Assessment of fitness and exercise tolerance of chronic obstructive pulmonary disease patients in correlation with their lifestyle

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Background Chronic obstructive pulmonary disease (COPD) is a progressive, chronic disease in which the patient's nutritional status is critical for optimizing outcomes. Pulmonary system abnormalities certainly limit exercise in patients with COPD.

Aim of the work The aim of the present study was to assess the fitness and exercise tolerance of COPD patients in correlation with their lifestyle as regards their nutrition and daily activities.

Participants and methods This study involved 50 patients diagnosed with COPD who attended the pulmonary outpatient clinic of the Chest Department at Ain Shams University Hospital, as well as COPD inpatients at the time of discharge. All participants were interviewed using a face-to-face questionnaire to assess their nutrition, and their lifestyle as regards daily activities. The BMI, obstruction of the airway (FEV_1% predicted), degree of dyspnea [modified Medical Research Council (mMRC)], and exercise capacity cardiopulmonary exercise test (CPET) were also assessed.

Results The mean age of the participants was 51.4 ± 8.2 years and all were men. There were significant positive correlations between mMRC and duration after diagnosis of COPD, age of the participants, and GOLD score. There were significant positive correlations between VO_2 max and VO_2/kg and spirometric parameters, calorie intake, estimated energy requirement percentage, carbohydrate intake, protein intake, and serum total plasma protein. Ex-smokers had significantly higher spirometric parameters, protein intake, total calorie intake, estimated energy requirement percentage, serum total plasma protein, and CPET parameters; however, they had significantly lower BMI, duration of COPD, and mMRC score. Participants with average nutrition had significantly higher total calorie intake, serum total plasma protein, CPET parameters, and spirometric parameters; however, they had significantly lower duration after diagnosis of COPD, mMRC score, and BMI.

Conclusion The lifestyle among COPD patients, as regards physical activity, balanced diet, and caloric intake, is highly related to the severity of the disease and their quality of life. *Egypt J Broncho* 2016 10:38–45
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Introduction

Chronic obstructive pulmonary disease (COPD), a common preventable and treatable disease, is characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airways and the lung to noxious particles or gases. Worldwide, cigarette smoking is the most commonly encountered risk factor for COPD, although in many countries, air pollution resulting from the burning of wood and other biomass fuels has also been identified as a COPD risk factor. Exacerbations and comorbidities contribute to the overall severity in individual patients [1].

Weight loss is now recognized as a poor prognostic feature in COPD, and underweight individuals have considerably increased mortality [2].

The nutritional status of patients with COPD has been considered an important factor that influences the experiencing symptoms and prognosis of the disease [3].

Approximately, 20–40% of COPD patients have been reported as being underweight or malnourished [4].

In advanced stages of COPD, nutritional therapy may only be effective if combined with exercise or other anabolic stimuli [5].

Pulmonary system abnormalities certainly limit exercise in patients with COPD [6].

Fatigue is a common and debilitating symptom for all patients suffering from severe COPD. This can have a profound effect on their quality of life, causing a decreased ability to perform daily activities of living independently. Fatigue is a subjective experience, which can leave the patient extremely tired with an overwhelming desire to rest and sleep [7].

The cardiopulmonary exercise test (CPET) is the standard clinical tool to evaluate dyspnea and exercise tolerance [8].

Aim of the work

The aim of the present study was to assess the fitness and exercise tolerance of the COPD patients in correlation with their lifestyle as regards their nutrition and daily activities.

Participants and methods
Participants

We recruited 50 COPD patients from the pulmonary outpatient clinic of the Chest Department at Ain Shams University Hospital, as well as COPD inpatients at the time of discharge when they were considered to be in a clinically stable condition. The study was approved by the Ethics Committee of the Ain Shams University, and all participants provided written informed consent. All participants had been subjected to full history-taking, full clinical examination, radiological evaluation (posterior–anterior and lateral views), full laboratory investigations, and arterial blood gases analysis.

Exclusion criteria

Exclusion criteria were as follows: very severe cases of exacerbations, cases of respiratory failure, and cases with decompensated comorbid diseases. Exclusion criteria for CPET included unstable cardiac disease [e.g. myocardial infarction (<3 months)], uncontrolled hypertension, angina, neuromuscular conditions that would interfere with the exercise test, and/or inability to follow instructions.

Questionnaire

Face-to-face interviews were conducted with participants using a structured questionnaire. Confidentiality of the information provided and the right to withdraw without prejudice were ensured after explaining the purpose of the study. Interviews of the participants were undertaken in the presence of their next kin to minimize recall error, increase the response rate, and improve the accuracy of their answers.

Full detailed questionnaire was formed to assess nutritional status and lifestyle. The first part of the questionnaire sought demographic, lifestyle characteristics, and activity in the form of occupation and body effort (daily or non daily). The second part sought special habits, dyspnea scale of the modified Medical Research Council (mMRC) by walking distance by meters, any comorbid diseases (hypertension, diabetes, ischemic heart), and the state of participants' compliance to their medications (compliant or not). The third part of the questionnaire was the full detailed nutritional history and was obtained by using a 12-item food frequency questionnaire; food groups included were as follows: meats; poultry; eggs; fish; vegetables; pulses; rice; macaroni; fruits; dairy products; bread; tea; coffee; and sweets.

Cardiopulmonary exercise test

The test consisted of measurements during 2 min of rest, followed by 2 min of unloaded pedaling, and a ramp increase of load (increments of 10 W/min) to maximal workload.

Expired gas was analyzed breath-by-breath or in terms of oxygen uptake (VO_2), carbon dioxide output (VCO_2), minute ventilation (VE), tidal volume (VT), and end-tidal PCO_2 ($PETCO_2$); heart rate was monitored continuously using 12-lead ECG, and hemoglobin saturation was determined by pulse oximetry (SpO_2). Blood pressure, including systolic (SBP) and diastolic (DBP), was recorded at rest and then after each 2 min of exercise. Patients were strongly encouraged to achieve their point of maximal exercise, until they could no longer continue because of severe dyspnea, leg fatigue, chest pain with ischemic ECG changes, a fall in SBP of 20 mmHg from the highest value during the test, hypertension (SBP, 250 mmHg; DBP, 120 mmHg), severe desaturation with SpO_2 of 80%, sudden pallor, or faintness. The onset of anaerobic threshold was determined from a plot of VCO_2 versus VO_2 (the V-slope method) [9].

Nutritional intake assessment

Nutritional intake was assessed by calculating the total intake of calorie, carbohydrate, and protein. The nutrients database captured was quantified in terms of grams per day for each food item, and then converted to average daily calories intake of carbohydrates, proteins, and total daily calories by help of a nutritionist using Food Calories List (*http://www.weightloss.for.all.com*). The level of nutritional intake was determined by estimated energy requirement (EER). Considering the age and sex of each patient, we calculated the percentiles of EER (EER%); according to the EER, patients were classified into two groups: low intake group (£75% of the EER), included in which were patients whose oral intake was less than 75% of the recommended calories to their age group; and normal group (>75% of the EER), included in which were patients who consumed

more than 75% of the recommended calories to their age group [10]. The current study did not include the high intake group.

Disease severity

The degree of airflow obstruction was assessed by spirometry with the FEV_1% predicted, FVC, FEV_1/FVC, and FEF 25–75. Functional dyspnea was assessed by the mMRC score, which was used to evaluate the degree of the patient's dyspnea perception. This is a five-point scale with a range of 0–4; a higher score corresponds to higher levels of dyspnea. Assessment of GOLD score was done according to GOLD, 2015 [1].

Data collection and analysis

Collected data using questionnaires were analyzed with IBM SPSS statistics (Statistical Package for Social Sciences) software version 22.0 (2013; IBM Corp., Chicago, Illinois, USA). Descriptive statistics were used to describe quantitative data as mean ± SD and minimum and maximum of the range for quantitative parametric data, whereas qualitative data were described as number and percentage. Inferential analyses were carried out for quantitative variables using independent t-test in cases of two independent groups with parametric data. In qualitative data, inferential analyses for independent variables and for variables with small expected numbers were carried out using Fisher's exact test, while correlations were done using the Pearson correlation.

Results

In the current study, it was found that the mean age of the participants ($N = 50$) was 51.4 ± 8.2 years and all were men and married (84.0%). The mean duration of their respiratory illness was 7.8 ± 4.1 years. Manual workers comprised 17 participants (34%), employees comprised 13 (26%), and other occupations comprised 15 participants (30%). The average BMI was 21.0 ± 3.3 kg/m². Overall, 10% participants were overweight, and 28% were underweight. The mean FEV_1% predicted was 53.1 ± 13.4. The number of participants with daily activity was 29 (58%). The most common associated comorbidities were hypertension and diabetes. The distribution of GOLD stages of the participants was as follows: two participants as stage I (4%), 26 participants as stage II (52%), and 22 (44%) as stage III GOLD. Their mMRC dyspnea score were as follows: 21 participants (42%) had a score of 2, 18 participants (36%) had a score of 1, five participants (10%) had a score of 0, four participants (8%) had a score of 3, and last two participants (4%) had a score of 4.

As regards the nutritional intake of participants, the average daily intake of carbohydrate was 217.9 ± 54.0 g, and of protein was 61.9 ± 15.4 g. Average daily calorie intake was 1495.2 ± 315.0 kcal.

Grades of EER% were as follows: 40 participants (80%) belonged to the low-intake group (<75% of the EER), and 10 participants (20%) were normal or average (>75 to ≤125% of the EER). As shown in Table 1 there were a significant correlation between mMRC scale and the duration of COPD, spirometric parameters, GOLD score and the VO_2 max.

The main cardiopulmonary exercise test parameters are represented in Table 2. There were a significant correlations as regard nutritional and spirometric parameters in relation to vo_2 max as shown in Table 3, Figs. 1 and 3.

Table 4 and Fig. 2 represent a comparison between participants as regard their physical activity whereas,

Table 1 Correlation between modified Medical Research Council dyspnea scale and other parameters

	R	P
Demographic characteristics		
Age	0.438	<0.001*
BMI	−0.443	<0.001*
Duration of COPD	0.908	<0.001*
Spirometry		
FVC	−0.813	<0.001*
FEV_1	−0.777	<0.001*
FEV_1/FVC	−0.792	<0.001*
FEF 25 75	−0.700	<0.001*
GOLD score	0.640[a]	<0.001*
CPET		
VO_2 max	−0.351	0.013*
VO_2/kg	−0.418	0.003*
HR	0.174	0.226
Test duration	−0.548	<0.001*

COPD, chronic obstructive pulmonary disease; CPET, cardiopulmonary exercise test; HR, heart rate; The values are calculated using the Pearson correlation; [a]The value is calculated using the Spearman correlation; *Significant.

Fig. 1
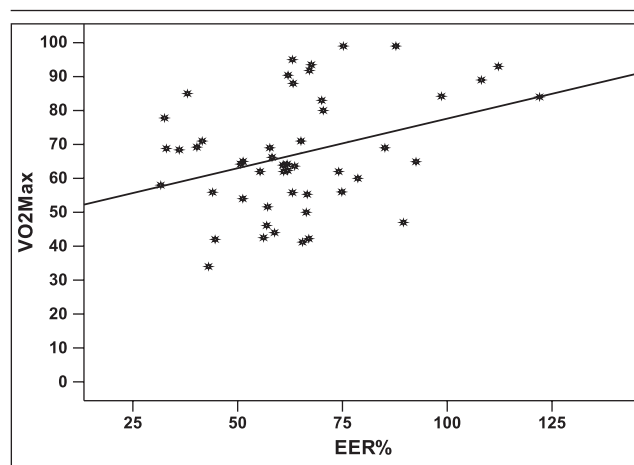
Correlation between VO_2 max and estimated energy requirement percentage (EER%).

Table 2 Main cardiopulmonary exercise test parameters among the studied cases

Variables	Mean ± SD	Range
VO$_2$ max (ml/min)	67.1 ± 17.0	34.0–99.0
VO$_2$/kg (ml/min)	12.0 ± 3.9	5.9–26.1
HR (bpm)	46.8 ± 12.9	22.0–81.0
Duration (min)	16.9 ± 4.5	5.0–20.0
O$_2$ saturation [N (%)]		
Stable		41 (82.0)
Desaturated		9 (18.0)
Causes of test stopping [N (%)]		
Fatigue		10 (20.0)
Dyspnea		36 (72.0)
ECG changes		4 (8.0)

HR, heart rate.

Table 4 Comparison between participants' daily and nondaily physical activities

Variables	Nondaily (N = 29)	Daily (N = 21)	P^a
Age (years)	54.0 ± 7.9	47.8 ± 7.3	0.007*
BMI (kg/m^2)	22.6 ± 3.1	18.8 ± 2.0	<0.001*
Duration of COPD (years)	10.5 ± 3.1	4.1 ± 1.9	<0.001*
Total intake calorie (kcal)	1393.3 ± 245.6	1635.9 ± 350.4	0.006*
EER%	58.2 ± 14.9	72.2 ± 23.4	0.013*
Total protein (g)	6.6 ± 0.6	7.0 ± 0.5	0.015*
Albumin (g)	3.5 ± 0.4	3.6 ± 0.4	0.347
FVC	54.5 ± 8.0	68.7 ± 4.9	<0.001*
FEV$_1$	44.5 ± 7.3	64.9 ± 10.0	<0.001*
FEV$_1$/FVC	58.7 ± 3.1	65.5 ± 3.1	<0.001*
FEF 25 75	30.5 ± 3.2	35.6 ± 2.9	<0.001*
mMRC score	2.2 ± 0.7	0.8 ± 0.4	<0.001*
GOLD score [n (%)]			
GOLD I	0 (0.0)	2 (9.5)	<0.001^b*
GOLD II	8 (27.6)	18 (85.7)	
GOLD III	21 (72.4)	1 (4.8)	
VO$_2$ max (ml/min)	62.5 ± 17.0	73.5 ± 15.4	0.023*
VO$_2$/kg (ml/min)	10.7 ± 3.3	13.9 ± 4.1	0.004*
HR (bpm)	49.3 ± 13.5	43.4 ± 11.4	0.111
Duration (min)	15.9 ± 5.4	18.3 ± 2.4	0.034*

COPD, chronic obstructive pulmonary disease; EER%, estimated energy requirement percentage; HR, heart rate; mMRC, modified Medical Research Council; ^{a}The values are calculated using the independent *t*-test; ^{b}The value is calculated using the Fisher's exact test; *Significant.

Table 3 Correlation between VO$_2$ max and VO$_2$/kg and demography, nutrition, laboratory parameters and spirometric parameters

	VO$_2$ max		VO$_2$/kg	
	R	P	R	P
Demography				
Age	−0.463	<0.001*	−0.484	<0.001*
BMI	−0.223	0.104	−0.313	0.027*
Duration of COPD	−0.391	0.005*	−0.506	<0.001*
Nutritional parameters				
Calorie	0.350	0.013*	0.221	0.122
EER%	0.343	0.015*	0.233	0.103
Spirometry				
FVC	0.256	0.006*	0.433	0.118
FEV$_1$	0.223	0.006*	0.378	0.216
FEV$_1$/FVC	0.238	0.011*	0.422	0.169
FEF 25–75	0.304	0.008*	0.470	0.047*
GOLD score	−0.291^	0.040*	−0.466^	<0.001*

The values are calculated using the Pearson correlation; COPD, chronic obstructive pulmonary disease; EER%, estimated energy requirement percentage; *Significant; ^Spearman correlation.

Table 5 Comparison between smokers and ex-smokers

| Variables	Smokers (N = 37)	Ex-smokers (N = 13)	P^a
Age (years)	52.5 ± 7.9	48.2 ± 8.5	0.099
BMI (kg/m^2)	28.2 ± 3.9	23.3 ± 2.4	<0.001*
Duration of COPD (years)	9.2 ± 3.8	3.8 ± 1.8	<0.001*
Total intake calorie (kcal)	1442.6 ± 261.8	1644.8 ± 408.4	0.045*
EER%	80.9 ± 20.4	98.3 ± 37.6	0.042*
Total protein (g)	6.6 ± 0.6	7.1 ± 0.5	0.014*
Albumin (g)	3.5 ± 0.4	3.7 ± 0.4	0.257
FVC	57.3 ± 9.2	69.6 ± 3.9	<0.001*
FEV$_1$	48.3 ± 10.7	66.6 ± 10.0	<0.001*
FEV$_1$/FVC	60.0 ± 4.1	65.9 ± 2.7	<0.001*
FEF 25 75	31.4 ± 3.5	36.2 ± 2.8	<0.001*
mMRC score	1.9 ± 0.8	0.6 ± 0.5	<0.001*
GOLD score [n (%)]			
GOLD I	0 (0.0)	2 (15.4)	<0.001^b*
GOLD II	15 (40.5)	11 (84.6)	
GOLD III	22 (59.5)	0 (0.0)	

COPD, chronic obstructive pulmonary disease; EER%, estimated energy requirement percentage; mMRC, modified Medical Research Council; ^{a}The values are calculated using the independent *t*-test; ^{b}The value is calculated Fisher's exact test; *Significant.

Tables 5 and 6 illustrates the comparison between smokers and ex-smokers.

It was found that around 75% of patients categorized as GOLDIII have a low estimated energy requirements Fig. 4.

Discussion

Nutritional state is an important determinant of symptoms, disability, and prognosis in COPD;

being either overweight or underweight can be a problem [1].

Administration of nutritional supplements have a significant improvement in body weight and hand-grip strength, decrement in airflow limitation, and increment in quality of life [11].
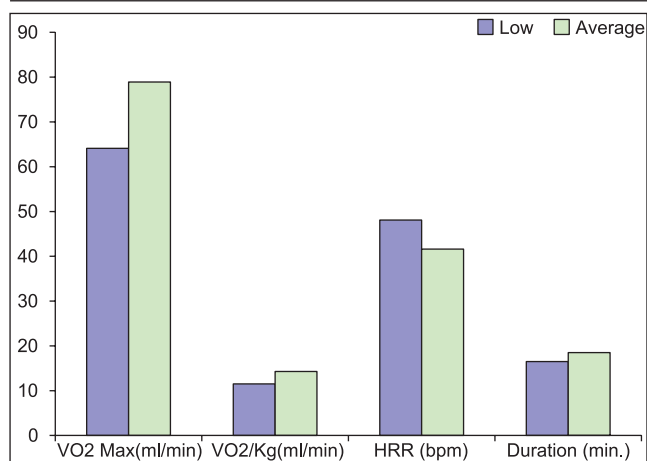
Grading the participants according to their BMI provided the following: 10% of the participants were overweight, 28% of the participants were underweight,
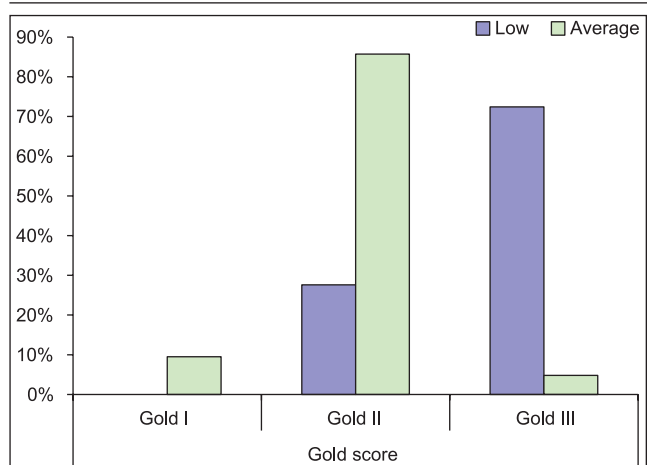
Fig. 2
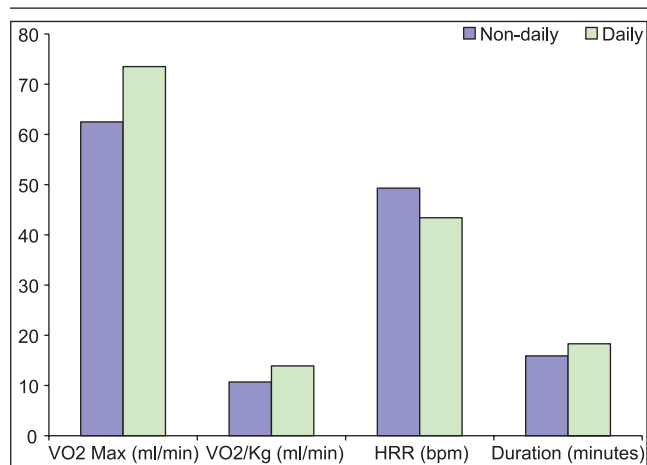
Comparison between participants with daily activity and participants with nondaily activity in relation to their cardiopulmonary exercise test (CPET) parameters.

Fig. 3

Relation between low, average estimated energy requirement percentage (EER%) to cardiopulmonary exercise test (CPET) parameters.

Fig. 4

Relation between low, average estimated energy requirement percentage (EER%) to GOLD score.

Table 6 Comparison between grades of estimated energy requirement percentage

Variables	Low (N = 40)	Average (N = 10)	P^a
Age (years)	52.9 ± 7.5	45.5 ± 8.5	0.010*
BMI (kg/m^2)	21.6 ± 3.3	18.4 ± 1.7	<0.001*
Duration of COPD (years)	8.7 ± 3.9	4.3 ± 3.1	0.002*
Carbohydrate (g)	212.2 ± 56.2	240.5 ± 38.4	0.140
Protein (g)	59.8 ± 13.8	70.2 ± 19.3	0.057
Total protein (g)	6.7 ± 0.6	7.0 ± 0.5	0.123
Albumin (g)	3.5 ± 0.4	3.7 ± 0.4	0.176
FVC	58.6 ± 9.8	68.1 ± 5.2	<0.001*
FEV$_1$	50.5 ± 12.7	63.2 ± 10.4	0.005*
FEV$_1$/FVC	60.7 ± 4.5	65.0 ± 3.2	0.006*
FEF 25 75	31.8 ± 3.7	36.1 ± 2.7	<0.001*
mMRC score	1.8 ± 0.9	0.8 ± 0.8	0.002*
GOLD score [n (%)]			
GOLD I	0 (0.0)	2 (9.5)	<0.001^b*
GOLD II	8 (27.6)	18 (85.7)	
GOLD III	21 (72.4)	1 (4.8)	
VO$_2$ max (ml/min)	64.1 ± 15.7	78.9 ± 17.7	0.013*
VO$_2$/kg (ml/min)	11.5 ± 3.8	14.3 ± 3.7	0.039*
HR (bpm)	48.1 ± 12.8	41.6 ± 12.6	0.156
Duration (min)	16.5 ± 4.8	18.5 ± 2.4	0.213

COPD, chronic obstructive pulmonary disease; HR, heart rate; mMRC, modified Medical Research Council; ^{a}The values are calculated using the independent t-test; ^{b}The value is calculated using the Fisher's exact test; *Significant.

and 62% of the participants had normal BMI, and this is in line with a study conducted by Raguso and Luthy (2011) [4], in which ~20–40% of COPD patients were reported as being underweight or malnourished.

The current study revealed that the average daily intake of carbohydrate was 217.9 ± 54.0 g, and the average daily intake of protein was 61.9 ± 15.4 g, and these results agree with those of a study by Lee *et al.* (2013) [10], in which the average daily intake of carbohydrate was 223.13 ± 69.56, and the average daily protein intake was 58.72 ± 29.57. In addition, the current results agree with those of a study conducted by Ahmadi *et al.* (2012) [12], in which the average daily protein intake was found to be 62.9 ± 40.7.

The mean total calorie intake in the present study was 1495.2 ± 315.0 kcal, which was close to the value in a study by Lee *et al.* (2013) [10] (1431.65 ± 492.50 kcal), but it was slightly lower than that in the study by Ahmadi *et al.* (2012) [12] (1721 ± 759.6 kcal) and in the study by Yoon *et al.* (2008) [13] (1588 kcal).

As regards grades of EER%, 40 participants (80%) belonged to the low intake group (<75% of the EER%) in comparison with 66.1% in Lee *et al.* (2013) [10] indicating higher malnutrition status in our participants.

CPET parameters of the participants were as follows: mean VO_2 max was 67.1 ± 17.0 ml/min; mean VO_2/kg was 12.0 ± 3.9 ml/min; and mean heart rate was 46.8 ± 12.9 bpm with a mean duration of the test about 16.9 ± 4.5 min with only nine participants desaturated during CPET (18%).

The MRC scale measures activity limitation or disability due to dyspnea rather than the severity of dyspnea itself, and thus, measures the chronic effect of disease [14].

The current study revealed significant positive correlations between mMRC scale and duration after diagnosis of COPD; this is supported by a study by Lee *et al.* (2013) [10], in which the duration after diagnosis with COPD and physical activities were positively related with mMRC scale and negatively related to FEV_1% predicted.

The current study also revealed significant positive correlations between mMRC scale and age of the participants; this is supported by a study conducted by Waschki *et al.* (2011) [15], in which age, the duration after diagnosis with COPD, and physical activities have been reported as significant predictors of the severity of COPD.

The current study showed the effect of the nutritional intake on disease severity through the significant negative correlations between mMRC scale and calorie intake, EER%, carbohydrate intake, protein intake, and serum total plasma protein; this is supported by a study by Lee *et al.* (2013) [10], which revealed that total calorie, carbohydrate intake, and protein intake were significantly related to mMRC scale; these findings are also consistent with those of a study by Ahmadi *et al.* (2012) [12], in which the severe group had lower mean intake of energy and all other nutrients that were analyzed.

In contrast to the current study, Battaglia *et al.* (2011) [16] found that energy intake is not correlated with disease severity. This might be explained by the sample characteristics of the study, which included 460 COPD outpatients (376 males and 84 females) and all patients were greater than or equal to 65 years of age; this narrowed range may explain this lack of expected correlation.

The current study revealed significant negative correlation between mMRC scale and BMI; this is supported by studies conducted by Rodríguez *et al.* (2014) [17] (in which BMI was inversely associated with age and dyspnea score) and Lee *et al.* (2013) [10] (in which although there were no statistically significant differences, decreased energy intake tended to have higher mMRC scores and lower BMI). The current results are also consistent with those of a study conducted by Ahmadi *et al.* (2012) [12], in which severe COPD patients had lower BMI than did those in the control group.

The current study noted that there were significant negative correlations between mMRC scale and VO_2 max and VO_2/kg; this is supported by the strong relationship between dyspnea score and exercise performance in COPD patients, independently to the exercise protocol in a study by Rodríguez *et al.* (2014) [17].

The current study also noted that there were significant negative correlations between mMRC scale and spirometric parameters; this is supported by a study conducted by Ozalevli and Ucan (2006) [18], in which the dyspnea score obtained from mMRC scale was correlated with spirometric measurement (FEV_1).

The current study found significant positive correlation between mMRC scale and GOLD score, and is supported by Okutan *et al.* (2013) [19] who found positive correlation between dyspnea scale scores and GOLD stage in their patients.

The current study revealed significant negative correlations between VO_2 max and VO_2/kg and GOLD score; likewise, Yamasawa *et al.* (2015) [20] in a study found out that peak VO_2 was significantly higher in patients with GOLD grade I than in those with grade III and IV.

Similarly, Schneider and Funk (2013) [21] found that exercise capacity, oxygen uptake, ventilation volume, oxygen pulse, carbon dioxide output, and arterial oxygen pressure decreased significantly ($P < 0.001$) with advancing GOLD stage.

The current study revealed significant negative correlations between VO_2 max and VO_2/kg and BMI, unlike the study of Salepçi and colleagues (2007), in which it was found that as regards arterial blood gases, exercise capacity, symptoms, activity, impact, and total scores, there was no statistically significant difference between low and normal BMI groups. This might be because exercise capacity had been measured by both six-minute walking test and quality of life according to Turkish version of San George Questionnaire [22].

The current study noted significant negative correlations between VO_2 max and VO_2/kg and the duration of COPD, and significant negative correlations between VO_2 max and VO_2/kg and age of the participants;

this is in line with the study conducted by Rodríguez et al. (2014) [17], in which VO_2 peak had negative association with age and mMRC scale.

The present study found significant positive correlations between (VO_2 max and VO_2/kg and calorie intake, EER%, carbohydrate intake, protein intake, and serum total plasma protein; this is in agreement with a study by Lan et al. (2012) [23], in which VO_2 at anaerobic threshold or peak exercise was found to be significantly lower in the underweight patients than in the normal-weighted and overweight patients.

The present study also found significant positive correlations between VO_2 max and VO_2/kg and spirometric parameters. This is supported by studies conducted by Rodríguez et al. (2014) [17] (in which VO_2 peak was related positively to FEV_1) and by Efremidis et al. (2005) [24] [in which the most consistent predictors of VO_2 peak were measurements of expiratory airflow limitation (FEF 25–75) and inspiratory–expiratory strength (MVV)].

This result is in contrast to those of a study by Starobin et al. (2006) [25], in which there was no statistically significant correlation between the PFT results and functional capacity by exercise tests so that the PFT could not accurately predict exercise performance of patients with COPD; this might be because functional capacity in 50 COPD patients was graded according to each test of the following three exercise tests separately: up-right maximal CPXT, the six-minute walking test, and the 15-step exercise oximetry test.

Participants with daily activities had significantly higher protein intake, total calorie intake, EER%, serum total plasma protein, spirometric parameters, and CPET parameters; however, they had significantly lower age, duration after diagnosis of COPD, and mMRC score. They also had significantly lower BMI, which differs from a study conducted by Rodríguez et al. (2014) [17], in which BMI had positive relationship with daily physical activity; this might be because 43% of the cases were obese with a BMI greater than or equal to 30 kg/m².

Ex-smokers had significantly higher spirometric parameters; likewise, Hirayama et al. (2009) [26] found out that over 20% of COPD patients continued to smoke after their diagnosis of COPD, and thus, as expected, they had lower lung function than did controls.

Ex-smokers also had significantly higher protein intake, total calorie intake, EER%, serum total plasma protein, and CPET parameters, but they had significantly lower BMI, duration of COPD, and mMRC score.

Participants with average nutrition had significantly higher total calorie intake, serum total plasma protein, and CPET parameters; this is in agreement with a study by Sergi et al. (2006) [27], in which underweight patients with COPD often demonstrated poor clinical condition compared with nonunderweight patients.

Participants with average nutrition also had significantly higher spirometric parameters; this is supported by a study conducted by Lee et al. (2013) [10], in which the participants who consumed less than 75% of the required energy intake exhibited a significant decrease in PFT (lower FEV_1% predicted) and physical function.

Similarly, in a study conducted by Scichilone et al. (2008) [28], which included 32 COPD patients less than 60 years of age, and in which FEV_1% predicted was found to be significantly lower in patients at risk of malnutrition, the severity of dyspnea was significantly higher in patients at risk of malnutrition than in the well-nourished group.

The present study revealed that participants with average nutrition had significantly lower duration of COPD and mMRC score; this is in agreement with a study conducted by Battaglia et al. (2011) [16], in which severe COPD and advanced age were independent and likely concurrent conditions that could cause malnutrition.

The results were also in agreement with Benedik et al. (2011) [29] who found that patients with poor nutritional status reported severe dyspnea, tended to be in an advanced stage in terms of disease severity, and were more likely to be admitted to a hospital within 6 months.

Participants with average nutrition also had significantly lower BMI; this coincides with the results of a study by Renvall et al. (2009) [30], according to which BMI was inversely related to caloric intake per kilogram.

In contrast to the mentioned results, Battaglia and colleagues (2011) noted that BMI decreases along with Mini Nutritional Assessment groups (well nourished; at risk of malnutrition; malnourished); this might be because that classification had been done according to the total score achieved by Mini Nutritional Assessment questionnaire and not by EER% (like in the current study). In addition, it has to be taken into account that no single measurement has emerged as gold standard in defining malnutrition in the elderly [16].

Limitations of this study
We did not check fat-free mass in our patients. A reduced fat-free mass may occur despite normal BMI. All the patients were male although the cases were randomly selected as COPD is more prevalent in males

than in females as the smoking prevalence was higher in males referred to the university hospital, there is a possibility that they were apart from the male–female frequency of COPD in general population. We used rough nutritional questionnaire and depended on patients' memories for the nutritional intake data. Limitation of FFQs include substantial amounts of measurement error in the estimated portion sizes of foods, and inaccuracies resulting from incomplete listings of all possible foods, and that the estimation of tasks required for analysis can be complex and time-consuming. Even with these limitations, the study highlighted the importance of nutrition assessment and the potential risk of nutritional deficit among COPD patients. Further study to intervene in their potential nutritional deficit would guide valuable nursing intervention for COPD patients.

Conclusion

The study highlighted the importance of the nutrition and the physical activity aspects on the COPD patients and its relation to their life performance manifested by mMRC score and exercise capacity. The study also indicated the importance of assessment of nutritional status and monitoring weight changes in COPD patients.

Recommendations

Nutritional support and physical activity are a critical part of the treatment plan for the patient with COPD. GOLD score, mMRC dyspnea score, and spirometric parameters might be used as indicators of predict exercise capacity, muscle performance and even physical fitness of COPD patients.

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Conflicts of interest

There are no conflicts of interest.

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