ORIGINAL RESEARCH

Nutritional deficits in elderly smokers with respiratory symptoms that do not fulfill the criteria for COPD

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Background and objective: Whereas nutrition deficits are recognized as an expression of systemic inflammation in the elderly with diagnosed chronic obstructive pulmonary disease (COPD), if they occur in symptomatic elderly smokers, unfulfilled COPD criteria are not confirmed.

Methods: Respiratory function, anthropometry assessment, and diet intake evaluation of 13 COPD patients (COPD group), ten symptomatic elderly smokers (SYSM group), and 27 healthy volunteers (control group) were compared. All were 70 years old or older.

Results: The SYSM group had lower body weight, body mass index, percentage ideal body weight, body fat percentage, arm muscle circumference, tricep skin fold thickness, serum albumin, prealbumin, and transferrin than the control group and were similar to the COPD group ($P < 0.05$ each and nonsignificant each). Resting energy expenditure was no different among the groups. Intake of energy, vitamins (A, B1, B2, and C), calcium, iron, fiber, and sodium was also lower in the SYSM group than in the control group ($P < 0.05$ all) and was similar to the COPD group.

Conclusion: Elderly smokers who are symptomatic but who do not fulfill the COPD diagnostic criteria have nutritional deficits related to insufficient energy intake that are similar to those seen in COPD patients.

Keywords: chronic obstructive pulmonary disease (COPD), nutritional status, body composition, resting energy expenditure (REE)

Introduction

Chronic obstructive pulmonary disease (COPD) is an airway inflammatory disease caused by inhalation of toxic particles, mainly cigarette smoking, and is now accepted as a disease associated with systemic characteristics.[1] Nutritional status is one of them. Twenty-six percent to 70 percent of COPD patients with the disease have malnutrition.[2,3] In the Global Initiative for Chronic Obstructive Lung Disease, which was revised in 2006, however, the malnutrition is considered to be developed only in moderate or severe patients.[4] We often see smokers who do not fulfill the COPD criteria on spirometry test (forced expiratory volume in 1 second [FEV_1]/forced vital capacity [FVC] $<70\%$) but who suffer from COPD-like symptoms (eg, cough, sputum, dyspnea on effort) and/or have COPD-like findings on chest x-ray and/or computed tomography.[5]

There are few reports that have evaluated nutritional status of COPD-like symptomatic elderly smokers compared with elderly COPD patients or healthy elderly. In the current study we compared anthropometrics, dietary intake, and nutritional status among elderly smokers with and without COPD diagnosis and healthy elderly controls.

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Methods

Study participants

Thirteen clinically diagnosed COPD patients, ten smokers with COPD-like symptoms but with $FEV_1/FVC > 70\%$, all of whom were current smokers with at least a 40 pack-year smoking history, and 27 never-smoking healthy controls were enrolled. All of them were males and 70 years old or older. Inclusion criteria for the COPD group and the symptomatic smokers (SYSM) group were having COPD-related symptoms (dyspnea on effort, cough, sputum), regardless of the existence of COPD-related image findings (chest X-ray hyperinflation, flattened diaphragm, low attenuation area, or bullous changes on high-resolution computed tomography for chest), no medication for COPD, and no participation in a rehabilitation program for the last 6 months. Patients were excluded if they had exacerbation, respiratory infection in the last 4 weeks, a history of chronic liver or renal failure, electrolyte abnormality, malignancy, insulin-dependent diabetes mellitus, usage of systemic corticosteroids, atopy, self-reported asthma, or reversibility $> 12\%$ of airway obstruction after administration of a β2-agonist for asthma or clinically apparent heart failure. Atopic status was assessed by the negative history and the negative immunoglobulin E radioallergosorbent test to 26 common allergens. Due to the aforementioned exclusion criteria, 65 subjects were excluded (58 for respiratory infection in the last 4 weeks, 13 for asthma diagnosis or complications, three for malignancy, one for heart failure). The study was approved by the scientific ethical committee of Kawasaki Medical School Hospital, and all patients gave informed consent.

Study protocol

All subjects underwent a medical history taking and medical examination by an experienced pulmonologist, spirometry for measuring FEV_1 and FEV_1/FVC before and after bronchodilation, and biochemical blood tests, including analysis for albumin, prealbumin and transferrin, electrolytes, and renal and liver function. Anthropometry factors, resting energy expenditure (REE), and diet intake were evaluated.

Pulmonary function tests

Lung function was evaluated using a dry spirometer (CHESTAC-33; CHEST MI, Tokyo, Japan), which met the 1994 American Thoracic Society recommendations for diagnostic spirometry. Three trials were performed, and the two higher inspiratory capacity values had to agree within 5% or 60 mL.[6] The patients with $FEV_1/FVC < 70\%$ were classified to the COPD group, and patients with $FEV_1/FVC > 70\%$ to the

SYSM group. For calculation of spirometric "lung age" we used the Japanese Respiratory Society's normal prediction equation for FEV_1. The measured FEV_1 and the patient's height were substituted to calculate the functional age, which has been termed the "lung age" as follows: $(0.036 \times \text{height (cm)} - 1.178 - FEV1.0 \text{ (L)})/0.028$. When the result was more than 95, "lung age" was set to 95 years old.[7–9]

Anthropometry assessment

Height, weight, percentage ideal body weight, body mass index (BMI) (calculated as weight/height squared), body fat percentage measured by bioelectrical impedance analysis (SS-103 Bio Impemeter™, Sekisui, Osaka, Japan), midupper arm muscle circumference (AMC), tricep skin fold thickness (TSF), and REE were measured. Predicted values were quoted from Japanese standardized data.[10]

Skin fold measurements were taken from the triceps and shoulder blade (subscaplar). The body fat percentage was estimated using the equations of Brozek et al.[11] The equations for predicting body surface area (BSA), body density (D), and body fat percentage were as follows:

$BSA = 72.46 \times \text{height} \verb|^| 0.725 \times \text{body weight} \verb|^| 0.425$, $D = 1.0923 - 0.000514$ (the total of skin fold thickness of the back of the arm and shoulder blade $\times$ BSA/10,000/ body weight (kg) $\times$ 100, body fat percentage (%) = $(4.570/D - 4.142) \times 100$.

For REE measurements, an indirect calorie meter was used (Deltatrac™; Datex Corp, Helsinki, Finland). All food, except for water or tea, was forbidden from 21:00 on the previous day. The REE was measured awake, in a resting state, and while in a supine position between 07:00 and 08:00. The device was calibrated each morning before use.

Diet intake assessment

Diet intake in a different 24 hours from the examination day was evaluated using a food value calculating software based on Japanese standard nutrition allowance surveillance data for intake energy, protein, fat, carbohydrate, vitamins, phosphorus, calcium, potassium, magnesium, iron, fiber, and sodium.[11]

Statistical analysis

Data are presented as mean or median (95% confident interval [CI]). The statistical significance of differences among the three groups (control, SYSM, and COPD groups) was estimated with the Kruskal-Wallis test and analysis of variance. The associations between the variables were determined using Spearman rank correlation analysis. The analysis was performed using statistical software (Stat

Table 1 Clinical characteristics of the subjects[a]

	CONT group (n = 27)	SYSM group (n = 10)	P-value vs CONT	COPD group (n = 13)	P-value vs SYSM	P-value vs CONT
Age, year	73.0 [70.3, 79.1]	79.0 [72.2, 83.8]	0.38	78.5 [70.3, 81.7]	0.8333	0.77
Height, cm	162.7 [160.8, 165.5]	165.2 [161.0, 167.6]	0.89	160.0 [155.9, 165.4]	0.5118	0.43
FEV_1, L	2.4 [2.2, 2.5]	2.3 [1.8, 2.6]	0.68	1.0 [0.8, 1.3]	<0.0001	<0.0001
FEV_1/FVC ratio, %	87.2 [83.7, 91.8]	91.3 [81.9, 97.3]	0.42	36.3 [30.5, 42.1]	<0.0001	<0.0001
FEV_1% predicted, %	104.3 [97.8, 113.3]	104.9 [82.3, 124.7]	0.80	44.9 [37.7, 61.1]	<0.0001	<0.0001
FVC, L	3.5 [2.8, 3.2]	2.6 [2.0, 3.0]	0.0003	2.9 [2.5, 3.3]	0.14	0.005
%FVC, %	110.7 [104.7, 117.2]	82.7 [64.3, 95.4]	<0.0001	87.8 [82.1, 105.2]	0.083	0.007
Lung age, year	78.7 [75.3, 85.1]	90.4 [79.5, 94.4]	0.241	95	0.113	0.0003

Note: [a]Data are presented as median [95% confidence interval].
Abbreviations: CONT, control group; COPD, COPD patients; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; SYSM, symptomatic smokers.

View 4.0; Abacus Concepts Co, Ltd, Baltimore, MD) and $P < 0.05$ was considered significant.

Results

Clinical characteristics of the subjects are shown in Table 1. Height and age were no different among the groups. The mean spirometric "lung age" of the control group was no different from their mean real age (80.2 [95% CI: 75.3 to 85.1] vs 74.7 [70.3 to 79.1]). Symptomatic smokers had significantly lower FVC and %FVC than the control group ($P < 0.001$, respectively).

Anthropometry indexes are shown in Table 2. REE was no different among the groups. The SYSM group had significantly lower weight, BMI, percentage ideal body weight, body fat percentage, AMC, and TSF than the control group did ($P < 0.01$ each), and all of them were similar to the COPD group.

Biochemical factors are shown in Table 3. Albumin, prealbumin, and transferrin in the SYSM and COPD groups were significantly lower than those in the control group ($P < 0.02$ each).

Diet intake assessment is shown in Table 4. Energy, vitamins (A, B1, B2, and C), calcium, iron, fiber, and sodium were significantly lower in the SYSM group than in the

control group ($P < 0.05$ each), and they were similar to the COPD group, respectively.

In total, FEV_1% predicted was positively correlated with iron, calcium, vitamin A, and vitamin B1 intake ($P < 0.03$ each). In the SYSM and control groups, FEV_1% predicted was not correlated with any factors. In the COPD group, FEV_1% predicted was positively correlated with vitamin A ($P = 0.03$) and iron ($P = 0.03$) intake.

Discussion

We have found that elderly smokers who are symptomatic but who do not fulfill the COPD diagnostic criteria have nutritional deficits that may be related to insufficient energy intake similar to that seen in COPD patients.

From the late 1950s, it has been observed that many COPD patients have low body weight, which suggests it as an independent predictor for the mortality of the disease.[12–17] Subjects with COPD are known to have elevated respiratory consumption energy and REE compared with healthy persons, and they intake less and thereby develop malnutrition or cachexia.[18,19] Our study showed the nutritional similarities between the COPD patients who are known to be very sick and the symptomatic patients whom the clinicians may not recognize as being really sick.

Table 2 Anthropometry factors of the subjects[a]

	CONT group (n = 27)	SYSM group (n = 10)	P-value vs CONT	COPD group (n = 13)	P-value vs SYSM	P-value vs CONT
Weight, kg	62.2 [58.2, 66.3]	48.3 [42.6, 53.9]	0.0008	47.9 [41.1, 54.7]	0.435	0.0002
BMI, kg/m²	23.3 [22.1, 24.6]	17.8 [15.9, 19.6]	<0.0001	18.8 [16.5, 21.2]	0.65	<0.0001
%IBW, %	105.5 [100.0, 111.1]	81.1 [73.2, 88.9]	<0.0001	84.1 [73.7, 94.4]	0.64	<0.0001
Body fat percentage, %	22.0 [18.3, 25.7]	19.0 [16.2, 21.9]	0.009	21.1 [14.6, 27.7]	0.68	0.001
Arm muscle circumference, cm	391 [376, 406]	339 [280, 398]	0.012	346 [291, 401]	0.66	0.03
Triceps skin fold thickness, mm	14.6 [13.7, 15.4]	2.5 [2.0, 3.0]	<0.0001	2.9 [2.5, 3.3]	0.32	<0.0001
Resting energy expenditure, kcal	1015 [963, 1068]	971 [882, 1059]	0.11	997 [910, 1084]	0.26	0.78

Note: [a]Data are presented as median [95% confidence interval].
Abbreviations: BMI, body mass index; CONT, control group; COPD, COPD patients; IBW, ideal body weight; SYSM, symptomatic smokers.

Table 3 Biochemical factors of the subjects[a]

	CONT group (n = 27)	SYSM group (n = 10)	P-value vs CONT	COPD group (n = 13)	P-value vs SYSM	P-value vs CONT
Total protein, g/dL	7.1 [7.0, 7.3]	6.6 [6.1, 7.1]	0.007	6.9 [6.4, 7.3]	0.53	0.84
Albumin, g/dL	4.2 [4.0, 4.3]	3.7 [3.3, 4.0]	<0.0001	3.9 [3.7, 4.1]	0.09	0.0013
Total lymphocyte number/μL	1315 [1049, 1580]	1133 [758, 1507]	0.03	1646 [1362, 1929]	0.09	0.31
Choline esterase, IU/L	287 [264, 309]	209 [183, 234]	<0.0001	238 [198, 278]	0.01	0.11
Total cholesterol, mg/dL	202 [178, 226]	199 [152, 245]	0.99	187 [169, 206]	0.82	0.68
Prealbumin, mg/dL	31 [22, 40]	18.5 [10.6, 26.4]	0.012	27.4 [18.8, 26.0]	0.32	0.0005
Transferrin, mg/dL	245 [190, 300]	189 [134, 245]	0.001	202 [185, 219]	0.55	<0.0001
Hemoglobin, g/dL	13.6 [13.0, 14.3]	12.6 [11.7, 13.4]	0.003	13.5 [12.6, 14.5]	0.18	0.98
Hematoclit, %	41.4 [39.3, 42.8]	37.0 [35.0, 39.0]	0.004	40.2 [37.1, 43.3]	0.015	0.83

Note: [a]Data are presented as median [95% confidence interval].
Abbreviations: CONT, control group; COPD, COPD patients; SYSM, symptomatic smokers.

The lower levels of BMI, TSF (an indicator of body fat deposition), AMC (an indicator of muscle volume), albumin, prealbumin, and transferrin in the SYSM group than in the healthy control group were similar to those of the COPD patients. However, REE levels were no different among the groups. The intake of energy, vitamins, calcium, iron, fiber, and sodium was significantly decreased in the SYSM and COPD subjects compared with the healthy controls. This may suggest that the nutrition decline of the subjects was not caused by REE increase but possibly by intake insufficiency. In the SYSM group, protein and fat intake insufficiency was noticeable. A study reported that a high carbohydrate diet accelerates the production of carbon dioxide and respiratory quotient.[20] Therefore, a lower carbohydrate diet might

prevent or improve subjects' respiratory situation. Diet education may be important.[21]

In the study, iron and vitamin A intake was correlated with FEV_1 predicted only in COPD groups, not in the SYSM or control groups. There are few reports about the iron nutrition effect on lung function.[22] For vitamin A and lung function, respiratory cell damage, as provoked by benzo[a]pyrene, which is present in cigarette smoke,[23] decreases the uptake of vitamin A into lung cells[24] and leads to a local vitamin A deficiency of the lung tissues.[25] These data suggest that in patients with mild COPD, a local vitamin A deficiency can occur that induces pathophysiologic consequences such as narrowing of the lumina and loss of distensibility of the airways.[26] Paiva et al[2] reported that vitamin A

Table 4 Diet intake assessment for a day[a]

	CONT group (n = 27)	SYSM group (n = 10)	P-value vs CONT	COPD group (n = 13)	P-value vs SYSM	P-value vs CONT
Energy, kcal	1966 [1800, 2131]	1667 [1360, 1971]	0.015	1742 [1458, 2026]	0.58	0.048
Energy/IBW*, kcal/kg	34.1 [30.5, 37.7]	28.0 [23.2, 32.7]	0.016	30.7 [25.7, 35.6]	0.31	0.17
Protein, g	74.4 [69.2, 79.6]	65.1 [53.8, 76.4]	0.053	61.4 [49.0, 73.8]	0.50	0.004
Protein/IBW, g/kg	1.27 [1.16, 1.39]	1.11 [0.94, 1.28]	0.09	1.10 [0.88, 1.32]	0.99	0.049
Protein rate, %	15.3 [14.1, 16.4]	15.7 [14.3, 17.1]	0.64	14.5 [11.8, 17.1]	0.24	0.32
Fat, g	47.0 [40.7, 53.3]	35.5 [26.6, 44.4]	0.012	40.5 [27.5, 53.5]	0.39	0.09
Fat/IBW, g/kg	0.81 [0.70, 0.92]	0.61 [0.44, 0.78]	0.03	0.73 [0.47, 0.99]	0.31	0.27
Fat rate, %	22.0 [18.3, 25.7]	19.0 [16.2, 21.9]	0.15	21.1 [14.6, 27.7]	0.44	0.56
Carbon, g	273 [249, 298]	256 [214, 298]	0.32	247 [188, 306]	0.73	0.13
Carbon/IBW, g/kg	4.7 [4.3, 5.1]	4.3 [3.7, 4.9]	0.25	4.3 [3.3, 5.3]	0.95	0.24
Carbon rate, %	56.0 [51.2, 60.8]	61.8 [58.2, 65.5]	0.07	55.6 [48.3, 62.9]	0.06	0.69
Vitamin A, IU	3714 [3133, 4315]	369 [169, 569]	<0.0001	656 [0, 1416]	0.78	<0.0001
Vitamin B1, mg	1.11 [0.98, 1.23]	0.81 [0.48, 1.15]	0.03	0.69 [0.40, 0.98]	0.40	0.001
Vitamin B2, mg	1.36 [1.19, 1.52]	0.95 [0.78, 1.11]	0.003	1.00 [0.70, 1.30]	0.71	0.005
Vitamin C, mg	175 [141, 208]	99 [44, 153]	0.010	96 [30, 162]	0.94	0.004
Calcium, mg	666 [564, 767]	455 [290, 619]	0.002	425 [306, 544]	0.695	0.002
Iron, g	11.9 [10.8, 13.1]	7.0 [4.4, 9.6]	<0.0001	5.7 [4.2, 7.1]	0.24	<0.0001
Fiber, g	16.1 [13.8, 18.3]	11.5 [8.4, 14.6]	0.006	9.5 [6.6, 12.5]	0.30	<0.0001
Sodium, g	11.2 [10.1, 12.3]	9.3 [6.9, 11.7]	0.04	8.1 [5.8, 10.5]	0.42	0.002

Note: [a]Data are presented as median [95% confidence interval].
Abbreviations: CONT, control group; COPD, COPD patients; IBW, ideal body weight; SYSM, symptomatic smokers.

supplementation increased FEV_1 in COPD. COPD is being recognized as a general disorder. Nutritional factors (iron and vitamin A) might be useful for early detection of COPD and general worsening.

The limitation of the study is that the subject number was very small. The target number of each group of the study was 20 by statistic power. The expected positive and negative rates were set as 80% and 40%, and for comparison of the difference of factors were set as half or double. The final omitted number was 65.

Although it is known that sarcopenia is the loss of muscle mass that happens to everyone with advancing age, our subjects were age matched, and the mean age was no different among the groups. Previous studies have already demonstrated that elderly COPD patients have higher REE compared with controls, but the subjects with moderate or more severe COPD, in contrast, in the smokers group in our study, did not have $FEV_1/FVC < 70\%$.[16]

Conclusion

Elderly smokers with COPD-like symptoms have insufficient energy intake, even if they do not have diagnosed COPD.

Disclosure

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