Evaluation of the Severity of Dietary Intake in Chronic Obstructive Pulmonary Patients

Kronik Obstrüktif Akciğer Hastalarının Diyet Alımının Hastalığın Evrelerine Göre Değerlendirilmesi

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ÖZ

Kronik obstrüktif akciğer hastalığının (KOAH) tedavisinin bir parçası olarak, anti-inflamatuar özelliğe sahip gıdalar açısından zengin beslenme düzenlerinin önerilmesi önem taşımaktadır. Bu çalışmanın amacı, farklı evrelerdeki KOAH hastalarının besin alımlarını değerlendirmektir.

KOAH tanısı alan, orta, ağır ve çok ağır olmak üzere farklı evrelerde, 50-80 yaş arası 65 hasta üzerinde kesitsel bir çalışma yapılmıştır. Besin alımı, 24 saatlik besin tüketim kayıtlarından elde edilmiş ve BEBİS 8.1 beslenme analiz programıyla değerlendirilmiştir.

Hastaların yaş ortalaması 65.16 ± 7.69 yıl olup, çoğunluğunun erkek olduğu saptanmıştır (%86.2, n=56). KOAH'ın farklı evrelerindeki hasta gruplarında enerji, besin öğesi alımları ve besin grubu tüketiminde istatistiksel olarak anlamlı bir farklılık gözlemlenmemiştir. Omega-3 (g) (p=0.054), enerji (kcal/gün) (p=0.064), protein (g) (p=0.085) ve doymuş yağ asidi (g) alımı (p=0.091), ağır KOAH grubunda daha düşük olduğu saptanmıştır; ancak bu farklar istatistiksel olarak anlamlı bulunmamıştır. Toplam enerji (r=-0.282), karbonhidrat (r=-0.258) ve sodyum alımı (r=-0.294) Zorlu Ekspiratuvar Volüm 1. Saniye/Zorlu Vital Kapasite (FEV_1/FVC) ile negatif korelasyon göstermiştir (p<0.05).

Çalışma ağır KOAH hastalarının enerji, protein, karbonhidrat ve omega-3 alımının düşük olduğunu, temel mikrobesin maddelerinin ise önerilen düzeylerin altında kaldığını ortaya koymuştur. Bu bulgular göz önüne alındığında, diyetisyenler KOAH hastalarının enerji ve protein ihtiyaçlarını doğru bir şekilde değerlendirmeli, meyve ve sebze tüketimi arttırılmalıdır.

Anahtar Kelimeler: KOAH, besin alımı, besin eksiklikleri, makrobesinler, mikrobesinler.

ABSTRACT

It is crucial to recommend dietary patterns rich in anti-inflammatory foods as part of the treatment for Chronic Obstructive Pulmonary Disease (COPD). The aim of this study is to evaluate the nutrient intakes of COPD patients at different stages of the disease.

A cross-sectional study was conducted involving 65 patients aged 50-80 years with COPD, categorized into mild, moderate, severe, and very severe stages. Nutrient intake was assessed based on 24-hour dietary recall data and analyzed using the BEBIS 8.1 nutrition analysis program.

The mean age of the patients was 65.16 ± 7.69 years, with a majority being male (86.2%, n=56). No statistically significant differences were observed in energy, nutrient intakes, or food group consumption among the different stages of COPD. Omega-3 (g) (p=0.054), energy (kcal/day) (p=0.064), protein (g) (p=0.085), and saturated fatty acid (g) intake (p=0.091) were found to be lower in the severe COPD group, although these differences were not statistically significant. Total energy (r=-0.282), carbohydrate (r=-0.258), and sodium intake (r=-0.294) showed a negative correlation with Forced Expiratory Volume in 1 second/Forced Vital Capacity (FEV_1/FVC) (p<0.05).

The study found that patients with severe COPD had lower intakes of energy, protein, carbohydrates, and omega-3, and that their intake of essential micronutrients was below recommended levels. Given these findings, it is important for dietitians to accurately assess the energy and protein needs of COPD patients and to increase fruit and vegetable consumption.

Keywords: COPD, dietary intake, macronutrients, micronutrients, nutrient deficiencies.

The study received approval from the Marmara University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (approval date 22.07.2022 and number 09.2022.892)

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition marked by ongoing airflow limitation from extensive exposure to harmful particles or gases.[1] The onset and progression of COPD are influenced by risk factors such as smoking and exposure to air pollution, which exacerbate lung inflammation and oxidative stress, thereby reducing antioxidant capacity. Increasing evidence indicates that oxidative stress plays a critical role in COPD pathology, affecting both the lung and other tissues.[2]

COPD incidence is a significant public health issue due to adverse health outcomes such as dyspnea, cough and/or phlegm production, functional disability, hospitalization, poor quality of life, and increased mortality.[3]

This adverse clinical profile negatively impacts nutritional status by reducing appetite and increasing energy expenditure in the body.[4] Patients often experience weight loss, muscle wasting, and nutritional deficiencies.[4] Malnutrition is common among COPD patients and adversely affects disease prognosis.[5] Research has consistently demonstrated that individuals with COPD typically intake less energy and protein than needed, negatively impacting their pulmonary function and nutritional status.[6, 7] Studies have shown that nutrient deficiencies are prevalent among individuals with COPD.[8-10]

Body mass index (BMI) in COPD patients has been significantly associated with oxidative status.[11] Inadequate nutritional intake to meet daily energy expenditure leads to losses in body weight, fat mass (FM), and fat-free mass (FFM), further negatively impacting functional capacity. Micronutrient deficits most likely arise from an imbalance caused by elevated usage (oxidative stress, systemic inflammation) or inadequate nutritional intake, similar to the pathophysiology of malnutrition in COPD patients.[12]

Adopting healthy dietary patterns and ensuring adequate nutrient intake can help mitigate inflammation and oxidative stress, thereby slowing the decline in pulmonary function in COPD patients.[13, 14] Vitamins such as A, C, and E and flavonoids exhibit potent anti-inflammatory and antioxidant effects and may protect against the progression of COPD.[15] For instance, vitamin C, an antioxidant, protects against airway inflammation, while inadequate intake of fruits, vitamin E, and beta-carotene has been linked to impaired lung function.[16, 17] While these studies indicate that certain dietary nutrients protective against airway inflammation in the general population, few studies have explicitly focused on COPD patients.[18] Given the observed oxidant imbalance in COPD, antioxidant supplementation improved the antioxidant status in these patients.[19] It was reported that increased intake of carbohydrates, protein, fiber, thiamin, riboflavin, niacin, and vitamin C in older men with COPD reduced the severity of airway impairment.[18]

Assessing the dietary intake and nutritional status of COPD patients is crucial because malnutrition is a common comorbidity in this population and can significantly impact disease outcomes and quality of life. In this study, we hypothesized that dietary intake in COPD patients varies according to the severity of the disease.

MATERIALS AND METHODS

This cross-sectional study was conducted to evaluate the nutritional status of COPD patients who attended outpatient respiratory clinics at Istanbul Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital in Turkey from September 2022 to September 2023. Fifty-two participants with a confirmed COPD diagnosis (defined as having a forced expiratory volume in 1 second (FEV_1) < 80% of the predicted value), aged over 50-80 years, nonsmokers, without any signs of infection, and possessing the cognitive capability to answer questions were recruited for the study. The severity of COPD was assessed following the criteria established by the Global Initiative for Chronic Obstructive Lung Disease.[1] The exclusion criteria were smoking, having signs of infection, chronic kidney failure, diabetes, malignancy, congestive heart failure, myocardial infarction, rheumatic and hormonal diseases, adherence to any specific diet (e.g., vegan or vegetarian diet) and not possessing the cognitive capability to answer questions.

During the study period, 66 out of 75 patients who met the study criteria and volunteered were included. After the study commenced, one patient who did not undergo spirometry testing was excluded. As a result, the study was conducted with 65 patients (Figure 1).

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Data collection tools and evaluation

At the first visit, participants who met the study inclusion criteria and agreed to participate completed a sociodemographic questionnaire about age, gender, educational level, and working status, as well as the Chronic Obstructive Pulmonary Disease Assessment Test (CAT), was administered through face-to-face interviews. Body composition analysis, anthropometric measurements, and blood samples were obtained on the same day during a second visit as part of the study protocol, following instructions for participants to fast for 8 hours. Respiratory function tests were conducted at a third visit after a COVID-19 test due to the pandemic and were administered by the same spirometry technician. The hospital's routine unit conducted the patients' biochemical analyses.

Anthropometric measurements and body composition analysis

Body height was measured using a clinical stadiometer (Inbody) while the participants stood upright, held their heads in the Frankfurt plane during deep inspiration, and were barefoot. A sliding headpiece with a width of at least 6 cm was attached to a wall, allowing the subjects to be aligned vertically in the appropriate manner and then lowered to the vertex of the head. The height was recorded in centimeters with an accuracy of 0.5 cm by measuring the distance between the soles of the feet and the highest point of the head with a thin rod parallel to the surface touching the head.[20]

Bioelectrical impedance analysis (BIA) was conducted using tetrapolar-8-point tactile electrodes (Inbody 120, InBody Co., Ltd., Istanbul, Turkey), emitting a low electrical current at 20 and 100 kHz frequencies. During the examination, participants were asked to remove jewelry, stand upright, and wear light clothing. According to the manufacturer's guidelines, the participants were instructed to stand barefoot on the device platform and grasp the hand electrodes. Measurements were taken in the early morning between 8:30 and 9:30 AM after fasting for a minimum of 8 hours.

BMI was calculated as weight divided by height squared (kg/m^2). Body weight, obtained from BIA. BMI was categorized according to previous studies for patients with COPD and according to the recommendations of the European Respiratory Society (ERS) and American Thoracic Society (ATS) as follows: underweight (<21 kg/m^2), normal weight (21-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2).[21, 22]

Nutritional intake

The dietary intakes of the participants were assessed using the 24-hour dietary recall by a trained dietitian. All consumed foods and beverages, including enteral nutrition formulas, were precisely and thoroughly documented, along with the preparation methods and recipes. The dietary analysis was conducted using BEBIS 8.1 software.[23] Daily intakes of energy, macronutrients, and micronutrients were calculated. The presented data are based solely on dietary intake, excluding fortified foods and vitamin and mineral supplements. The estimated nutrient intakes were compared to the dietary reference intake (DRI) specified for each subject's sex and age according to the Turkey Dietary Guidelines.[24]

Assessment of Lung Functions

The patients underwent spirometric testing using a computerized spirometer administered by spirometry technicians. In this test, patients were initially instructed to breathe normally three times, followed by taking as deep a breath as possible and then exhaling at maximum speed after holding for a few seconds. Consequently, the FEV_1, FVC, and FEV_1/FVC were recorded as percent predicted values.

The CAT is a concise eight-item test that is easy to administer in clinical practice. This test comprehensively assesses the effects of COPD, encompassing symptoms such as cough, sputum production, respiratory symptoms, fatigue, and confidence in leaving home. It was validated[25] in Turkish by Yorgancıoğlu et al. (2012). CAT scores typically range from 0 to 40, with a higher score indicating worse symptoms and quality of life.

Statistical analysis

The data collected underwent statistical analysis using the SPSS 29.0 software package. Continuous data are presented as the means and standard deviations, while categorical variables are presented as counts (n) and percentages (%). One-way ANOVA was used to compare continuous variables among the three COPD groups, followed by the LSD test for multiple comparisons. The Kruskal-Wallis test was used for nonparametric data. Spearman's correlation analysis assessed the correlations between anthropometric measurements, nutrient levels, and lung function. In all analyses, a p-value < 0.05 indicated statistical significance.

Limitations of the study

This original study comprehensively assessed the dietary intake of COPD patients across varying severity levels. To our knowledge, this is the first study in our country to evaluate the dietary intake of COPD patients according to disease severity, which is a significant strength of the research. However, this study has several limitations. The limited sample size of 65 patients may restrict the generalizability of the findings to the broader COPD patient population. The cross-sectional design of the study limits the ability to infer causality between dietary intake and COPD severity. While dietary habits in this age group may not vary significantly from day to day, longer-term dietary records rather than 24-hour recalls could provide more accurate results. Future longitudinal studies are needed to evaluate the nutritional status of COPD patients more comprehensively.

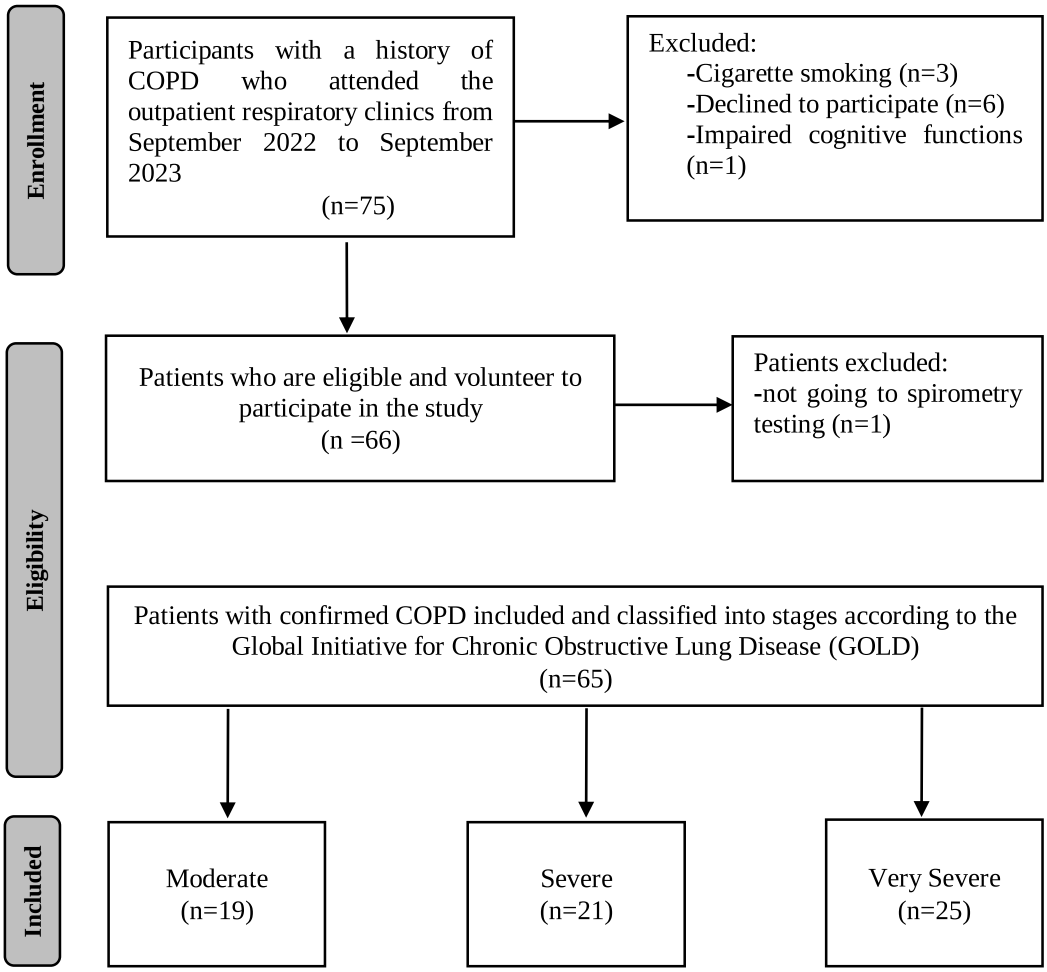

Figure 1: Study flow diagram

RESULTS AND DISCUSSION

In total, 65 patients who were classified according to the GOLD criteria were enrolled in this study: moderate (29.2%), severe (32.3%), and very severe (38.5%). The mean age of the patients was 65.16 ± 7.69 years, and 86.2% (n=56) of the patients were males. Most participants (70.8%) had a primary school-middle school education. Additionally, 80% of the participants were married, and 83.1% were unemployed. The mean BMI for all patients was 26.41 ± 5.89 kg/m² (Table 1).

Table 1. Characteristics of COPD Patients According to Severity Level (n=65)

Characteristics	COPD			
	Total n (%)	Moderate (n=19)	Severe (n=21)	Very Severe (n=25)
Gender, n (%)				
Female	9 (13.8)	2 (10.5)	4 (19.0)	3 (12.0)
Male	56 (86.2)	17 (89.5)	17 (81.0)	22 (88.0)
Age (years), mean ± SD	65.16 ± 7.69	66.05 ± 8.70	66.19 ± 7.47	63.64 ± 7.09
Education level, n (%)				
Primary school-Middle school	46 (70.8)	12 (63.2)	14 (66.7)	20 (80.0)
High school	12 (18.4)	3 (15.8)	6 (28.6)	3 (12.0)
Bachelor and higher	7 (10.8)	4 (21.1)	1 (4.8)	2 (8.0)
Marital status, n (%)				
Single	13 (20.0)	2 (10.5)	5 (23.8)	6 (24.0)
Married	52 (80.0)	17 (89.5)	16 (76.2)	19 (76.0)
Employment status, n (%)				
Employed	11 (16.9)	5 (26.3)	3 (14.3)	3 (12.0)
Unemployed	54 (83.1)	14 (73.7)	18 (85.7)	22 (88.0)

BMI, body mass index; n, number; SD, standard deviation

Biochemical parameters, such as glucose, total cholesterol, HDL, LDL, AST, and ALT, were not significantly different between the groups (Table 2). The mean percentage of FEV_1/FVC was 66.21 ± 13.14. The moderate group had significantly lower CAT scores than did the very severe group ($p<0.05$).

Table 2: Comparison of Biochemical and Lung Function Variables among COPD Patients with Different Severity Levels (n=65)

	COPD				p value
	Total	Moderate (n=19)	Severe (n=21)	Very Severe (n=25)	
Biochemical variables					
Glucose (mg/dL), mean ± SD	97.85 ± 19.19	99.68 ± 18.48	99.05 ± 24.44	95.56 ± 15.43	0.474[b]
Total cholesterol (mg/dL), mean ± SD	188.81 ± 42.94	183.52 ± 49.87	195.31 ± 42.14	187.41 ± 42.62	0.705[a]
HDL-Cholesterol (mg/dL), mean ± SD	56.40 ± 13.13	51.83 ± 8.78	54.94 ± 12.86	60.76 ± 14.92	0.485[b]
LDL-Cholesterol (mg/dL), mean ± SD	109.55 ± 37.10	110.35 ± 39.15	115.72 ± 42.13	104.37 ± 32.15	0.623[a]
Triglyceride (mg/dL), mean ± SD	117.27 ± 43.53	111.05 ± 44.11	124.68 ± 33.63	116.08 ± 50.44	0.114[b]
AST (mg/dL), mean ± SD	20.17 ± 7.27	20.89 ± 5.89	18.26 ± 3.78	21.12 ± 9.87	0.153[b]
ALT (mg/dL), mean ± SD	17.61 ± 9.50	19.68 ± 12.76	15.52 ± 7.42	17.62 ± 7.86	0.208[b]
Lung Function					
FVC, mean ± SD	59.85 ± 16.34	78.98 ± 11.03[de]	57.55 ± 10.46[f]	47.25 ± 8.36	0.001[a]
FEV_1/FVC, mean ± SD	66.21 ± 13.14	75.85 ± 7.80[e]	71.27 ± 12.30[f]	55.02 ± 7.78	0.001[a]
FEV_1, mean ± SD	39.30 ± 14.51	58.46 ± 6.48[de]	38.86 ± 5.03[f]	25.10 ± 2.93	0.001[a]
CAT scores, mean ± SD	18.50 ± 8.54	15.05 ± 8.2[e]	18.10 ± 8.52	21.58 ± 7.99	0.041[a]
BMI (kg/m^2)	26.41 ± 5.89	28.61 ± 6.48[e]	26.95 ± 4.83	24.28 ± 5.73	0.045[a]
BMI classification, n (%)					
Underweight	9 (13.8)	1 (5.3)	2 (9.5)	6 (24.0)	
Normal weight	22 (33.8)	4 (21.1)	7 (33.3)	11 (44.0)	0.161*
Overweight	17 (26.2)	7 (36.8)	7 (33.3)	3 (12.0)	
Obesity	17 (26.2)	7 (36.8)	5 (23.8)	5 (12.0)	

AST, aspartate aminotransferase; ALT, alanine aminotransferase; CAT, chronic obstructive pulmonary disease assessment test; FEV_1, forced expiratory volume in 1 second, FVC, forced vital capacity; HDL cholesterol, high density lipoprotein cholesterol; LDL cholesterol, low density lipoprotein cholesterol; n, number; SD, standard deviation. The data are presented as the means ± SDs (ANOVA test and Kruskal–Wallis Test), which are denoted by a and b, respectively.
d, e, f Post hoc analysis between moderate and severe, moderate and very severe, and severe and very severe, respectively.
** The data are presented as the n (%) are presented (Chi-Square Test).*

The dietary intake of COPD patients at different severity levels is presented in Table 3. The total energy intake was 1277.49 kcal/day, protein intake was 53.35 g/day, fat intake was 54.84 g/day, carbohydrate intake was 137.92 g/day, calcium intake was 673.84 mg/day, and iron intake was 7.15 mg/day of COPD patients. No statistically significant differences in energy or nutrient intake according to severity group were found.

The mean omega-6/omega-3 ratio was 6.10±3.89, with no significant differences observed between groups. Although the differences were not statistically significant, the intake of omega-3 (g) (p=0.054), energy (kcal/day) (p=0.064), protein (g) (p=0.085), and SFA (g) (p=0.091) were lower in the severe group.

Table 3. Energy, Dietary Intakes and Food Group Consumption among COPD Patients Based on Severity Level (n=65)

	COPD				
	Total mean±SD	Moderate (n=19) mean ± SD	Severe (n=21) mean ± SD	Very Severe (n=25) mean ± SD	p value
Energy (kcal/day)	1277.49±650.85	1308.73±471.38	1052.11±340.52	1443.08± 890.25	0.064[b]
Protein (g)	53.35±29.93	52.62±15.33	43.57±14.83	62.14±43.17	0.085[b]
Fat (g)	54.84±33.30	59.60±29.94	43.45±14.65	60.77±44.03	0.113[b]
Carbonhydrate (g)	137.92±68.87	137.89±55.41	118.41±51.71	154.34±86.63	0.189[b]
Vitamin A (µg)	846.82±770.61	1092.16±1151.78	745.44±537.23	745.52±529.90	0.218[b]
Vitamin D (µg)	3.20±5.04	4.48±8.47	2.68±2.38	2.65±2.70	0.850[b]
Vitamin E (mg)	6.98±7.34	6.88±5.47	6.79±3.18	8.81±10.79	0.579[b]
Vitamin C (mg)	71.97±53.19	69.70±48.36	69.48±41.91	75.78±65.59	0.989[b]
Vitamin B_6 (mg)	0.93±0.54	0.95± 0.45	0.79±0.38	1.04±0.69	0.297[b]
Vitamin B_{12} (µg)	3.70±2.67	3.57±1.98	3.18±1.65	4.23±3.64	0.533[b]
Folate (µg)	249.41±126.05	241.67±134.77	243.36±100.49	260.37 ± 141.87	0.524[b]
Sodium (mg)	2722.33±1231.51	2823.68±1381.24	2577.99±1047.70	2766.55 ± 1292.41	0.946[b]
Potassium (mg)	1785.58±1306.70	1631.48± 558.51	1528.21±543.84	2118.88 ± 1969.87	0.579[b]
Calcium (mg)	673.84±643.79	568.30± 280.19	553.05±271.94	855.53 ± 963.72	0.797[b]
Iron (mg)	7.15±3.75	7.49± 2.92	6.40±2.80	7.52 ± 4.88	0.198[b]
Magnesium (mg)	198.80±107.17	201.33± 75.91	172.24±60.05	219.21 ± 149.15	0.250[b]
Zinc (mg)	8.36±4.40	8.47± 3.25	7.57±2.96	7.52±4.88	0.465[b]
Phosphorus (mg)	870.90±584.85	845.10± 349.58	732.08±246.02	1007.12 ± 856.33	0.310[b]
Carotene (mg)	2.99±4.67	4.73±7.40	2.86±3.56	1.79 ± 1.59	0.456[b]
MUFA (g)	19.05±11.63	21.55±12.44	15.48±5.61	20.14 ± 14.18	0.180[b]
PUFA (g)	8.30±5.86	8.84±5.44	6.92±2.47	9.03 ± 7.87	0.597[b]
Omega-3 (g)	1.28±1.14	1.46±1.15	1.01±0.64	1.38 ± 1.43	0.054[b]
Omega-6 (g)	6.46±5.59	6.99±5.31	5.21±2.45	7.10 ± 7.42	0.579[b]
Omega6/omega3	6.10±3.89	5.74 ± 4.47	6.09 ± 3.26	6.38 ± 4.04	0.350[b]
SFA (mg)	23.01±15.86	24.71±15.67	17.61±7.28	26.25 ± 20.08	0.091[b]
Cholesterol (mg)	279.04±203.50	250.63±108.16	232.15±126.32	340.03 ± 286.22	0.636[b]
Dietary fiber (g)	14.21±6.93	16.10±8.16	13.56±6.78	13.32 ± 5.98	0.370[a]

COPD, chronic obstructive pulmonary disease, MUFAs, monounsaturated fatty acids; n, number; PUFAs, polyunsaturated fatty acids; SD, standard deviation; SFAs, saturated fatty acids.
The data are presented as the means ± SDs (ANOVA and Kruskal–Wallis Tests), which are denoted by a and b, respectively.

Despite no statistically significant differences observed among the severity groups regarding the percentage of patients meeting DRI levels for energy and protein, the lowest percentage of patients meeting these levels was observed in the severe group. The average percentage of energy intake meeting the DRI for all patients was 67.64 ± 33.11, and the average percentage of protein intake was 82.92 ± 45.95.

No statistically significant differences were detected among the severity groups for other nutrients, such as vitamins (A, D, E, C, B_6, and B_{12}), folate, calcium, iron, magnesium, zinc, and phosphorus. Carbohydrates, vitamin A, and phosphorus met the daily requirements across all groups, while vitamin B_{12} (44.27 ± 21.81), vitamin B_6 (46.70 ± 22.70), and magnesium (50.54 ± 17.81) were present at varying rates in the severe group.

The vitamin E intake was below the DRI for 90.8% of the total participants, and the vitamin C intake was below the DRI for 81.5% of the total participants (Table 4).

Table 4: Nutrient intake percentages meeting the DRI levels of COPD patients based on different severity levels (n=65)

Nutrient intake percentages meeting the DRI levels and	COPD				p value
	Total mean±SD	Moderate (n=19)	Severe (n=21)	Very Severe (n=25)	
Energy	67.64±33.11	69.35± 23.65	56.14±18.37	76.01±45.07	0.072[b]
<DRI	60 (92.3)	18 (94.7)	21 (100.0)	21 (84.0)	
Protein	82.92±45.95	81.84± 23.79	68.03±22.68	96.25±66.33	0.107[b]
<DRI	50 (76.9)	15 (78.9)	18 (85.7)	17 (68.0)	
Carbonhydrate	106.10±52.98	106.07±42.63	91.08±39.77	118.72±66.63	0.189[b]
<DRI	32 (49.2)	9 (47.4)	12 (61.9)	10 (40.0)	
Vitamin A	116.50± 114.09	152.67±176.09	102.41±77.67	100.85±70.47	0.261[b]
<DRI	41 (63.1)	11 (57.9)	14 (66.7)	16 (64.0)	
Vitamin D	21.34±33.60	29.91±56.48	17.93±15.92	17.69±18.03	0.850[b]
<DRI	64 (98.5)	18 (94.7)	21 (100.0)	25 (100.0)	
Vitamin E	58.90±57.64	57.08±43.61	54.88±26.32	63.65±82.56	0.695[b]
<DRI	59 (90.8)	17 (89.5)	21 (100.0)	21 (84.0)	
Vitamin C	66.41±48.44	64.01±43.62	64.78±39.30	69.60±59.36	0.924[b]
<DRI	53 (81.5)	16 (84.2)	17 (81.0)	20 (80.0)	
Vitamin B_6	55.09±31.79	56.38±27.05	46.70±22.70	61.15±40.19	0.323[b]
<DRI	60 (92.3)	17 (89.5)	20 (95.2)	23 (92.0)	
Vitamin B_{12}	54.52±31.31	52.06±24.21	44.27±21.81	65.01±39.60	0.273[b]
<DRI	61 (93.8)	18 (94.7)	20 (95.2)	23 (92.0)	
Folate	75.43±38.38.21	73.25±40.75	67.53±30.14	83.75±41.98	0.989[b]
<DRI	53 (81.5)	16 (84.2)	19 (90.5)	18 (72.0)	
Calcium	70.93±67.76	59.82±29.49	58.22±28.63	90.06±101.44	0.797[b]
<DRI	57 (87.7)	18 (94.7)	19 (90.5)	20 (80.0)	
Iron	64.97±34.07	68.06±26.57	58.18±25.44	68.33±44.35	0.547[a]
<DRI	56 (86.2)	16 (84.2)	20 (95.2)	20 (80.0)	
Magnesium	57.85±30.63	58.58±22.23	50.54±17.81	63.45±42.29	0.189[b]
<DRI	62 (95.4)	19 (100.0)	21 (100.0)	22 (88.0)	
Zinc	77.51±40.31	77.98±28.99	71.15±29.26	82.51±54.12	0.642[a]
<DRI	50 (76.9)	15 (78.9)	17 (81.0)	18 (72.0)	
Phosphorus	158.34±106.33	153.65±63.56	133.10±44.73	183.11±155.70	0.310[b]
<DRI	12 (18.5)	2 (10.5)	4 (19.0)	6 (24.0)	

DRI, dietary reference intake; n, number; SD, standard deviation.
The data are presented as the mean ± SD (ANOVA test and Kruskal–Wallis test), which are denoted by a and b, respectively. The mean ± SD was used to present the nutrient intake values and the percentage of individuals meeting the DRI.
The number and percentage (%) of patients with nutrient intakes below the DRI (<DRI) are indicated in parentheses.

Total energy (r=-0.282), carbohydrate (r=-0.258), and sodium intake (r=-0.294) were negatively correlated with FEV_1/FVC ($p<0.05$). On the other hand, BMI (r=0.354) was positively correlated with FEV_1, while CAT scores (r=-0.317) ($p<0.01$, all) were negatively correlated with FEV_1 (r=0.275) ($p<0.05$) (not shown in the table).

Nutrition and dietary patterns are important factors in developing chronic illnesses, including COPD. Both macro- and micronutrients significantly impact antioxidant capacity and inflammatory responses.[26-28] Chambaneau et al. (2016) reported a mean daily energy intake of 1930.72 kcal/day.[29] On the other hand, Anderson et al. (2007) reported a 2039 kcal/day intake for a predominantly male COPD population.[10] Another study by Van de Bool et al. (2014) reported a 2118 kcal/day intake.[9] Additionally, a study conducted by Yılmaz et al. (2015) in Turkey reported an energy intake of 1906.3 ± 567.4 kcal/day among 65 male moderate-to-severe stable COPD patients.[8] In our study, the mean energy intake of COPD patients was 1277.49 ± 650.85 kcal/day, which is lower than that reported in previous studies. In our study, the mean protein intake was 53.35±29.93 g/day. Elevated energy expenditure, hypermetabolism, inflammation, hormonal changes, and protein imbalance may have led to insufficient energy and protein intake in participants with COPD, with higher protein intake (1.2 to 1.5 g/kg/day) recommended for severe cases.[6, 30] Insufficient energy and protein intake in COPD patients may exacerbate symptoms and worsen respiratory function; therefore, a nutrition specialist should make a more accurate assessment of energy and protein needs to reflect increased energy expenditure.

However, the role of carbohydrates in COPD is unclear. Previous studies have indicated that a low-carbohydrate, high-fat diet results in lower levels of carbon dioxide production, oxygen consumption, and minute ventilation in COPD patients.[31] Recent research suggests that complex carbohydrates containing highly resistant starch may improve disease outcomes.[32] In COPD patients and individuals with both low and normal body weights, protein synthesis should be encouraged, and lean body mass should be preserved by ensuring adequate protein intake. It is accepted as an optimal nutritional therapy for which 40-55% of daily energy comes from carbohydrates, 30-45% from fats, and 20% from proteins.[33] In our study, the macronutrient distribution was 17.15% protein, 45% carbohydrates, and 37.63% fat (with 15.67% saturated fats). Similarly, other studies reported comparable macronutrient distributions, with the study by Chambaneau et al. (2016) showing 19% protein, 42.7% carbohydrates, and 34.5% fat (13% from saturated fats) and the study by Van de Bool et al. (2014) reporting median values of 15.0% protein, 44.3% carbohydrates, and 37.1% fat with 13.5% from saturated fats.[9, 29] Due to its lower metabolic CO_2 production and respiratory quotient, a higher fat-content diet with mono- and polyunsaturated fats may benefit COPD patients.[34]

Anti-inflammatory micronutrients

Micronutrients, such as vitamins C and E, which are antioxidants, reduce oxidative stress and protect cells from damage, which may benefit COPD patients.[15] Van de Bool et al. (2014) reported that 35% of patients had intakes below the vitamin C recommendations, and 33% of the participants had intakes below the vitamin E recommendations.[9] Similarly, Yılmaz et al. (2015) reported that 32.3% of patients had an intake <DRI for vitamin C and that 36.9% of patients had an intake <DRI for vitamin E. The same study also reported higher DRIs, with 128.4 ± 62.4% for vitamin C and 114.3 ± 44.3% for vitamin E, than our study.[8] Previous studies conducted by Chambaneau et al. (2016) and de Batlle et al. (2009) revealed that the mean daily intake met the requirements for vitamin C but not for vitamin E.[14, 29] De Batlle et al. (2009) reported that 79% of participants met the recommendations for vitamin C, while only 34% of the patients met the recommendations for vitamin E.[14] Similarly, Anderson et al. (2007) reported sufficient vitamin C intake.[10] The results of our study revealed that among COPD patients, 58.90 ± 57.64% of the DRIs for vitamin E were met, with 90.8% of the patients falling below the DRIs. Additionally, 66.41 ± 48.44% of the DRIs for vitamin C were met, and 81.5% of the patients had intakes below the DRIs. Vitamins have been associated with improvements in various aspects of COPD, including symptoms, exacerbations, and

pulmonary function; thus, ensuring adequate intake is crucial.[35]

An increase in the omega-6/omega-3 ratio has been associated with an increased risk of postoperative complications, particularly prolonged air leakage, in patients undergoing lung resection.[36, 37] In this study, the mean omega-6/omega-3 ratio was 6.10±3.89, whereas the TÜBER guidelines recommend a ratio of 10.8 for males over the age of 65.[24] Furthermore, it has been reported that the omega-6/omega-3 ratio in Western diets has increased from approximately 4:1 to 20:1 over time, contributing to excessive inflammation and exerting adverse effects on health.[38]

Lung function, dietary intake, and anthropometric measurements

The high consumption of fruits, vegetables, catechins, omega-3 fatty acids, oily fish, and whole grains has been reported to be positively associated with FEV_1 and FVC.[39, 40] Our results indicate a negative association between daily energy, carbohydrate, and sodium intake and the FEV_1/FVC ratio. These findings are consistent with other studies in the literature. Jimenez-Cepeda et al. (2019) showed that the FEV_1/FVC ratio decreased as carbohydrate intake increased, but this relationship was not observed with energy intake.[41] This suggests that higher intakes of these dietary components might be linked to lower lung function efficiency in COPD patients.

Research indicates that compared to individuals with a normal BMI, those with a lower BMI face an increased risk of compromised lung function. At the same time, the estimated rate of decrease in FEV_1 decreases with increasing BMI.[42] This study revealed a positive correlation between BMI and FEV_1, suggesting that BMI is linked to enhanced lung function capacity. This finding aligns with previous literature indicating that a higher BMI is associated with increased FEV_1 levels, which are observed in both individuals with obstructive spirometry and those without respiratory conditions.[43, 44]

CONCLUSION AND RECOMMENDATIONS

In conclusion, this study indicated that COPD patients frequently consume lower amounts of macro- and micronutrients daily than recommended. Moreover, lower energy and protein intake and reduced carbohydrate and omega-3 intake were observed among patients with severe COPD. Although the hypothesis of decreasing nutrient intake with COPD severity could not be substantiated, the overall daily intake of essential micronutrients, including vitamins D, E, C, B_6, B_{12}, and magnesium, remained below 60%, suggesting inadequate fulfillment.

Furthermore, our findings indicated negative correlations between total energy, carbohydrate, and sodium intake and lung function, while positive correlations were observed between BMI and lung function. Considering the increased energy needs of patients and the potential protective role of micronutrients in this disease, a nutrition specialist should make a more accurate assessment of energy and protein needs to reflect increased energy expenditure and provide support in terms of antioxidants obtained through diet.

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