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Assessment of Body Composition of Patients with COPD*

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Abstract
The intention of the study was to determine nutritional state and body cell mass in patients with COPD in comparison with healthy volunteers between 50 and 75 years of age. Therefore, body cell mass (BCM), phase angle and the relation between extra cellular mass and body cell mass ECM/BCM was measured with the help of bioelectrical impedance analysis (BIA).

While 10.4 % of COPD patients (male 5.0 %, female 18.8 %) had a BMI of < 18.5, no subject was underweight in the healthy volunteers. Overweight was found in 31.7 % patients (male 36.0 %, female 25.0 %) and in 54.2 % healthy subjects (male: 62.5 %, female 46.9 %), 17.1 % of our patients (male 16.0 %, female 18.8 %) versus 21.7 % of healthy subjects (male 14.3 %, female 28.1 %) were obese. While there was no statistic significance for a lower BMI in COPD patients, there were significantly decreased values concerning muscle mass – represented by BCM-values - and state of nutrition – represented by BCM, phase angle and ECM/BCM values - in COPD patients compared with healthy volunteers. These results suggest that BMI alone doesn't allow conclusions regarding to nutritional state and physical training.

A malnutrition requiring intervention might exist in spite of a normal or even high BMI in COPD patients.

Key words: COPD, malnutrition, BIA, BMI, BCM, phase angle

Introduction:

The main symptom in patients with COPD is dyspnea and loss of physical activity.

Weight loss, malnutrition and skeletal muscle weakness are frequently observed in patients with COPD and play an important role in exercise intolerance[3, 21] Body weight and body composition influence symptoms and prognosis [5]. But the mere body weight, expressed as BMI (body mass index (body weight (kg)/ height (m)^2), does not allow any clues concerning body composition, muscle mass and nutritional state. Therefore, it is crucial to determine body composition in these patients [6].

With the help of BIA (Bioelectrical Impedance Analysis) it is possible to divide the body into three compartments (so called 3-compartment-model of the human body): fat mass and fat free mass, whereas, fat free mass is divided into BCM (body cell mass) and ECM (extra cellular mass). BCM mainly includes the cells of muscle and organs and is defined as the sum of all oxygen-harnessing, potassium-rich, glucose-oxidizing, working cells. It includes about 98% of body's potassium. The percentage of cell mass in fat free mass (BCM %) is a good indicator of an anabolic or catabolic process. A good state of nutrition is represented by a high BCM [8, 16] Therefore, BCM in particular, represents a very useful parameter concerning physical activity and quality of life [10].

Extra cellular mass consists of fluid and solid parts. The interstitial water and blood plasma represent the fluid part, connective tissue the solid one. In case of good nutrition body cell mass is always bigger than extra cellular mass. ECM/BCM index should be smaller than 1. Values bigger than 1 indicate malnutrition, water deposit or a lack of physical training [16]. Phase angle between current and voltage maximum of a sinus current is another sign concerning muscle mass depletion and nutritional state. A high phase angle is typical of a good state of nutrition and training whereas a decrease of under 4 is associated with even shorter survival times [2, 7, 11, 15, 23].

In summary, a good state of nutrition is represented by high values of phase angle, high BCM percentages and low values of ECM/BCM index.

With increasing age BCM and phase angle worsen [7, 12]. Because of the fact that COPD mostly occurs in the elderly and since there are not many existing studies concerning body composition in older patients with COPD, the present study was designed to adress the following question:

Are there any differences in BCM, phase angle and ECM/BCM in COPD patients and healthy volunteers of the same age?

Methods

Patients
For this study we recruited 164 consecutive patients with COPD referred to our pulmonary department for further evaluation as well as 120 healthy volunteers. The COPD patients consisted of 100 males (51-80 years; mean age 68 yrs) and 64 females (51-79 years;

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mean age 68 yrs). Diagnosis was confirmed by spirometry according to GOLD (Global Initiative for Chronic Obstructive Pulmonary Disease) guidelines. All patients had severity scales II to III.

The healthy volunteers consisted of 56 males (50-80 years; mean age 65 yrs) and 64 females (50-78 years; mean age 63 yrs) without any previously known pulmonary problems and without regard whether they were smokers or non-smokers. Exclusion criteria for all subjects included malignancy, HIV, severe endocrine, hepatic, gastrointestinal or renal disorders.

Body Composition Assessment – Anthropometry

Body weight was determined in underwear (digital scale, accuracy of measurement: 0.1 kg); patients were bare-foot when body height was measured (accuracy of measurement: 0.1 mm).

BMI was defined as follows:

BMI < 18.5 = underweight,

25 < BMI ≤ 30 kg/m² = overweight;

BMI > 30 kg/m² obesity.

This definition reflects the current opinion of the German obesity society (Deutsche Adipositas Gesellschaft).

Body Composition

Multi-frequency bioelectrical impedance assessment ("Nutrigard M" by "Data Imput", Darmstadt, Germany) was performed in the morning after a 10 minute rest in a relaxed supine position. Patients were not allowed to eat, drink or to take part in any physical activity for at least 8 hours before analysis started. Electrodes were placed on hands and feet according to manufacturer´s instructions. Fat free mass, BCM, phase angle and ECM/BMC were calculated using Nutri 4 (Data Input, Darmstadt, Germany).

Only absolute values were taken into consideration for statistic analysis.

The fat free mass index, which is another prognostic factor of mortality in COPD patients was calculated as FFM in kg divided by body height (m)² [24].

Pulmonary Function Test

Pulmonary function test was performed only in COPD patients using body plethysmography (Fa. Jäger, Germany). Data were calculated using manufacturers supplied equations.

Analysis

Statistical analysis of the data was performed by using Student's t-test with non-identical variances with the help of the program Microsoft Excel XP®. Significance was accepted at P<0.05. P<0.01 was defined to be very significant and P<0.0001 to be highly significant.

Results

Demographic data for all subjects are presented in Table 1. 29 of the 164 patients (m= 16; f= 13) had an FEV_1 below 40 %, whereas only 8 patients (m= 3; f = 5) received a level of more than 80 %. We did not find any correlations between FEV_1 and BCM or FFMI respectively.

Body Composition

While 10.4 % of COPD patients (male 5.0 %, female 18.8 %) had a BMI of < 18.5, no subject was underweight in the healthy volunteers. Overweight was found in 31.7 % patients (male 36.0 %, female 25.0 %) and in 54.2 % healthy subjects (male: 62.5 %, female 46.9 %). 17.1 % of our patients (male 16.0 %, female 18.8 %) versus 21.7 % of our healthy subjects (male 14.3 %, female 28.1 %) were obese.

Table 1. Anthropometric characteristics and lung function.

	Patients n = 164		**Healthy Controls** n = 120		p
Sex	100 male	64 female	56 male	64 female	
Age yrs. (median range)	68.1 (51 - 80)	67.8 (51 - 79)	65.3 (50 - 80)	63.2 (50 - 78)	m: < 0.0283 f: < 0.0013
Height (cm) (95 % Cl)	173.7 (1.72, 1.75)	161.0 (1.59, 1.63)	175.0 (1.73, 1.77)	163.0 (1.61, 1.65	m: n.s. f: < 0,0827
Weight (kg) (95 % Cl)	77.0 (73.79, 80.17)	63.3 (58.8, 67.72)	83.3 (80.56, 86.14)	73.3 (70.52, 76.2)	m: < 0.0085 f: < 0.0002
BMI (kg/m²) (95 % Cl)	25.4 (24.95, 26.32)	24.3 (22.7, 25.88)	27.1 (26.43, 27.85)	27.6 (26.65, 28.64)	m: < 0.0104 f: < 0.0005
FEV 1 (l) (95 % Cl)	1.32 (0.48, 3.21)	1.05 (0.28, 2.57)			
FEV 1 (%) (95 % Cl)	51.4 (26, 86.5)	55.5 (28.8, 92.6)			

Definition of abbreviations: BMI = Body Mass Index

T*able 2*. Characteristics of Body Composition.

	Patients		Healthy Controls		
Sex	100 male	64 female	56 male	64 female	p
FM (kg) (95 % Cl)	18.6 (16.64, 20.54)	21.2 (18.09, 24.32)	20.7 (18.91, 24.32)	26.6 (24.74, 28.4)	m: < n.s. f: < 0,0036
FFM (kg) (95 % Cl)	58.5 (56.42, 60.56)	42.1 (40.42, 43.7)	62.7 (60.92, 64.47)	46.8 (45.56, 47.99)	m: < 0.0072 f: < 0.0001
FMI (kg/m^2) (95 % Cl)	6.15 (5.52, 6.78)	8.14 (6.99, 9.29)	6.7 (6.16, 7.23)	10.02 (9.35, 10.68)	m: n.s. f: < 0.0055
FFMI (kg/m^2) (95 % Cl)	19.32 (18.77, 19.87)	16.2 (15.67, 16.72)	20.39 (19.93, 20.86)	17.62 (17.22 - 18.2)	m: < 0.0092 f: < 0.0001
BCM (kg) (95 % Cl)	24.9 (23.68, 26.13)	18.0 (16.81, 19.23)	31.9 (30.8, 33.0)	23.0 (22.18, 23.77)	m: < 0.0001 f: < 0.0001
BCM % (95 % Cl)	42.4 (41.05, 43.79)	42.8 (40.76, 44.8)	50.9 (49.97, 51.73)	49.0 (48.19, 49.87)	m: < 0.0001 f: < 0.0001
ECM (kg) (95 % Cl)	33.7 (32.32, 35.03)	24.0 (22.96, 25.11)	30.8 (29.8, 31.78)	23.8 (23.17, 24.43)	m: < 0.0039 f: n.s.
Phase angle (95 % Cl)	4.4 (4.23, 4.62)	4.5 (4.21, 4.75)	5.8 (5.63, 5.99)	5.5 (5.31, 5.61)	m: < 0.0001 f: < 0.0001
ECM/BCM (95 % Cl)	1.43 (1.34, 1.52)	1.45 (1.30, 1.60)	0.97 (0.94, 1.01)	1.05 (1.01, 1.09)	m: < 0.0001 f: < 0.0001

Definition of abbreviations: FM = Fat Mass; FFM= Fat-free Mass; FMI = Fat Mass Index; FFMI = Fat-free mass Index; BCM = Body Cell Mass; ECM = Extracellular Mass

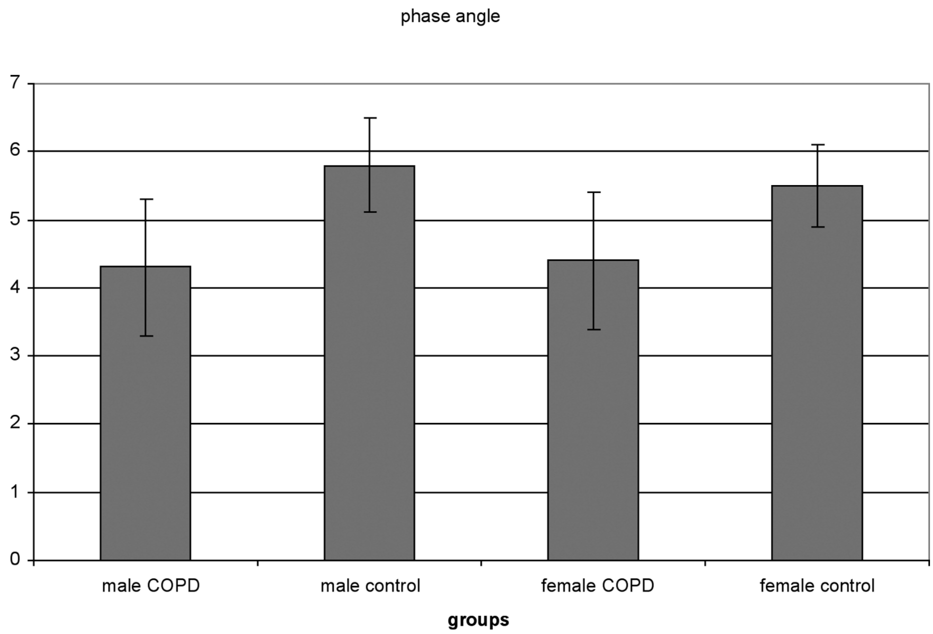

Fig. 1. Phase angle of COPD patients vs. healthy volunteers, P<0.001, T = standard deviation.
SD, confidence levels = 95%.

Bioelectrical Impedance Analysis (BIA)

Phase angle which is an indicator of nutritional state (used reference values: males > 5.5, females > 5) was sufficient in only 38 of the 164 patients (m= 17; f = 21) and in 88 of 120 healthy subjects (m= 37; f = 51), ECM/BCM ratio, which represents a further parameter to determine nutritional state showed nearly the same results. Compared to our healthy controls 85 % of controls (m = 91.1 %, f = 79.7 %) were in the normal range, whereas we could only find normal values for 32 % of our patients (m = 30 %, w = 35.9 %) (Table 2).

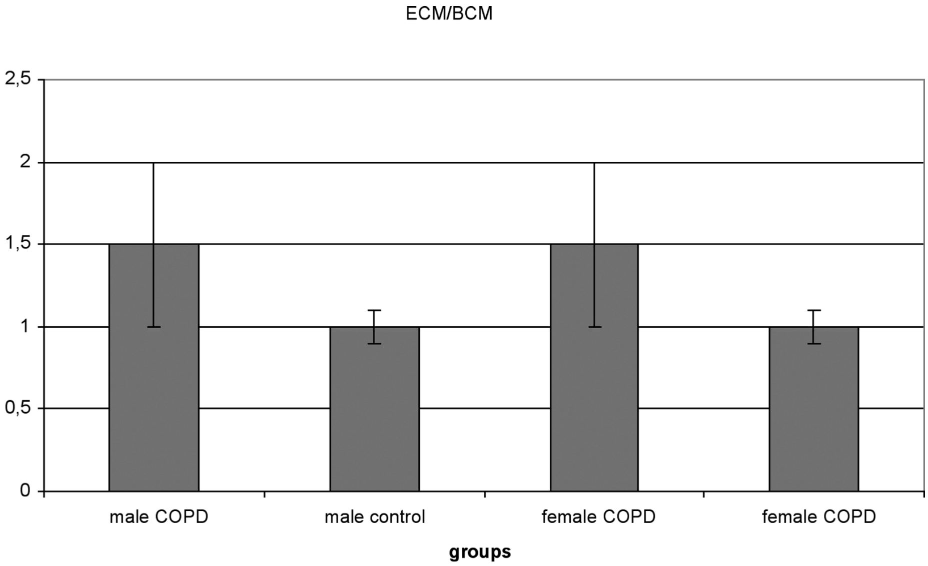

Fig. 2. ECM/BCM of COPD patients vs. healthy volunteers, P<0.001, T = standard deviation.
SD, confidence levels = 95%.

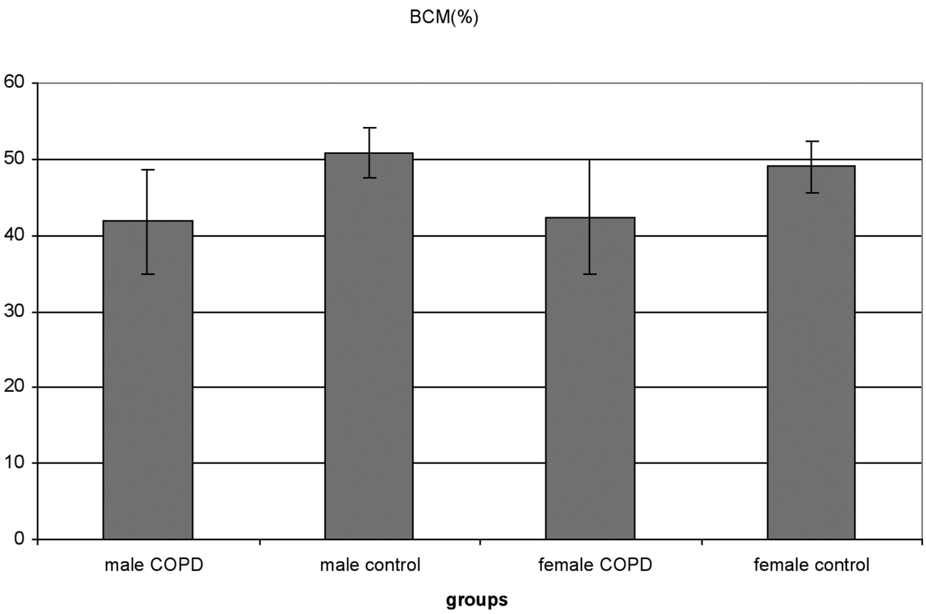

Fig. 3. BCM % of COPD patients vs. healthy volunteers, P<0.001, T = standard deviation.
SD, confidence levels = 95%.

DISCUSSION

Dyspnea on exertion, loss of physical activity, weight loss and malnutrition are common symptoms in patients with COPD and are already seen in patients with moderate disease. Loss of physical activity and dyspnoe are associated with wasting of BCM, but not with airflow obstruction [9]. The nutritional depletion is proved to be an independent risk factor for mortality and hospitalization in patients with COPD [5].

Several studies suggest that BCM (body cell mass) is decreased in patients with COPD despite a normal to high BMI [6]. However, most studies were done in small groups of patients. Since loss of BCM is not only described in patients with COPD and patients with other consuming diseases, but also in the healthy elderly, the main goal of our study was the comparison of patients with COPD and healthy controls of the same age.

Whereas only 11.53 % of COPD patients showed a BMI < 18.5, we found significantly worse results concerning muscle mass and nutritional state among this group compared to healthy volunteers. These results suggest that BMI alone doesn't allow conclusions to be drawn regarding nutritional state and physical activity in these patients. A malnutrition requiring intervention can exist in spite of a normal to high BMI.

Concerning BMI and BIA it must be noted that in this study a BMI < 18.5 was defined as underweight. However, other authors [22] even consider a BMI ≤ 21 to be a clear risk factor of increased mortality in patients with COPD. If we define a BMI < 21 as underweight, the average nutrition state of our patients would be even worse. Since standards for BIA values only exist in order to evaluate the state of nutrition in a healthy population, special regression analysis to create COPD specific reference values are needed. Further nutrition studies should determine possible differences in nutrition schemes of COPD patients and healthy comparison groups. The use of BIA to control the state of nutrition during COPD therapy urgently requires repeated measurements. Today, COPD is discussed as a systemic disease with changes in several organs and in the metabolism [19]. Several groups describe altered structures in the muscles of COPD patients [14, 18, 20]. Muscle fatigue is increased in patients with COPD [13]. Further there is a negative effect of reduced body mass on muscle aerobic capacity in COPD patients [17]. Severe depletion of fat-free mass in COPD patients leads to a decreased peak oxygen pulse and an early anaerobic metabolism. A depletion of muscle mass effects peak oxygen consumption, ventilatory response, oxygen pulse and anaerobic energy metabolism [1].

Our data demonstrate that the majority of patients with moderate to severe COPD show a significant decrease in muscle cell mass and a worse nutritional state compared to age matched healthy controls. Since the study was designed to investigate the incidence of decreased muscle mass and nutritional state in COPD patients, it is not possible to answer the question as to whether the findings are a result of the discussed systemic effect in COPD or a result of decreased physical activity due to dyspnoe and muscle fatigue.

However, only few studies exist comparing elder COPD patients with a similar aged healthy control group. Our study clearly demonstrates that COPD patients suffer from a depletion of muscle mass and poor nutritional state which is in accordance with the study of Bolton [4]. Since FFM consists of BCM and ECM, and since BCM represents muscle mass we will have to discuss whether FFMI or BCM will be a better predictor for depletion of muscle mass.

These data further suggest that nutritional intervention and increase of load bearing capacity through activity and physical exercise are very important components in the treatment of COPD patients.

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