been largely ignored. Although one of such factors is diet, the association between diet and the risk of COPD has not been yet well-documented (4).

As lungs function in an oxygen rich environment, it is reasonable to posit that certain exposures (and local inflammation) can further increase the burden of oxidants. The balance between these potentially toxic substances and the protective actions of antioxidant defenses, including those derived from diet, may play a role in the loss of lung function over time and the eventual development of COPD (9).

Antioxidant vitamin intake (e.g., vitamins C and E, β-carotene) (9) foods rich in antioxidants (e.g. fruits and vegetables), omega-3 fatty acids and fish consumption have been shown to demonstrate positive effects on respiratory symptoms (10). Some studies demonstrated that whole fruit intake has a stronger effect than simply consuming vitamins such as vitamin C and carotenoids, which are also present in fruits. Moreover, other nutrients may be equally effective in providing protection to the lungs from oxidative stressors (10). On the other hand, frequent consumption of cured meat raises the risk of occurrence of COPD and obstructive pattern of lung function (11). According to a cohort study on Chinese Singaporeans, a higher consumption of fiber also proved protective against the development of symptoms of chronic bronchitis (12).

Another large cohort study on American women (13) and men (8) with ''prudent'' dietary pattern (i. e., with ample intakes of fruits, vegetables, fish, whole grains) revealed that this diet reduced the risk of newly diagnosed COPD. However, it was found that a 'Western'' diet (i.e., with ample intakes of cured and red meats, desserts, refined grains, French-fries) escalated the risk of newly diagnosed COPD (13).

Nevertheless, individual nutrients and foods are the sole subject of some of the studies. However, since foods are taken as a whole and nutrients do interact with each other, it has been suggested that any study done on this subject should assess the overall diet (8,14).

Diet quality indices are instruments for evaluating overall diet quality and are based on nutritional requirements and guidelines, by which researchers are able to analyze nutrients and food interactions and provide suitable diets (4).

The aim of this study, which has been performed for the first time, was to examine the association between three diet quality indices -the Healthy Eating Index-2005 (HEI-2005), the Healthy Eating Index-2010 (HEI-2010), and Mediterranean diet score (MED)- and the severity of disease in chronic obstructive pulmonary patients.

Methods

This cross-sectional study was performed from Jan 2014 to May 2015 in Rasul-e-Akram Hospital in Tehran on 121 COPD patients with a mean age (SD) of 66.1 (10.9) years. A pulmonary specialist diagnosed all the participants with COPD, using a spirometry test. COPD severity for all participants was determined in accordance with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines. At the time of the study, all COPD patients were no more exacerbated and were in a stable condition. The exclusion criteria were as follows: Liver, heart or kidney failure, cancer, endocrine abnormalities and fever, presence of other pulmonary diseases in addition to COPD. The medications taken by each participant was recorded. Since all the participants suffered from pure

COPD, no significant difference was noticed based on their medication consumption. All were informed and signed a written consent prior to taking part in the study. The Ethics Committee of Isfahan University of Medical Sciences approved this study.

Spirometry and Determination of COPD Severity

The spirometry test is a simple and the most common of the pulmonary function tests and measures lung function, using a device called a spirometer. All participants underwent the test with a nurse who was specially trained to perform spirometry. Patients were instructed not to use Bronchodilator on the day of pulmonary function assessment. All patients were studied in a sitting position. Data were used from the highest amount of flow volume curve Forced Vital Capacity (FVC) and Forced Expiratory Volume in One Second (FEV1) for the calculations. FEV1 was expressed as FEV1% predicted based on gender, height and age, using the reference of the American Thoracic Society. Moreover, the severity of disease in accordance with GOLD guidelines was determined and was as follows (15):

Stage1: FEV1/FVC<70% and FEV1≥ 80%,

Stage2: FEV1/FVC<70% and 50%≤FEV1<80%,

Stage3: FEV1/FVC<70% and 30%≤FEV1<50%,

Stage4: FEV1/FVC<70% and FEV1<30%,

Assessment of Dietary Intake and Diet Quality Indices

Dietary Intake: We used a verified FFQ to collect dietary intake information of the previous 12 months. The FFQ has been used in many studies in Iran. A validation study of the FFQ, which was conducted on 132 randomly selected participants, showed high reliability for nutrients. For instance, the correlation coefficients were 0.81 for dietary fiber, 0.85 for magnesium and 0.79 for vitamin E. Validity was verified by comparing FFQ with intakes gathered from the average of twelve 24-hour dietary recalls (one for each month of the year).The observed correlation coefficients were 0.69, 0.61 and 0.67 for dietary fiber, vitamin E and magnesium consumption, respectively. In general, these data reveal the valid measurements of the average long-term dietary intakes as provided by the FFQ (16).

Each food was organized into its standard portion size. There were nine categories of frequency of consumption for each food on the list covering -never to- six times per day. A nutrient database (Nutritionist IV) was used to analyze all food items, and an educated dietitian carried out the FFQ.

In this study, we used three diet quality indices such as Healthy Eating Index-2005 (HEI-2005), Healthy Eating Index-2010 (HEI-2010) and Mediterranean-diet score (MDS) to assess total diet quality in COPD patients.

Details on the diet quality indices, their components and the scoring levels are described in Appendix 1.

Diet Quality Indices: Guenther et al. proposed HEI-2005 according to MyPyramid and the dietary guidelines of 2005. Twelve components of the index are scored ranging from 0 to 100. With this index, the adequacy and moderation of the diet can be assessed.

Total grains, whole grains, total vegetables, dark-green vegetables, orange vegetables, and legumes, total fruit, and whole fruit are scored 0 to 5 points each; milk, meats and beans, oils, saturated fat and sodium are scored 0 to 10 points each; and one component (calories from solid fat, alcohol, and added sugar) is distributed 0 to 20 points.

Scoring components are energy-adjusted on a density basis (per 1,000 calories) (17). Details on HEI-2005 components and scoring are described in Appendix 1.

Scores are distributed evenly except for saturated fat and sodium; these components are assessed with 0 to 8 and 8 to 10 points (with 8 and 10 points being the acceptable and optimal levels, respectively) (17,18).

Total score is divided into three levels:

scores<51 = ‘‘inadequate diet;’’ scores between 51 and 80 = ‘‘diet requiring modifications;’’ and scores >80 =‘‘healthy diet.’’(18)

Both HEI-2005 and HEI-2010 have 12 components, and the standard is set using density approach or the percentage of calories (19).

Food quality was emphasized more in the 2010 edition of HEI; e.g., whole grains were separated from the refined ones and were more important in the index. To encourage healthy eating, seafood and plant proteins and the ratio of unsaturated to saturated fatty acids were introduced (19,20). Details are presented in Appendix 1.

Trichopoulou et al. designed MDS to analyze adherence to the traditional Mediterranean diet. The original index included nine items: Vegetables, legumes, fruits and nuts, dairy, cereals, meat and meat products, fish, alcohol, and the monounsaturated to saturated fat ratio. However, it was later edited to include fish consumption (21).

In this study, the original MDS was altered: Two separate groups were created for nuts and fruit components. Alcohol component was deleted; a negative point was given to the ratio of red meat to white meat; and whole grain and refined grain were categorized into two groups. Polyunsaturated fatty acid (PUFA) replaced MUFA intake (22). For each component of MDS, the median of the target group consumption was calculated, and then the score of zero and one were allocated to the healthy components if they were below the median and above the median, respectively. If the detrimental component consumption was below the median, the score of 1 was given. When it was at or above the median, a score of 0 was assigned (21,22).

Ultimately, the edited MDS includes: (i) fish, (ii) fruits, (iii) legumes, (iv) nuts, (v) PUFA : SFA, (vi) vegetables, (vii) whole grains, (viii) refined grains, (ix) dairy products, and (x) ratio of red and processed meats to white meat. Thus, the total score has a range from 0 (lowest adherence) to 10 (highest adherence) (22) (Appendix 1).

Assessment of Other Variables

Information on smoking status included the categories of never- smokers, ex-smokers, and current smokers. Educational achievements were categorized in four groups (illiterate, high school, high school graduation, university). Body weight was assessed with a beam scale to the nearest 0.1 kg with the participants standing barefoot and in light clothing. Height was measured by a clinical stadiometer in bare or stocking feet. BMI, defined as weight (kg) divided by the square of height (meters), was calculated.

Statistical Analysis

We used Kolmogorov-Simonov test to assess the normal distribution of data.

To assess the significant differences in the HEI-2010 and HEI-2005 among GOLD stages (three subgroups), ANCOVA test was used; and Kruskal-Wallis test was utilized for the MDS variable. BMI and smoking status were observed as covariates.

Multiple linear regression analysis was used to examine the relationship between independent variables (diet quality indices, their components, sex, educational levels, BMI, age, smoking status), and FEV1, FVC as dependent variables. All analyses were performed using SPSS 18. A p-value less than 0.05 was assumed as significant.

Results

This study was conducted on 121 COPD patients (103 men: 85.1%; 18 women: 14.9%), with a mean age (SD) of 66.1(10.9) years, who were in the COPD stages 1 to 4. The participants were divided into four groups based on the severity of the disease (GOLD stage): 3.3% of the COPD patients were classified in stage 1; 38% in stage 2; 38% in stage 3; and 20.7% in stage 4. Of the patients, 47.1% (n = 57) and 52.9% (n = 64) were smokers (current smokers) and non-smokers (ex-smokers and never smokers), respectively. Nine of

Table 1. Distribution of the COPD Patients according to Dietary Quality Indices

	Mediterranean - Diet score			HEI-2005			HEI-2010		
	1-3 n(%) 35(28.9)	4-6 n(%) 70(57.9)	7-10 n(%) 16(13.2)	<51 n(%) 18(14.9)	51-80 n(%) 96(79.3)	>80 n(%) 7(5.8)	<51 n(%) 45(37.2)	51-80 n(%) 73(60.3)	>80 n(%)
Sex									
Male	30(29.1)	60(58.3)	13(12.6)	16(15.5)	81(78.6)	6(5.8)	41(39.8)	60(58.3)	2(1.9)
Female	5(27.8)	10(55.6)	3(16.6)	2(11.1)	15(83.3)	1(5.6)	4(22.2)	13(72.2)	1(5.6)
Age									
<60	13(39.4)	16(48.5)	4(12.1)	5(15.2)	27(81.8)	1(3)	17(51.5)	16(48.5)	0(0)
>=60	22(25)	54(61.4)	12(13.6)	13(14.8)	69(78.4)	6(6.8)	28(31.8)	57(64.8)	3(3.4)
Education level									
Illiterate	9(34.6)	15(57.7)	2(7.7)	8(30.8)	18(69.2)	0(0)	11(42.4)	14(53.8)	1(3.8)
High school	16(30.8)	28(53.8)	8(15.4)	7(13.5)	41(78.8)	4(7.7)	20(38.5)	31(59.6)	1(1.9)
High school education	8(27.6)	17(58.6)	4(13.8)	2(6.9)	25(86.2)	2(6.9)	12(41.4)	16(55.2)	1(3.4)
University	2(14.3)	10(71.4)	2(14.3)	1(7.1)	12(85.8)	1(7.1)	2(14.3)	12(85.7)	0(0)
Smoking status									
Current smoker	18(31.6)	35(61.4)	4(7)	8(14)	46(80.7)	3(5.3)	28(49.1)	28(49.1)	1(1.8)
Ex-smoker	12(30.8)	20(51.3)	7(17.9)	9(23.1)	28(71.8)	2(5.1)	14(35.9)	25(64.1)	0(0)
Never smoker	5(20)	15(60)	5(20)	1(4)	22(88)	2(8)	3(12)	20(80)	2(8)
BMI									
<20kg/m^2	8(38.1)	8(38.1)	5(23.8)	4(19)	16(76.2)	1(4.8)	9(42.8)	11(52.4)	1(4.8)
20-24.9 kg/m^2	11(22.9)	36(75)	1(2.1)	9(18.7)	37(77.1)	2(4.2)	20(41.7)	28(58.3)	0(0)
25-29.9 kg/m^2	10(27.8)	18(50)	8(22.2)	4(11.1)	29(80.6)	3(8.3)	13(36.1)	21(58.3)	2(5.6)
>30 kg/m^2	6(37.5)	8(50)	2(12.5)	1(6.3)	14(87.4)	1(6.3)	3(18.7)	13(81.3)	0(0)
Severity of disease									
Stage 1,2	10(20)	30(60)	10(20)	6(12)	42(84)	2(4)	17(34)	32(64)	1(2)
Stage 3	15(32.6)	27(58.7)	4(8.7)	7(15.2)	34(73.9)	5(10.9)	16(34.8)	28(60.9)	2(4.3)
Stage 4	10(40)	13(52)	2(8)	5(20)	20(80)	0(0)	12(48)	13(52)	0(0)

HEI-2010: Healthy Eating Index- 2010, HEI-2005: Healthy Eating Index-2005, MED: Mediterranean Diet, Healthy Eating Index, scores <51, 51-80 and >80 equals "poor diet", "needs improvement" and "good" respectively. In MED scale, scores 1-3, 4-6 and 7-10 means low adherence, moderate and high adherence respectively

the smoker patients were female. Nine of the female patients did not have any smoking history, but some were passive smokers, or had a history of bread baking using biomass fuels in rural places. Some of the non-smoker male patients were passive smokers at work or exposed to occupational pollutants.

Table 1 displays the characteristics of the variables based on the diet quality indices.

In Healthy Eating Index, scores <51, 51-80 and >80 equals poor diet, needs improvement and good, respectively. In MED scale, scores 1-3, 4-6 and 7-10 means low adherence, moderate and high adherence, respectively.

Our results revealed that according to the MED score, 28.9% of the participants adhered little, 57.9% adhered moderately and 13.2% adhered highly to the Mediterranean diet.

According to healthy index 2010, 37.2% of the patients had a poor diet, 60.3% had an inadequate diet and needed improvement and 2.5% had good diet. According to healthy index 2005, 14.9% of the participants had a poor diet, 79.3% needed improvement and 5.8% had a good diet. These results are demonstrated in Table 1.

The results of dietary quality indices categorized by disease severity according to GOLD stage are shown in Table 2. Four COPD patients were in stage 1. For better analysis, stage 1 and 2 were merged and represented as stage 1, 2 in Table 2.

The mean value of the Mediterranean diet

Table 2. Relation of Diet Quality Indices and GOLD Stage in COPD Patients

Score	Stage 1,2	Stage 3	Stage 4	p
Mediterranean diet score	5.1(1.7)*	4.5(1.5)	4(1.6)	NS
Healthy Eating Index-2010 (HEI-2010)	56.8(13.5)	55.8(12.1)	52.7(11.3)	NS
Healthy Eating Index-2005 (HEI-2005)	63.7(11.2)	64.4(11.8)	61(10.7)	NS

* Mean (SD)
MED score from 0 to 10, HEI-2010 from 0 to 100, HEI-2005 from 0-100
Results of diet quality indices by GOLD stage in COPD patients are adjusted for BMI and smoking status
NS means not significant

score and Healthy Eating Index-2010 (HEI-2010) diminished as the severity of disease increased; the results of HEI-2010 and HEI-2005 measurements did not significantly differ among disease stages.

Kruskal-Wallis test was used to assess MED score difference among GOLD stages (three subgroups). BMI and smoking status were observed as covariates. The results of MED score measurements did not significantly differ among disease stages (Table 2).

Multiple linear regression test revealed a significant relationship between MED score and FEV1, FVC (β=2.9, 95% CI (1.1, 4.8), p=0.002), (β=2.8, 95% CI (0.9, 4.8), p=0.007), respectively. Our results showed that everyone increase in the MED score was associated with a 2.9 increase in FEV1; also, a one-unit increase in MED score was associated with a 2.8 increase in FVC.

The association of dietary quality indices and lung function in COPD patients is presented in Table 3.

We conducted an additional analysis and examined the association between the components of the three diet quality indices (MED, HEI-2010, HEI-2005) and lung

Table 3. Association of Dietary Quality Indices & their Components with Lung Function in COPD Patients

Variables	FEV1		FVC	
	Coefficient (95% CI)	p	Coefficient (95% CI)	p
MED score	2.9(1.1,4.8)	*0.002	2.8(0.9,4.9)	* 0.007
Components of MED				
• Vegetables	0.04(0.01,0.08)	*0.009	0.03(0.0,0.07)	*0.041
• Fruits	0.01(-0.01,0.03)	0.338	0.01(-0.01,0.03)	0.405
• Fish	0.01(-0.1,0.2)	0.887	0.07(-0.1,0.3)	0.520
• Legumes	0.08(-0.1,0.3)	0.392	0.03(-0.1,0.3)	0.730
• Nuts	0.1(-0.04,0.3)	0.148	0.06(-0.1,0.3)	0.483
• Whole grains	0.01(-0.01,0.04)	0.295	0.01(0.01,0.04)	0.462
• Dairy products	*-0.004(-0.02,0.01)	0.682	®0.0(-0.02,0.01)	0. 791
PUFA : SFA	5.8(0.01,11.5)	*0.049	8(1.7,14.2)	*0.013
Red & processed meat : white meat	®-0.4(-1.4,0.7)	0.516	®-0.2(-1.2,1)	0.748
Refined grains	®-0.01(-0.03,0.004)	0.120	®-0.01(-0.03,0)	0.207
HEI-2010	0.2(-01,0.5)	0.210	0.1(0.1,0.4)	0.365
Components of HEI-2010				
Total Fruit	3.4(-5.4,12)	0.445	2.8(-6.8,12.5)	0.563
Whole Fruit	2.1(-7.5,11.8)	0.662	1.5(-9,12)	0.777
Total Vegetables	3.8(-6,13.5)	0.447	3.3(-7.5,14)	0.544
Greens and Beans	0.9(-14,12)	0.820	1.9(-13,17)	0.794
Whole Grains	1.5(-0.5,3.5)	0.149	1(1,3.2)	0.327
Dairy	®-0.3(-1.6,1)	0.372	®-0.3(-1.7,1.2)	0.722
Total Protein Foods	2.1(-1.8,5.9)	0.291	2.5(-1.8,6.7)	0.265
Seafood and Plant Proteins	4.9(-0.1,10.7)	0.1	3.9(-2.5,10.5)	0.233
Fatty Acids	4(0.1,7.8)	®0.043	5(0.8,9.1)	®0.019
Refined Grains	®-1.7(-3.5,0.3)	0.084	®-1.3(-3.2,0.8)	0.229
Sodium	0.004(0.0,0.0)	0.051	0.004(0.0,0.0)	0.082
Empty Calories	®-0.2 (-0.8,0.3)	0.472	®-0.2 (-0.8,0.4)	0.622
Components of HEI-2005	0.1(-0.2,0.4)	0.588	0.04(0.2,0.4)	0.788
Total Fruit	3.4(-5.4,12)	0.445	2.8(-6.8,12.5)	0.563
Whole Fruit	2.1(-7.5,11.8)	0.662	1.5(-9,12)	0.777
Total Vegetables	3.8(-6,13.5)	0.447	3.3(-7.5,14)	0.544
Dark Green and Orange Vegetables and Legumes	®-0.3(-2.2,1.6)	0.769	®-0.5(-2.6,1.6)	0.639
Total Grains	®-0.7(-3,1.8)	0.602	®-0.6(-3.5,2)	0.665
Whole Grains	1.5(-0.5,3.5)	0.149	1(1,3.2)	0.327
Milk	®-0.3(-1.6,1)	0.372	®-0.3(-1.7,1.2)	0.722
Meat and Beans	2(-1.8,5.9)	0.291	2.5(-1.9,6.8)	0.261
Oils	0.2(-0.1,0.6)	0.249	0.01(-04,0.4)	0.949
Saturated Fat	®-0.7(-2.2,0.8)	0.331	®-1.6(-3.2,0.03)	0.053
Sodium	0.004(0.0,0.0)	0.051	0.004(0.0,0.0)	0.082
Calories from SoFAAS	®-0.2 (-0.8,0.3)	0.472	®-0.2 (-0.8,0.4)	0.622

FEV1: Forced Expiratory Volume in 1 Second, FVC: Forced Vital Capacity, HEI-2010: Healthy Eating Index- 2010, HEI-2005: Healthy Eating Index-2005, MED: Mediterranean Diet, PUFA: poly unsaturated fatty acid, SFA: saturated fatty acid. SoFAAS: solid fats and added sugars. All components are explained in appendix1

*p<0.05 is significant., ® non-significant inverse relationship function parameters, using multiple linear regression analysis. The results of examining the relation between MED score, HEI-2010, HEI-2005, their components and FEV1, FVC are presented in Table 3. A significant positive relationship was found between vegetables (β=0.04 ; 95% CI (0.01,0.08), p=0.009), (β=0.03; 95%CI (0.0,0.07), p=0.041), the ratio of PUFA to SFA (β=5.8; 95% CI (0.01,11.5), p=0.049) (β=8; 95% CI (1.7,14.2), p=0.013) of MED component and FEV1, FVC, respectively (Table 3).

In MED quality index, an inverse association was observed between the component of ratio of red and processed meat to white meat, dairy products and refined grains of MED diet score with FEV1 and FVC, but this negative relationship was not significant (Table 3).

We found a significant positive relationship between the score of fatty acids (Ratio of poly- and monounsaturated fatty acids to saturated fatty acids) and FEV1, FVC, respectively, in the COPD patients (β=4; 95% CI (0.1,7.8), p=0.043) (β=5; 95% CI (0.8,9.1), p=0.019). In addition, an inverse relationship was detected between refined grains, dairy, empty calories and lung functions in HEI-2010, although not significant. Moreover, we observed a non-significant negative relation between total grain, saturated fat, milk and calories from SoFAAS and lung function parameters in HEI-2005 (Table 3).

Discussion

In this cross- sectional study, the association between lung function parameters and three dietary quality indices was examined in a population of 121 patients with COPD in stages 1-4.

Based on HEI-2010 and HEI-2005, our results showed that most individuals had the diet score of “needs improvement”; and when the score was based on MED scale, it was observed that 57.9% of the COPD patients were in “moderate adherence group”. This is one of the first studies to make an overall assessment of the diet quality of COPD patients.

Results of this study revealed that measured parameters (Mediterranean diet score, Healthy Eating Index-2010 (HEI-2010) decreased in the COPD patients as the disease became more severe. These reductions were much more severe in stage 4 than in any other stage.

Since lungs function in an oxygen rich environment, they are more susceptible to inflammations and oxidants; hence, they require more anti-oxidant defense, which are extracted from the daily diet. Therefore, a balanced diet plays a crucial role in the lungs’ health and in preventing COPD progression (9). A higher HEI-2010, HEI-2005 and Mediterranean diet score reflects high intakes of vegetables, fruits, whole grains, polyunsaturated fatty acids, MUFA, nuts. Furthermore, low intakes of red and processed meat, refined grains, empty calories and sodium were associated with a better lung function test (19,21).

These findings confirm that diet quality index scores are vital to chronic diseases, and particularly in this case, to the pathogenesis of COPD (9).

To date, the role of nutrition in disease prevention was analyzed one nutrient at a time and studies have concentrated on their impact on general health. However, the interaction between different nutrients is of great importance (8,14). Hence, diverse diet indices have been designed to measure the overall compliance with a given diet, using certain components and then scoring them (4).

Our findings confirmed the findings of a previous prospective cohort study performed on the association between dietary patterns and Alternate Healthy Eating Index 2010 (AHEI-2010) and the risk of newly diagnosed COPD in participants in the Nurses’ Health Study and the Health Professionals Follow-up Study in the United States (4). That study showed that the “prudent pattern” diet was negatively and “Western pattern” diet positively associated with the risk of the onset of COPD (8,13). In addition, the risk of newly diagnosed

COPD was inversely associated with the AHEI-2010 diet score (4).

Five studies have explored the links between dietary pattern and lung function or COPD symptoms or its occurrence. Four of them observed a detrimental function of the "Western pattern" diet. One of these studies was conducted on the Chinese Singaporeans, whose diet included high intake of chicken, pork, fish, rice and noodle dishes, and preserved foods (23). Another was done among the Dutch adults, whose diet pattern included a consumption of cured and red meat, potato, boiled vegetables, added fat, coffee, and beer (24). Another one was performed among the U.S. adults. The Americans consumed a high amount of cured and red meat, refined grains, desserts, sweets, French- fries, and full fat dairy products (8,25).

To the best of our knowledge, this was one of the first studies to investigate the association between diet quality (through dietary quality indices) and the severity of disease (according to GOLD stage) and lung function parameters in COPD patients.

Our results showed that selecting those components from the three dietary indices that correspond to healthy foods such as vegetables and healthy fat might have positive effects on the lung function. In addition, a higher ratio of red and processed meat to white meat, an increased intake of refined grains, empty calories and saturated fatty acids were accompanied with an inverse association with lung function.

One of the remarkable results of this study was finding a significant relationship between healthy fat consumption and better lung function and an inverse relationship between saturated fat and lung function.

According to one study, in the general population, an increase in the consumption of n-3 fatty acid was linked to a higher lung function in smokers and correlated to a decrease in the incidence of chronic bronchitis, emphysema and COPD, as detected by pulmonary function test (26). Another study observed a positive relation between trans-fatty acid intake and prevalence of asthma, eczema and hay fever (27). Nevertheless, there is only limited evidence on the relation between individual fatty acids and lung function. Our findings are similar to those of previous studies although these studies were done on asthma not COPD.

In this study, a non-significant inverse relation was found between refined grains, total grains, calories from SoFAAS with lung function.

According to Varraso et al., the "Western pattern" diet was linked with a lowered lung function because this diet is rich in foods categorized in the "high glycemic" index, and it has been proposed that hyperglycemia is linked to damaged lung functions (4). McKeever et al. also observed that an increased consumption of refined foods was linked to a fast decline in FEV1 over a five- year period (24). According to the current hypothesis, the COPD pathogenesis involves an up regulation of inflammatory biomarkers, which in turn cause connective tissue damage due to smoking. According to Walter et al. an association exists between glycemic state and lowered lung function. The regulation of inflammatory pathways might be influenced by hyperglycemia, which could also increase the inflammatory response in the lungs and could help develop chronic ventilator degradation (28).

According to a study, postprandial blood glucose might act as a more important risk factor than fasting hyperglycemia in case of cardiovascular diseases. Sudden increases in glycemic state might act as surrogate markers of oscillations of plasma glucose after meals. They observed that cytokine levels were influenced more by oscillatory hyperglycemia than by continuous hyperglycemia; hence, IGT might intensify this situation (29).

Our results on refined grains and added sugar and worsened lung function were consistent with those of previous studies.

Furthermore, in some studies diet patterns rich in processed and red meat accompanied lower FEV1 and a more prevalent COPD. One of the main causes could be the existence of nitrite in processed meat, which could produce reactive nitrogen species, which in turn could amplify nitrosative stress. This stress may help the deterioration progression in lung function (4). What we observed corresponded to the findings of the previous study: An inverse relation between the ratio of red and processed meat to white meat in the participants.

One of the components studied in this paper was sodium. Four cross- sectional studies found a positive association between sodium intake and airway hyper-reactivity or asthma, but four other studies observed no correlation (30). A study observed an intensified airway inflammation in asthmatic subjects following exercise when the diet was rich in salt. Nevertheless, no data were found on COPD patients (31). In this study, we observed no inverse relationship between sodium and lung function.

In addition, we found a non-significant inverse relationship between dairy products intake and lung function, which may be due to the high amount of fat in dairy products consumed by the COPD patients; most of the participating patients consumed high fat cheese and yogurt.

In one study, they observed two different dietary patterns. One diet was rich in fruit, vegetables, fish, poultry, whole-grain products and low-fat dairy products; this diet was linked to a significant lowered risk of new cases of COPD. The other diet was full of refined grains, cured and red meat, desserts and sweets, French- fries and high-fat dairy products; this diet was linked to a higher risk of COPD (25).

Thus, the cause of the negative relation between dairy products and lung function might be correlated to a high fat dairy consumption. However, we need to conduct more studies to understand this relation better.

Another finding of our study demonstrated that a higher consumption of vegetables, which were a component of MED index, was linked to a better lung function. According to a study, “prudent pattern” diet, which is rich in fruits and vegetables, is linked to a lower newly diagnosed COPD (8). This finding correlates with the previous epidemiological literature, which suggests that antioxidant consumption has a beneficial effect on COPD or FEV1 (9,32).

There were some limitations in the study. Patients suffering from COPD showed signs of boredom and lack of cooperation with the medical staff due to their advanced respiratory problems; thus, nutritional evaluation was hampered. The target group was those with pure COPD, without any other normally accompanying disease such as asthma, cardiovascular and endocrine diseases and this led to the time-consuming process of finding a suitable sample group.

Conclusion

In summary, a higher MED scale, HEI-2010 and HEI-2005 dietary score, a higher intake of vegetables, ratio of PUFA to SFA and a lower intake of red/processed meat to white meat, empty calories and SFA were associated with a better lung function although in some parts it was not significant. This novel finding supports the importance of diet in managing COPD. However, efforts to prevent COPD should continue to focus on smoking cessation, and our findings support the inclusion of a healthy diet in programs to prevent or manage COPD. Our results encourage clinicians to consider the potential effect of a healthy diet in promoting lung health. We highly recommend that further studies be conducted on COPD patients in this field.

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Appendix 1. Healthy Eating Index-2010, Healthy Eating Index-2005 and Mediterranean Diet Components and Standards for Scoring

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
HEI-2010[1]			
Adequacy:			
Total Fruit[2]	5	≥0.8 cup equiv. per 1,000 kcal	No Fruit
Whole Fruit[3]	5	≥0.4 cup equiv. per 1,000 kcal	No Whole Fruit
Total Vegetables[4]	5	≥1.1 cup equiv. per 1,000 kcal	No Vegetables
Greens and Beans[4]	5	≥ 0.2 cup equiv. per 1,000 kcal	No Dark Green Vegetables or Beans and Peas
Whole Grains	10	≥1.5 oz equiv. per 1,000 kcal	No Whole Grains
Dairy[5]	10	≥1.3 cup equiv. per 1,000 kcal	No Dairy
Total Protein Foods[6]	5	≥2.5 oz equiv. per 1,000 kcal	No Protein Foods
Seafood and Plant Proteins[6,7]	5	≥0.8 oz equiv. per 1,000 kcal	No Seafood or Plant Proteins
Fatty Acids[8]	10	(PUFAs + MUFAs)/SFAs >2.5	(PUFAs + MUFAs)/SFAs <1.2
Moderation:			
Refined Grains	10	≤1.8 oz equiv. per 1,000 kcal	≥4.3 oz equiv. per 1,000 kcal
Sodium	10	≤1.1 gram per 1,000 kcal	≥2.0 grams per 1,000 kcal
Empty Calories[9]	20	≤19% of energy	≥50% of energy
HEI-2005[10]			
Adequacy:			
Total Fruit[2]	5	≥0.8 cup equiv. per 1,000 kcal	No Fruit
Whole Fruit[3]	5	≥0.4 cup equiv. per 1,000 kcal	No Whole Fruit
Total Vegetables[4]	5	≥1.1 cup equiv. per 1,000 kcal	No Vegetables
Dark Green and Orange Vegetables and Legumes[4]	5	≥0.4 cup equiv. per 1,000 kcal	No Dark Green or Orange Vegetables or Legumes
Total Grains	5	≥3.0 oz equiv. per 1,000 kcal	No Grains
Whole Grains	5	≥1.5 oz equiv. per 1,000 kcal	No Whole Grains
Milk[5]	10	≥1.3 cup equiv. per 1,000 kcal	No Milk
Meat and Beans[6]	10	≥2.5 oz equiv. per 1,000 kcal	No Meat or Beans
Oils[11]	10	≥12 grams per 1,000 kcal	No Oil
Moderation:			
Saturated Fat[12]	10	≤7% of energy12	≥15% of energy
Sodium[12]	10	≤0.7 gram per 1,000 kcal12	≥2.0 grams per 1,000 kcal
Calories from SoFAAS[13]	20	≤20% of energy	≥50% of energy
Mediterranean dietary score components	Criterion	point	Score range
Vegetables	≥Median	1	0-1
	<Median	0	
Fruits	≥Median	1	0-1
	<Median	0	
Whole grains	≥Median	1	0-1
	<Median	0	
Refined grains	<Median	1	0-1
	≥Median	0	
Dairy products	<Median	1	0-1
	≥Median	0	
Red-to-white meat ratio	<Median	1	0-1
	≥Median	0	
Fish	≥Median	1	0-1
	<Median	0	
Nuts	≥Median	1	0-1
	<Median	0	
Legumes	≥Median	1	0-1
	<Median	0	
PUFA/SFA	≥Median	1	0-1
	<Median	0	

[1]Intakes between the minimum and maximum standards are scored proportionately. [2]Includes fruit juice. [3]Includes all forms except juice. [4]Includes any beans and peas (called legumes in HEI-2005) not counted as Total Protein Foods (called Meat and Beans in HEI-2005). [5]Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages. [6]Beans and peas are included here (and not with vegetables) when the Total Protein Foods (called Meat and Beans in HEI-2005) standard is otherwise not met. [7]Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods. [8]Ratio of poly- and monounsaturated fatty acids to saturated fatty acids. [9]Calories from solid fats, alcohol, and added sugars; [10]Intakes between the minimum and maximum standards are scored proportionately, except for Saturated Fat and Sodium. [11]Includes non-hydrogenated vegetable oils and oils in fish, nuts, and seeds. [12]Saturated Fat and Sodium get a score of 8 for the intake levels that reflect the 2005 Dietary Guidelines, <10% of calories from saturated fat and 1.1 grams of sodium/1,000 kcal, respectively. Intakes between the standards for scores of 0 and 8 and between 8 and 10 are scored proportionately. [13]Calories from solid fats, alcoholic beverages, and added sugars
PUFA=Polyunsaturated fatty acid, SFA=Saturated fatty acid