ORIGINAL REPORT

Energy and Protein Intake and Its Relationship with Pulmonary Function in Chronic Obstructive Pulmonary Disease (COPD) Patients

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Received: 10 Jun. 2009; Received in revised form: 4 Feb. 2010; Accepted: 24 May 2010

Abstract- Chronic Obstructive Pulmonary Disease (COPD) is a public health problem worldwide. Increased energy and protein needs, decreased energy and protein intake are common in COPD patients. Adequate intake is essential to improve pulmonary function and immune system, prevention of weight loss and maintaining muscle mass and strength. Assessment of energy and protein intake and its relationship with pulmonary function in COPD patients was performed in this study. The study group included 63 COPD patients. For all subjects, evaluation of energy and protein intake by Food Frequency Questionnaire (FFQ) and 24-hour recall, spirometry for measuring pulmonary function and determining disease severity were performed. The subjects were divided into three groups based on disease severity according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) stages. Relationship between energy and protein intake with pulmonary function was assessed. Energy and protein intake were lower than the calculated energy and protein demand for all groups. Significant relationship was found between the amount of protein intake extrapolated from food frequency questionnaire with Forced Vital Capacity (FVC) ($r=0.2$, $P=0.02$) and Vital Capacity (VC) ($r=0.3$, $P=0.008$). The results of the study suggest that accurate evaluation of protein and energy intake and requirements should be included in the goals of medical treatment of COPD patients.

Acta Medica Iranica 2010; 48(6): 374-379.

Key words: Proteins; pulmonary disease, chronic obstructive; forced vital capacity

Introduction

COPD is characterized by a slow progressive obstruction of the airways (1). The disease is a major and growing public health problem in the world. The World Health Organization (WHO) estimates that COPD will be the third most common cause of death and the fifth most common cause of disability in the world by 2020 (2). COPD imposes a high economic burden on the society and healthcare system (3), and as one of the target groups of the disease is the working age population, this can spell losses in wages and salaries for workers and also in the overall productivity (4).

Cigarette smoking is a major risk factor for COPD (5). The use of biomass fuel, mainly wood and animal dung for cooking and heating especially in rural areas of developing countries is a potential risk factor for obstructive pulmonary disease (6). Air pollution, occupational smoke or dust and genetic factors are other causes of COPD (7). Malnutrition commonly occurs in COPD patients (8,9) and is associated with increased disability, diminished respiratory and muscle strength and endurance, alteration in ventilatory capacity, increased susceptibility to infections and impaired quality of life (9). Factors like elevation of energy expenditure and hypermetabolism, systemic inflammation like cytokines, hormonal alterations, decreased food intake (1,10), imbalance between synthesis and breakdown of protein, negative nitrogen balance, particularly during acute exacerbations of COPD may be the causes of inadequate energy and protein intake in COPD patients (10,11). It is known that energy and nitrogen balance is closely related to each other. Preserving suitable energy balance is important to sustain visceral proteins and somatic protein mass (pulmonary tissues and muscles) (1).

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Analyses of usual dietary intake in COPD patients are scarce. Studies focus on diet energy and protein supplementation (12,13), synthesis and breakdown of protein and altered profile of amino acids in plasma and muscle in COPD patients (14,15). In regard to adverse effects of lung disease on nutritional status and importance of adequate energy and protein intake in improving the health of COPD patients, evaluation of energy and protein intake and determination of needs are necessary in the patients diagnosed with COPD. The aim of the present study, which is performed for the first time in Iran, was to assess the energy and protein intake in the stable COPD patients and their relationship with pulmonary function in COPD patients.

Patients and Methods

This cross-sectional study was performed during 10-month period (from august 2006 to June 2007) at Rasul Akram hospital in Tehran on 63 COPD patients admitted to the hospital (except the COPD patients in emergency ward and ICU) with mean age (SD) of 67.6 (9.4) years. All subjects had COPD diagnosed by a pulmonary specialist based on a spirometry test. According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines, COPD severity for all subjects determined and then at analysis, COPD patients were separated into three groups (2, 3, 4 stages of disease) to assess differences in dietary energy and protein intake and requirements between groups according to the severity of disease. None of the patients was in the stage 1 of disease.

At the time of the study all COPD patients were no more exacerbated and were in stable condition. For all subjects, the exclusion criteria were: liver, heart or kidney failure, cancer, endocrine abnormalities and fever, presence of other pulmonary disease in addition to COPD. The spirometry test is a simple and noninvasive method for measuring lung function. All subjects underwent the spirometry with especially trained nurse technicians. Forced Expiratory Volume in 1 Second (FEV_1) was expressed as FEV_1% predicted, based on gender, height and age, using the reference of the American Thoracic Society, and then severity of disease in accordance to GOLD guidelines was determined as follows:

Stage1: FEV_1/FVC<%70 and $FEV_1 \geq 80\%$, Stage2: $FEV_1/FVC < 70\%$ and $50\% \leq FEV_1 < 80\%$, Stage3: $FEV_1/FVC < 70\%$ and $30\% \leq FEV_1 < 50\%$, Stage4: $FEV_1/FVC < 70\%$ and $FEV_1 < 30\%$ (16, 17).

In this study, evaluation of energy and protein intake was performed by using two questionnaires (food frequency questionnaire and 24-hour recall) that is completed once for each person. Twenty four-hour recall provides overall, quick and easy picture of intake and food frequency questionnaire is a retrospective review of intake frequency (food consumption per day, per week or per month). Because during acute stage of disease and hospitalization food consumption patterns can change, we completed food frequency questionnaire for the one month period immediately before hospitalization and before acute stage of disease to obtain a complete and accurate history. Concurrent use of food frequency questionnaire and 24-recall questionnaires improves the accuracy of intake estimates (18). Obtained information of questionnaires was coded for computer nutrient analysis (food processor2) to known mean dietary energy and protein intake.

The weight and height of the subjects were measured and used to calculate the BMI (weight/height^2).

Estimates of amount needs of energy for participating COPD patients were obtained from Harris-Benedict equation × stress factor ×physical activity (9). For COPD patients, stress factor is considered 1.2 (9) and sufficient protein is 15-20% of calories (1). In this study, amount of protein needs was considered 15% of calories.

We used non-parametric test (Kolmogrove-Simirnov) for assessing normal distribution of data. To assess the significant differences in normally distributed variables (energy and protein intakes and needs) among GOLD stages (three subgroups) we used One-Way Anova test. Kruskal-Wallis test was used for the variable age that wasn't distributed normally. All analyses were performed using SPSS 14 for windows package.

Results of energy and protein intake and demand, spirometric parameters are expressed as mean and standard derivation (SD). A *P*-value less than 0.05 were considered to be statistically significant. To assess energy and protein intake extrapolated from food frequency questionnaire and 24-hour recall in comparison with energy and protein requirements, we used Paired-Samples T Test. Correlation test was used for assessing of relation between dietary energy and protein intake obtained from two questionnaires (food frequency questionnaire and 24-hour recall). Relationship between energy and protein intake and demand with pulmonary function was assessed with correlation test.

All subjects were informed and also signed a written consent prior to taking part in the study.

Results

Sixty three clinically stable COPD patients with a mean age (SD) of 67.6 (9.4) years in disease stages 2 to 4 participated in the study. The subjects, basis on severity of disease (GOLD stage) divided into three groups.

%28.6 of the COPD patients were classified in stage 2, %50.8 in stage 3 and %20.6 in stage 4.

All the male COPD patients and one female were smoker. The rest of the participating female COPD patients had a mean 20 year history of bread baking by using biomass fuels in rural places and their husbands were also smokers. In addition to these, one female patient had a history of carpet weaving.

Mean values of weight, age and BMI are shown in table 1. Dietary energy and protein intake were extrapolated from two questionnaires (24-hour recall and food frequency questionnaire) for all participating COPD patients. For all subjects, requirement of energy was calculated by using the Harris-Benedict equation× stress factor× physical activity and requirement of protein was considered %15 of daily calories.

Mean values of energy and protein intake extrapolated from 24-hour recall and food frequency questionnaire, and energy and protein needs are shown in table 2. In this study, energy and protein intake were lower than the calculated energy and protein demands for each group (Table 2).

Results of mean values of energy intake extrapolated from 24-hour recall and food frequency questionnaire were shown significant difference among three stages of disease (P=0.03, P=0.04). Significant differences were found between 3 and 4 stage. Significant statistically difference was observed in protein intake extrapolated from 24-hour recall and food frequency questionnaire among three stages of disease (P=0.01, P=0.03). Significant differences were found between stages of 3 and 4. By using correlation test, we found significant relationship between amount of energy intake obtained from 24-hour recall and food frequency questionnaire (r=0.9, P=0.000) that imply the accuracy of the study (Table 2).

Between the calculated energy requirement and protein need with energy and protein intake obtained from food frequency questionnaire and 24-hour recall, we observed significant statistically relationship (P=0.000). The relation implies that our subjects take energy and protein lower than their requirements.

Correlation between energy and protein intake with pulmonary function are shown in table 3.

In assessment of relationship between energy and protein intake with pulmonary function, we found significant relation between protein intake extrapolated from food frequency questionnaire with FVC (P=0.02, r=0.2) and VC (P=0.008, r=0.3). But we observed no significant relation between energy obtained from two questionnaires and protein intake obtained from 24-hour recall.

Table 1. Baseline characteristics categorized by GOLD Stages

Variables	**Stage of disease (Mean±SD)**		
	2	**3**	**4**
Age	67.1 ± 9.7	66.7 ± 10.3	70.3 ± 6.6
Weight	70 ± 17.2	66 ± 12.2	57.6 ± 9.5
BMI(kg/m^2)	25.9 ± 5.3	24.2 ± 4.1	22.3 ± 3.03

BMI (Body Mass Index)

Table 2. Mean values of energy and protein intake and needs categorized by GOLD Stage

Variables	**Stage of disease(mean±SD)**			
	2	**3**	**4**	**P value**
Energy intake (24 hours recall) (Kcal/day)	1573.05 ± 379.09	1724.2 ± 473.09	1364 ± 243.2	0.03
Energy intake (FFQ)(kcal/day)	1546.6 ± 417.3	1698 ± 500.1	1332 ± 178	0.04
Calculated energy need (kcal/day)	2180 ± 359.2	2289 ± 459.8	1925 ± 294.5	0.02
Protein intake (24-hour recall) (g/day)	51.05 ± 13.4	56.1 ± 17.7	41.2 ± 8.7	0.01
Protein intake (FFQ) (g/day)	49.2 ± 15.87	54.5 ± 14.8	41.7 ± 10.6	0.03
Calculated protein need (g/day)	81.6 ± 13.4	85.6 ± 17.1	71.9 ± 11.03	0.02

P <0.05 is significant

Table 3. Correlation between energy and protein intake with pulmonary function

Variables	Spirometry factors			
	FEV_1	FVC	FEV_1/FVC	VC
Energy intake (24 hours recall) (Kcal/day)	0.01 /NS	0.17/NS	-0.12/NS	0.16/NS
Energy intake (FFQ)(kcal/day)	0.001/NS	0.15/NS	-0.11/NS	0.15/NS
Calculated energy need (kcal/day)	0.1/NS	0.1/NS	0.000/NS	0.09/NS
Protein intake (24-hour recall)(g/day)	0.06/NS	0.19/NS	-0.007/NS	0.25/NS
Protein intake (FFQ)(g/day)	0.03/NS	0.2/0.02	-0.19/NS	0.3/0.008
Calculated protein need(g/day)	0.1/NS	0.1/NS	0.001/NS	0.09/NS

FEV_1(Forced Expiratory Volume in 1 Second), FVC(Forced Vital Capacity), VC (Vital Capacity)

*r/*P* value

P value<0.05 is significant

NS means not significant

Discussion

The results of the present study show that energy and protein intake were lower than the calculated energy and protein demand for each group. We found significant difference among 3 stages of disease in energy and protein intake. The significant relationship between the calculated energy and protein requirement with energy and protein intake obtained from two questionnaires implies that our subjects take energy and protein lower than their requirements. These findings confirm that insufficient energy and protein intake are common in COPD patients.

Also we observed relation between protein intake extrapolated from food frequency questionnaire with FVC and VC.

In this study, energy requirement for all subjects was calculated from Harris-Benedict equation×stress factor×physical activity and protein need was considered 15% of calories that is necessary to maintain or restore lung and muscle function and improve immune system (1).

In the present study, energy intake was lower than the calculated energy requirement for each group.

Elevated energy expenditure, increased work of breathing, inflammatory process like elevation of cytokines and TNF-α, medication (like bronchodilators), diminished food intake, dyspnea, oxygen desaturation at meal, anorexia, vomiting, problems with making food because of fatigue are possible agents of reduced and inadequate energy intake in COPD patients (1, 19).

Analyses of dietary intake in COPD patients are scarce. Schols et al reported an inadequate dietary intake for energy expenditure, especially in the more disabled COPD population (20). Fiaccadori et al. reported the same results in patients with more severe impairment of pulmonary gas exchange (21). In hospitalized patients in Sweden, the energy intake was lower than the calculated energy need in all BMI groups (underweight, normal and overweight) (22).

Tang and co-workers found a significant negative energy balance due to insufficient energy intake in seven out of ten patients (23).

In our subjects, intake of dietary protein was lower than the demand. Several studies showed increased protein turnover, negative nitrogen balance especially in COPD exacerbation, decreased protein synthesis in more severe cases of COPD, altered amino acid profile in plasma and muscle in COPD patients (12, 14, 15). In one study, patients with COPD exacerbation showed negative nitrogen balance that improved with increased energy intake (12). Another study in Iceland found that energy intake above 140% of calculated needs to be adequate to prevent protein losses (22). In addition to adequate dietary energy intake, consideration should be given to dietary protein intake to preserve nitrogen balance, protein synthesis and to avoid of muscle wasting (14). These findings suggest that, in addition to correcting deficiencies in dietary energy intake, assessment of the adequacy of protein intake is necessary(14). We found significant relation between protein intake extrapolated from food frequency questionnaire with respiratory factors FVC and VC. But we observed no significant relation between energy intake obtained from two questionnaires and also protein intake extrapolated from 24-hour recall questionnaire with respiratory factors. There is a slight difference between mean values of protein intake extrapolated from food frequency questionnaire and 24-hour recall. That is the possible cause of the lack of significant relationship observed between protein intake extrapolated from 24-hour recall with respiratory factors.

Unfortunately there is no study about assessment relationship between dietary energy and protein intake with respiratory factors. Studies focus on diet supplementation, especially caloric supplementation and its effect on pulmonary function. The association between malnutrition and pulmonary disease has long been identified. Malnutrition unfavorably influences lung structure, elastic quality and function; respiratory muscle mass, strength, and endurance, defense mechanisms of the lung immune system; and the ability to control the breathing (1). Increased energy and protein demand and insufficient dietary intake lead to weight loss and muscle wasting in COPD patients (19). Muscle wasting leads to reduced diaphragm mass, weaker respiratory muscle function, and reduction in the performance of the peripheral skeletal muscle, diminishing respiratory muscle strength, changing ventilator capacity (24). When the energy intake in extremely ill patients become insufficient, protein breakdown and glycyneogenesis become sources of energy and muscle protein pool turns into a vulnerable target (9). Inspiratory and expiratory muscle, especially the diaphragm and intercostals are skeletal muscles and therefore prone to this catabolic effect. Diaphragmatic muscle mass in healthy and ill people become diminished due to malnutrition. In a study, respiratory muscle strength, maximum voluntary ventilation and vital capacity were decreased by 37%, 41% and 63%, respectively. Nutritional repletion can strengthen the respiratory muscle, which has become weak, in some patients. For instance in a study a 37% increase in maximal respiratory pressure is observed (9). Amount and length of diet supplementation in undernourished COPD patients showed different effects on anthropometric and pulmonary function. Some of the studies showed no changes in pulmonary function and some of them found significant changes (24). In a study, hospitalized COPD patients consumed an additional 10kcal/kg/day, after two weeks FVC improved significantly and change in FEV_1 was in the same direction but it was not significantly different between treatment and control groups (12). After 3 months of supplementary oral nutrition in poorly nourished COPD patients, Efthimiou et al reported increase in respiratory muscle and handgrip strength in parallel with improvement of nutritional status, in spite of the fact that there were no significant changes in lung function(25).

In a study FEV_1 decreased significantly with increases urinary nitrogen excretion. This study suggests that may be malnourished elderly COPD patients could improve through not only supplementation of total caloric intake but also sufficient protein intake (13).

In conclusion, dietary energy and protein intake were lower than the calculated energy and protein need in our COPD patients. The deficiency observed in all stages of disease.

Sufficient dietary energy and protein intake is essential to maintain and restore body weight, fat mass, visceral and somatic stores in body. Therefore assessment of dietary intake of protein and energy is necessary in all patients with COPD, independent of the stage of disease severity.

Acknowledgements

The authors wish to thank the staff of Hazrat-e-Rasool-e-Akram Hospital and its hardworking and friendly pulmonary specialists who helped us throughout this project.

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