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ORIGINAL ARTICLE

EVALUATION OF ANTHROPOMETRIC METHODS FOR FAT MASS MEASUREMENT IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE PATIENTS

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ABSTRACT

Background. Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory lung disease that causes obstructed airflow from the lungs. The obesity is a global problem, which is set to increase over time. Chronic obstructive lung disease is the third-leading cause of death globally, and both obesity and diet appear to play roles in its pathophysiology (e.g., role in the development of obstructive sleep apnoea and obesity hypoventilation syndrome). However, the effects of obesity on the respiratory system are often underappreciated.

Objective. The objective of this study was to compare three anthropometric methods to evaluate of fat mass in COPD patients.

Material and Methods. Three anthropometric methods of evaluation fat mass in a group of 60 patients with COPD were compared. To the measurement of fat mass were used: (1) Dual Energy X-ray Absorptiometry method (DEXA), specifically by DEXA densitometer QDR Discovery Wi (S/N 80227) with additional software (Body Composition Analysis); (2) four-frequency bioelectrical impedance analysis (BIA) device Bodystat Quadscan 4000 (Bodystat Ltd, British Isles); (3) skin folds measurement (SFM) with caliper (Harpenden Lange Skinfold Caliper, Cambridge Scientific Industries, Inc. Cambridge, Maryland). The measured values were statistically processed and evaluated in a statistical program Statistica Cz. version 7.1 and Microsoft Office Excel 2010 (Los Angeles, CA, USA). Differences among anthropometric methods of measurement fat mass were tested with one-way analysis of variance (ANOVA). The data were presented as mean ± standard deviation (SD).

Results. DEXA method, generally accepted for assessing body composition, showed an average value of 22.48 ±11.32 kg of fat mass, which corresponds in percentage terms to the value of 29.62±9.28. BIA method for the parameter fat mass in the monitored group of COPD patients was found the mean value 25.08±10.14 kg (in percentages 30.85±8.15). An average value 28.50±8.08% of fat mass, was determined from the skinfolds measurements (SFM) and subsequent calculations. When comparing these methods (DEXA, BIA and SFM) used to determine body composition, a statistically insignificant difference was found ($P > 0.05$).

Conclusions. In this study a good correlation between three anthropometric methods (DEXA, BIA, SFM) for measuring fat mass in patients with COPD and statistically insignificant differences between them were observed. To better define changes in the nutritional status of patients with COPD using anthropometric methods over time, further studies are needed that also monitor the consequences of clinical status, rehabilitation, and nutritional treatment.

Key words: *anthropometric methods, body fat content, obesity, COPD patients*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable disease known to be a leading cause of morbidity and mortality worldwide and inducing a substantial economic and social burden [11, 34]. COPD is a prevalent and disabling chronic health condition associated with abnormally high morbidity and mortality [42, 17]. Patients with COPD present chronic airflow obstruction and respiratory symptoms; however, there is a substantial variation in risk of exacerbations, exercise capacity, level of physical activity and other characteristics among patients [11]. COPD is now recognized as a systemic disease affecting many extra-pulmonary tissues and organs [1, 3]. Important quantifiable extrapulmonary findings in COPD include coronary artery calcification, cardiac morphology, intrathoracic and extra thoracic fat, and osteoporosis. Current active research includes identification of novel quantitative measures for

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emphysema and airway disease, evaluation of dose reduction techniques, and use of deep learning for phenotyping COPD [4]. Skeletal muscle dysfunction is a common and particularly important systemic consequence (or extra-pulmonary manifestation) of COPD because of its adverse effect on clinical and patient-reported outcomes [24]. Muscle wasting is often shown [40] predominantly in the patients with emphysema [9]. Identifying causes and treatment of skeletal muscle wasting received a lot of attention [13] as it is negatively associated with exercise capacity [2], quality of life [26] and survival [31]. A joint statement by the American Thoracic Society and European Respiratory Society identified several structural and morphological alterations that combine to contribute to skeletal (limb) muscle dysfunction in people with COPD, including: abnormally low muscle strength and endurance; mitochondrial dysfunction; poor oxidative capacity; shift in muscle fiber-type (i.e. abnormally low and high percentage of type I and type II fibers, respectively); and muscle atrophy or loss of fat-free mass (FFM) [24].

In contrast, the contribution of fat mass (FM) and its distribution in the systemic pathology of COPD have reached only just some attention. Available data indicate a prevalence of obesity (defined by BMI >30 $kg.m^{-2}$) in mild-to-moderate COPD patients of about 20% [36]. Indeed, clinical studies mainly evaluated either obesity or severe muscle wasting, termed sarcopenia, in COPD. The prevalence of obesity in COPD ranges between 18% and 54% and seems higher in early COPD stages [38, 6]. The prevalence of obesity among COPD patients is variable [29]; however, obesity seems to be more common in global initiative for chronic obstructive lung disease (GOLD) stages I–II and less prevalent in GOLD IV [36]. Combining obesity with COPD leads to an interesting paradox. While on one hand, obesity seems to be associated with increased morbidity [20], overweight and obese COPD patients tend to have lower mortality rates compared to their normal weight counterparts [21]. Several studies have shown that low body mass index (BMI) is associated with worse outcomes in COPD [16, 14]. Nevertheless, malnutrition can occur at any BMI, and important changes in body composition can occur in patients with COPD, even with a normal BMI [41, 44]. Moreover, it has been recognized that fat-free mass (FFM), seems to be a stronger predictor of mortality and disease severity than does BMI [18, 32]. All of these evidences are actually justifying the routine assessment of body composition during COPD.

In some chronic conditions, body mass index (BMI) and the percentage of weight loss do not provide any insight about the respective contributions of FFM and FM in the body mass changes. Body compartments, such as FFM, fat mass and body water, can be measured quantitatively. Numerous methods of body composition measurement have been developed through time: anthropometry, including the 4-skinfold method, hydro densitometry, the measurements of mid-arm muscle circumference, nuclear magnetic resonance (NMR), dual-energy X-ray absorptiometry (DEXA) and other [39].

Single-frequency bioelectrical impedance analysis (BIA) is recognized as an appropriate measurement of body composition during COPD [33].

DXA system provides detailed measurements of the body by looking at bone density, lean mass, and fat mass. This information is critical for accurately assessing the state of a patient health and defining successful treatment plans and training programs [30]. Skinfold measurements allow the assessment of body composition due to the strong relationship between the amount of subcutaneous fat and total body fat. SF is a non-invasive method, easy to be measured and has low operating costs [12].

The objective of this study was to compare the anthropometric methods DEXA, BIA and SFM to evaluate of fat mass in COPD patients.

MATERIALS AND METHODS

The study was conducted on 60 patients with chronic obstructive pulmonary disease from Specialized St. Svorad Hospital Nitra Zobor, Slovakia, who were treated by means of hospitalization or outpatient basis. Observation group (48 men i.e., 80% and 12 women i.e., 20%) consisted of clinically stable patients' acute deterioration of the patients was excluded from the reference file. Inclusion criteria for including patients in the study were: women and men over 18 years of age; fulfilment of criteria for COPD according to GOLD, clinical signs of COPD, FEV1/FVC less than 70%, negative bronchodilation test. Exclusion criteria in this study were: known malignant disease; other known chronic lung disease; other acute inflammatory disease at the time of DEXA, BIA, SFM; postoperative state (within six weeks of surgery); conditions after organ transplantation or hematopoietic cell transplantation; long-term use of immunosuppressive treatment, except for glucocorticoids alone; known active specific process (TB), treatment with antituberculosis drugs; pregnancy; asthma bronchiale; inability to accept food per vias naturales; disagreement with anthropometric measurements.

The experiment was carried out in the Specialized Hospital of St. Svorada Zobor, n.o., Nitra, on I. and II. Departments of Pneumology and Phthisiology.

Three anthropometric methods (DEXA, BIA, SFM) for evaluation fat mass in a group of 60 randomly selected patients with COPD were compared. The research was approved by the Ethics Committee

(Approval number 4/071220/2020). Study Protocol Title: Long-term strategic research of prevention, intervention and mechanisms of obesity and its comorbidities. Approval for inclusion in the study and the performance of relevant examinations was signed by all subjects.

The examination of the functional state of the lungs of COPD patients was performed using spirometry and Bodyplethysmographic to confirm the diagnosis and determine the stage of the disease. Patients were classified into different groups according to the severity of the disease (Gold I to IV). Lung function was evaluated using spirometer ©2005 ZAN® Meßgeräte, GmbH Germany.

To the body weight measure of patients, a BRUTUS Tanita digital personal scale (Tanita Corporation, Tokyo, Japan) was used. Body weight was determined in underwear (digital scale, accuracy of measurement: 0.1 kg). To the measurement of body height, was used an ultrasonic height measuring unit BODYSON (Ultrasound Height Measuring Unit MZ10020) (ADE GmbH & Co., Hamburg, Germany). The measuring range is 500 - 2500 mm with a division of 5 mm and its weight is 330 g. The meter is characterized by high accuracy, can be checked (spirit level) and its operation is simple. Both were used to calculate body mass index (BMI).

FFM (fat-free mass) and FM (fat mass) examinations were performed by Dual Energy X-ray Absorptiometry method (DEXA), specifically by DEXA densitometer QDR Discovery Wi (S / N 80227) with additional software (Body Composition Analysis). If the patient is pregnant, the DEXA measurement must be postponed. The use of radiological contrast agents that are used for X-ray and CT in the previous 7 days may have an interfering effect on DEXA scans. Before the DEXA measurement, the patient undresses and is dressed only in underwear. It must not have anything metallic in the scanned field. The weight limit for the measurement is 277 kg.

To the measurement of body fat was used a device Bodystat Quadscan 4000 (Bodystat Ltd, British Isles). The device works by using four-frequency bioelectrical impedance analysis (BIA). The basic principle of the method is that lean tissue, which consists essentially of electrolyte-containing water, conducts the electrical current, whereas the fat acts as an insulator. The impedance of the body is therefore determined largely by the low-impedance lean tissues. Regression equations are then derived which relate impedance to FFM or TBW measured by independent techniques. Probands were informed about the measurement procedure, explained the possible risks of measuring in the case of pregnancy or having an artificial pacemaker at the heart. The measurement is performed on an empty stomach, after emptying. First, the basic values of the proband's body (body height, body weight, waist circumference, hip circumference) are measured. Then the proband is asked, to remove your shoes and socks and lie on a non-conductive mat on your back with your arms and legs slightly apart yourself. The patient should lie relaxed. To stabilize the fluids in the proband's body, wait 4-5 minutes before starting the measurement. Personal data of the proband are entered into the device: sex, age, height, weight, waist circumference, hip circumference and level of physical activity from 1-5 of the proband. The measurement will then start.

To skin folds measurement (SFM), we used a caliper (Harpenden Lange Skinfold Caliper, Cambridge Scientific Industries, INC. CAMBRIDGE, MARYLAND). To reduce the technical error of measurement (TEM), which is described by Perini [28] among other authors, the measurement was carried out by a trained and experienced person. We also tried to achieve the reduction of TEM by the following measures. Measurement of skin folds was performed on the right side of the patient's body. In measuring, we tried to create equal conditions and ensure maximum measurement in the measuring technique accuracy. The measurements were always performed by the same person. For evaluation of SFM, were taken in four standard places: triceps (back side middle upper arm); biceps (front side middle upper arm); subscapular (under the lowest point of the shoulder blade); suprailia (above the upper bone of the hip). Three measurements were taken at each anatomical site of skinfold measurement, the resulting skinfold value was the average of these three measurements. For this measurement the patient must be able to sit or stand in an upright position. Body density equations was calculated from the sum of these four skin folds, by calculation according to *Durnin* and *Womersly* method [8] and Body Fat (%) was calculated with the Siri questions [33]. The measured values were statistically processed and evaluated in a statistical programs STATISTICA Cz. Version 7.1 and Microsoft Office Excel 2010 (Los Angeles, CA, USA). All parameters were evaluated by descriptive statistic. The data were presented as mean ± standard deviation (SD). Differences among anthropometric data were tested with a one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Patients with moderate to severe COPD often present with multiorgan involvement with severe respiratory distress, reduced physical activity, right-sided heart failure, and reduced quality of life [20].

The measurement of body composition is of value in the nutritional assessment of patients with chronic obstructive pulmonary disease (COPD) [35].

Anthropometric measurements were performed in the Specialized Hospital of St. Svorada Zobor, n.o., Nitra, on I. and II. Department of Pneumology and Phthisiology. Based on the clinical stage of the disease according to GOLD (stage I - IV), were patients with COPD in the following stages of the disease: stage I 26.67%; stage II. 71.67%; stage III. 0% and stage IV. 1.66%.

The average age of COPD patients was 69.25±9.90 years (age range from 49 to 87 years; median 68 years). The average body weight of patients was 76.73±20.23 kg. Body height in patients with COPD averaged 164.04 ± 8.03 cm. Subsequently we calculated the Body Mass Index (BMI) from body height and body weight. In the monitored group was the mean BMI 28.51±7.05 $kg.m^{-2}$. From the obtained individual values, were calculated the data and statistical characteristics (Table 1).

A body mass index value higher than 25 $kg.m^{-2}$ to a value of 29.9 $kg.m^{-2}$ indicates overweight (mild obesity), BMI values from 30 $kg.m^{-2}$ to 34.9 $kg.m^{-2}$ indicate significant obesity, BMI values from 35 $kg.m^{-2}$ up to 39.9 $kg.m^{-2}$ indicate severe obesity, and values above 40 $kg.m^{-2}$ indicate extreme obesity, which is also reported by literary sources [27].

In the group of COPD patients, based on BMI was found: cachexia (BMI <17 $kg.m^{-2}$) in 1 case (1.67%), underweight (BMI <18.5 $kg.m^{-2}$) in 4 cases (6.67%), normal BMI in 17 cases (28.33%), overweight in 15 cases (25%), significant obesity in 7 patients (11.67%), severe obesity in 14 patients (23.33%) and morbid obesity in 2 patients (3.33%). Although BMI does not indicate the amount of fat mass in the proband's body, it is still used as a criterion for the classification of obesity. However, from the point of view of health risks or the presence of COPD and its associated diseases, it is very important to know the actual amount of fat mass. Fat mass has many metabolic consequences in both patients and healthy people.

Fat mass (%) from BMI calculated according to *Durnin* and *Womersley* [8] reached an average value of 25.50% in a group of patients with COPD. As we can see when comparing with measurements methods of fat mass (by DEXA it was 29.62%; by BIA 30.85%, and by SFM 28.50%) the value derived from BMI is significantly underestimated.

Other studies have reached similar conclusions. For example, BMI together with other anthropometric measurements (e.g., waist circumference, waist-hip ratio - WHR, percentage of body fat) in relation to obesity and ABSI (A Body Shape Index) were monitored by *Gažarová* et al. [10]. The authors of this study found that the diagnosis of obesity among participants showed considerable variation according to used anthropometric measurements and indices (BMI, WHR). In practice, many different determination methods and calculated indices are used to assess fat mass. Their use depends on several factors, such as the concept of the study, monitored probands, equipment, etc. [5].

A generally accepted method of assessing body composition is the DEXA (Dual Energy X-ray Absorptiometry) method. The DEXA method showed an average value of 22.48±11.32 kg of fat mass, which corresponds in percentage terms to the value of 29.62±9.28.

Table 1. Characteristics of COPD patients and fat mass measurement methods comparison

Characteristic	COPD patients (n=60)			
	average ± SD	min. – max.	med	mod
Age (yrs)	69.25 ± 9.90	49.00 – 87.00	68.00	62.00
Body weight (kg)	76.73 ± 20.23	38.60 – 136.80	72.70	65.10
Body height (cm)	164.04 ± 8.03	141.00 – 177.00	165.50	168.00
BMI ($kg.m^{-2}$)	28.51 ± 7.05	15.30 – 46.80	27.50	37.00
Fat Mass (%) by DEXA	29.62 ± 9.28	12.40 – 49.50	29.63	31.30
Fat Mass (%) by BIA	30.85 ± 8.15	15.10 – 49.30	30.30	24.90
Statistical difference between "gold standard" method DEXA (%) and BIA (%)				P>0.05
Fat Mass by SFM (%)	28.50 ± 8.08	13.80 – 50.06	28.80	17.40
Statistical difference between "gold standard" method DEXA (%) and SFM (%)				P> 0.05
Fat Mass (kg) by DEXA	22.48 ± 11.32	5.53 – 56.05	20.67	19.50
Fat Mass (kg) by BIA	25.08 ± 10.14	10.30 – 57.10	22.45	21.30
Statistical difference between "gold standard" method DEXA (kg) and BIA (kg)				P > 0.05

Data are expressed as average ± standard deviation (SD); min. – max.; med – median; mod – modus;
BMI – body mass index; DEXA – Dual Energy X-ray Absorptiometry; BIA – bioelectrical impedance analysis;
SFM – skin folds measurement

DEXA scans can also be used to measure total body composition and fat content with a high degree of accuracy comparable to hydrostatic weighing [37]. From the DEXA scans, a low resolution "fat shadow" image can also be generated, which gives an overall impression of fat distribution throughout the body [25].

Bioelectrical impedance analysis (BIA) is a method for estimating body composition, in particular body fat and muscle mass, where a weak electric current flows through the body and the voltage is measured in order to calculate impedance (resistance) of the body. Most body water is stored in muscle. Therefore, if a person is more muscular there is a high chance that the person will also have more body water, which leads to lower impedance. BIA determines the electrical impedance, or opposition to the flow of an electric current through body tissues which can then be used to estimate total body water (TBW), which can be used to estimate fat-free body mass and, by difference with body weight, body fat [19].

In this research was used the BIA method also. For the parameter fat mass in the monitored group of patients was found the mean value 25.08±10.14 kg. Bodystat Quadscan 4000 also calculates the amount of fat mass in percentages. The average value of the percentage of fat mass in COPD patients was 30.85±8.15%.

BIA method is a simple, inexpensive, quick and non-invasive technique for assessing body composition and its changes over time. This method is largely used in clinical trial settings and there is a whole series of literature on the theory and methodology of several different BIA techniques [19, 22, 23].

Values of fat mass (%) using SFM were obtained by calculation (methodology is given in the chapter material and methodology). An average value 28.50 ± 8.08 % of fat mass, was determined from the measurements of skinfolds and subsequent calculations.

The reliability of anthropometrics depends on standardizing the caliper and site of measurement, and upon the measuring skill of the anthropometrist. A reproducibility of ± 2% for C and ± 10% for SF measurements usually is required to certify the anthropometrist [43].

By statistically comparing these methods of determining body composition (DEXA, BIA and SFM methods), was found a statistically insignificant difference ($P > 0.05$), which means that the methods are correlated and suitable for monitoring body composition (Table 1).

Differences in the accuracy of determining body composition between these methods (professional literature states 5-7%) were also confirmed by measurement in patients with COPD (Figure 1).

Despite good statistical agreement among values obtained with dual-energy x-ray absorptiometry, skinfold thickness measurement, and bioelectrical impedance analysis, the study findings indicate that skinfold thickness measurement and bioelectrical impedance analysis, above all, tended to overestimate fat-free mass compared with dual-energy x-ray absorptiometry [7].

Fat mass and fat mass index, measured by skin-fold anthropometry and bioelectrical analysis were well correlate, with a small non-significant mean bias [15].

There are significant inter-method differences in the measurement of body composition in chronic obstructive pulmonary disease patients. The choice of measurement method will have implications for nutritional assessment in chronic obstructive pulmonary disease [35].

However, the BIA and SFM methods are less burdensome for the patient in terms of radiation and are also less expensive and time-consuming.

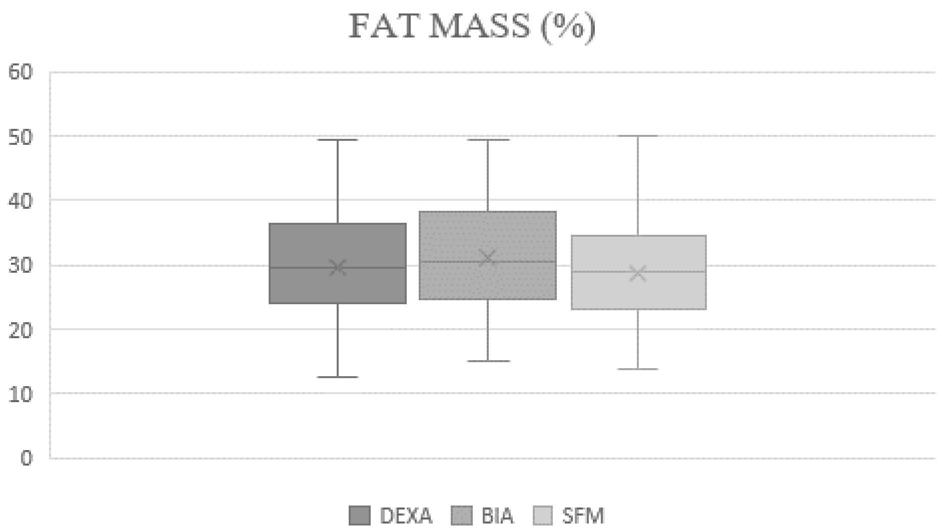

Figure 1. Comparison of the DEXA, BIA and SFM methods for measuring fat mass parameter

Therefore, it would be appropriate to use the BIA method for initial screening (or SFM - however, it is more time-consuming than BIA and has a higher risk of measurement error) and in later and more severe disease states, or in appropriate cases when the most accurate monitoring of the body structure would be necessary, used measurement with DEXA method.

CONCLUSION

1. In this study, associations between three anthropometric methods for measuring fat mass in patients with COPD were observed. The study showed a good correlation of anthropometric methods DEXA, BIA and SFM, and statistically insignificant differences between them.
2. In order to better define changes in the nutritional status of patients with COPD using anthropometric methods over time, further studies are needed that also monitor the consequences of clinical status, rehabilitation and nutritional treatment.

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Conflict of interest statement

The author declares no conflict of interest.

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