Acknowledgement

With this opportunity we want to thank the people who have helped us to realize this thesis.

First we want to thank our promotor prof. dr. Spruit Martijn and copromotor drs. Burtin Chris, who helped us through this process. Thanks to their expertise and proper guidance we managed to establish this thesis. Secondly our thanks goes to fellow students, family and friends for their advice and support the past two years.

Heirweg 55, 3680 Maaseik, 26/06/2017 C.F.

Stationstraat 22 B7, 3680 Maaseik, 26/06/2017 S.B.

Research context

This thesis, which is part of the master 'Rehabilitation sciences and Physiotherapy', is situated in the research domain cardiorespiratory and internal disorders (CRI) which is part of the REVAL rehabilitation Research Center, Biomedical Research Institute, Faculty of Medicine and Life Science, Hasselt University (Hasselt, Belgium). Coordinated by Prof. dr. Dominique Hansen, CRI focusses on one hand on optimization of training interventions or rehabilitation programs and on the other hand on the underlying mechanisms of the overall therapeutic effect of physical intervention programs. These cardiorespiratory and internal diseases lead to high health costs, a shorter life span and lower quality of life. That is why research that leads to improvement in the prevention, care and treatment is important. The CRI works with researchers from neurological and musculoskeletal research programs.

This duothesis is part of two broader research projects. The first, 'Functional status in patients undergoing curative treatment for lung cancer: a prospective follow-up study', is led by the investigators Chris Burtin, PT, PhD, Marc Daenen, MD, Michiel Thomeer, MD, PhD and Martijn A. Spruit, PT, PhD (principal investigator), who are a researcher at the REVAL Rehabilitation Research Center or pulmonologist at the Department Lung diseases at ZOL (Genk, Belgium).

The second project 'Oral β-alanine Supplementation in patients with COPD: Structural, Metabolic and Functional Adaptations' is achieved by Jana De Brandt, MSc, Martijn A. Spruit, PT, PhD (principal investigator), Wim Derave, PhD, Chris Burtin, PT, PhD, Dominique Hansen, PT, PhD, Frits Franssen, Phd, MD, Paul Dendale, MD, PhD and Jospeh Aumann, MD who are a researcher at the REVAL Rehabilitation Research Centre, part of the Department of Movement and Sport Sciences, University Ghent (Ghent, Belgium), part of the Heart Centre (Hasselt, Belgium) or pulmonologist at Jessa Hospital (Hasselt, Belgium).

The aim of this study is to examine the criterion validity of the Bioelectrical Impedance Analysis (BIA) for the estimation of fat free mass (FFM) in patients with lung cancer and Chronic Obstructive Pulmonary Disease (COPD).

Patients with both small cell and non-small cell lung cancer who underwent curative treatment are included in the study as well as patients with moderate to very severe COPD,

according to GOLD guidelines. All measurements are done at REVAL rehabilitation research center, Hasselt University (Hasselt, Belgium).

The data was collected by the broader research project and analysed by the students Femke and Bo.

Table of contents

Abstract

Background

Change in body composition is a common problem in lung cancer as well as Chronic Obstructive Pulmonary Disease (COPD), involuntary loss of muscle mass is seen in both populations. A body is divided in Fat Mass (FM) and Fat Free Mass (FFM) which includes muscle mass, organs, bone, water and connective tissue. Therefore it is important to have an available and valid assessment tool for the estimation of FFM. Bioelectrical Impedance Analysis (BIA) is a quick, portable, easy to use and relatively inexpensive instrument in comparison with the Dual Energy X-ray Absorptiometry (DEXA) which is quite expensive and only can be used by professionals.

Objectives

The aim of this study was to investigate the criterion validity of BIA in estimating FFM by comparing the results to those measured by the DEXA as a reference method.

Participants

22 patients are included for the study: 15 patients with COPD and seven patients with lung cancer. Patients with lung cancer were recruited from hospital Oost-Limburg, campus Sint-Jan at Genk. Patients with COPD were recruited at the department of Pneumology of Jessa Hospital at Hasselt.

Results

The Pearson correlation test resulted in a strong correlation between FFM measured by the BIA and FFM measured by the DEXA (r=0.980). The Bland and Altman analysis resulted in a mean underestimation of the BIA of -0.09 kg with limits of agreement of +4.88kg and -5.07kg.

Conclusion

The high correlation and moderate agreement between BIA and DEXA contribute to the validity of the BIA for the measurement of FFM. Nevertheless, an estimated error of ±5kg needs to be taken into account.

Introduction

Lung cancer is characterized by uncontrolled cell growth in tissues of the lung. It is one of the leading causes of cancer mortality worldwide (Shu et al. 2016). Signs and symptoms of lung cancer include coughing, shortness of breath and chest pain (www.cancer.gov).

Fat Free Mass (FFM) of patients with lung cancer may differ from healthy individuals of the same age and gender. Involuntary weight loss is common among patients with advanced cancer, contributing to poor treatment response, functional decline, and decreased survival (Dumler and Kilates 1999). Cachexia, the massive loss of both adipose tissue and skeletal muscle mass (up to 80%), is an underlying significant factor for the reduced muscle strength, the poor performance status and the recovery and wellbeing but also for the high mortality rate of cancer patients (Tisdale 2010; Dasarathy 2016).

Chronic Pulmonary Obstructive 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. Exacerbations and comorbidities contribute to the overall severity in individual patients (Vestbo et al. 2013). The characteristic symptoms of COPD are chronic and progressive dyspnea, cough, and sputum production (Vestbo et al. 2013).

Patients with severe COPD present weight loss due principally to muscle mass depletion (Wouters and Schols 1993). Independent of the severity of the bronchial obstruction, weight loss and low body weight correlate with increased morbidity, a poor prognosis, and may have far-reaching consequences (Engelen et al. 1994).

Because change in body composition is the common problem in lung cancer as well as COPD, it is important to assess the body composition in these patients. To evaluate nutrition status and the response to the treatment there is need to have a valid assessment tool for the estimation of FFM. The classic determinations of body weight or Body Mass Index (BMI) do not give the information about how the body is composed but there are devices available that can measure our body composition.

It is known that Dual Energy X-ray Absorptiometry (DEXA) is a valid and reliable tool to measure fat free mass in healthy people as well in patients with lung cancer and COPD (Cuijpers-Schroyen 2016).

Unfortunately, DEXA has several disadvantages: it can only be used by a trained professional, it makes use of X-rays, it is quite expensive and takes 10-15 minutes to measure the body composition while the subject has to lay down on a flat surface. Adversely, Bioelectrical Impedance Analysis (BIA) is a quick, portable, easy to use and relatively inexpensive instrument. It has been shown that BIA is valid compared to the DEXA to measure FFM in patients with chronic cardiorespiratory and internal diseases (Cuijpers-Schroyen 2016).

Little research has been done into the validity of the BIA compared to DEXA in patients with COPD. In the study of Steiner et al., who included 85 COPD patients, no correlation was calculated but the average results were similar (Steiner et al. 2002). Lerario et al. found a correlation of r=0.95 in the comparison of the BIA with the DEXA (Lerario et al. 2006). No research has been done into the validity of the BIA in patients with lung cancer. If this method is valid, compared with the DEXA in patients with lung cancer, this method can be used in the future to estimate the FFM in this population.

Therefore this study is set up to compare the results of the DEXA and BIA, specific for estimating FFM, in patients with lung cancer and COPD.

Methods

Research design

A series of 22 patients with lung cancer or COPD was asked to participate in this study about the criterion validity of the BIA, with the DEXA as a reference method. For the lung cancer group the assessments were performed in the time frame between the decision of medical staff to commence curative treatment and actual start of treatment. For the COPD group the assessment of the patients were performed after referral of the Department of Pneumology to the research project. Measurements with the BIA and DEXA are both taken once.

All assessments were performed at the same day by an experienced physiotherapist. Body weight was measured to the nearest 0.1kg. Body height was measured using a meter attached to the wall to the nearest 0.1m. Body Mass Index (BMI) was calculated as weight/height^2. Fat Free Mass Index (FFMI) was calculated as FFM/height^2. Patients were considered as nutritionally depleted if BMI ≤18.5 kg/m^2 or an FFMI of ≤ 15.4 kg/m^2 in women or ≤18.4kg/m^2 in men.

Participants

Inclusion criteria patients with lung cancer:

- Patients with a diagnosis of lung cancer (both small cell and non-small cell lung cancer)
- Have not started curative treatment (surgery and/or (adjuvant) chemotherapy and/or (adjuvant) radiotherapy)

Exclusion criteria patients with lung cancer:

- Presence of other neoplasms
- Progressive neuromuscular and neurological diseases
- Unstable cardiac disease
- Pulmonary hypertension
- Interstitial lung disease
- Orthopedic conditions that significantly impair functional status
- Mental or psychiatric disorders that impair the ability to comply with study procedures

- History of cerebrovascular accident with remaining functional consequences
- History of lung cancer
- Lack of knowledge of the Dutch, French or English language

The presence of stable cardiovascular disease and cardiovascular risk factors will not lead to exclusion.

Inclusion criteria patients with COPD:

- Patients with a diagnosis of moderate to very severe COPD (according to GOLD Guidelines)
- Between 40-80 years old

Exclusion criteria patients with COPD:

- Patients with other degenerative chronic or metabolic diseases
- The presence of known instable cardiac disease
- Neurological disease and/or musculoskeletal disease that preclude safe participation in an exercise test
- History of drugs/alcohol abuse
- Inability to understand the Flemish Language
- COPD exacerbation and/or hospitalization in the last 6 weeks
- Patients who already participated in a pulmonary rehabilitation program in the previous 12 months

Recruitment

A convenience sample of 22 patients is included in this study. All patients with lung cancer were recruited from hospital Oost-Limburg, campus Sint-Jan at Genk. All patients with COPD were recruited at the department of Pneumology of Jessa Hospital at Hasselt.

Medical ethics

Written informed consent is obtained from all patients prior to inclusion.

Procedure

Bioelectrical impedance analysis (BIA)

Bodystat 1500 was used to determine the FFM, Fat Mass (FM) and Fat Percentage (%FM) based on an impedance of a low-voltage current passing through the body. Those parameters can be calculated using regression equations based on the relationship between the impedance index of length²/R (R = Resistance) and water volume. FFM was also estimated directly from Total Body Water (TBW), calculated as the sum of Extracellular Water (ECW) and Intracellular Water (ICW) based on the assumption of a 73% hydration of the FFM. Results are reported in kilogram (Jager-Wittenaar et al. 2014; Ellegard et al. 2009; Ellis 2000).

First, height and weight must be determined before proceeding. While sitting down on a chair, the physician attached the first pair of electrodes under the head of the proximal metacarpophalangeal III and on the wrist medial of the ulnar head. The second pair of electrodes needed to be attached on the ipsilateral side as the previous electrodes, one electrode on the proximal side of the metatarsal II and the other on the ankle between the medial and lateral malleoli. The black electrode was always the most proximal electrode in each pair. This single-frequency BIA used a 50kHz current, which passed through the ECW and the cell membranes for the estimating of the total body water. The test took three seconds before data could be read from the screen.

Dual energy x-ray absorptiometry (DEXA)

DEXA analysis was performed in a supine position using a Lunar DPXL scanner (Wisconsin, USA). Whole-body scans were performed to measure FM, Lean Soft Tissue (LST) and Bone Mineral Content (BMC). FFM was defined as LST+BMC. The test took 15 minutes to complete and was performed by an experienced physiotherapist.

Data-analysis

Statistical analysis was performed using IBM SPSS v.24 for windows software (SPSS, Chicago, IL). The FFM, FM and %FM by DEXA and BIA were tested for normality by the Kolmogorov-Smirnov normality test: A Pearson correlation test was applied to test the correlation between DEXA and BIA for FFM and %FM. A Spearman's correlation was used by measuring the correlation of DEXA and BIA for FM. Bland and Altman analysis was used to assess the agreement between the two clinical measurements. In the Bland and Altman analysis, the difference between the values is plotted against their mean. This analysis allows the calculation of bias (estimated by the mean differences), the 95% confidence interval for the bias, and the limits of agreement (two standard deviations of the difference). Men and women were compared in the outcome of FFM by the BIA with an independent t-test.

Results

Patient characteristics

Table 1 shows the characteristics of the participating patients. 22 patients are included for the study, fifteen (68.18%) patients with COPD and seven (31.82%) patients with lung cancer, with a mean age of 64.45 years (SD of ± 6.36 years). The sample size exists of thirteen male (59.09%) and nine female (40.91%) subjects. Mean height and weight are 166.74cm (SD of ± 6.07cm) and 71.07kg (SD of ± 18.18kg) which results in a mean BMI of 25.51kg/m² (SD of ± 6.06 kg/m²). Mean waist and hip circumference are 90.23cm (SD of 16.44cm) and 98.27cm (SD of ± 11.28 cm) respectively, which results in a mean waist hip ratio of 0.91 (SD of ± 0.11). Fat Free Mass Index (FFMI) takes into account the amount of fat free mass of a person related to their height (Schutz, Kyle, and Pichard 2002). Mean FFMI in this sample size is 17.61kg/m² (SD of ± 3.08 kg/m²). The mean value of FFMI for men is 19.54kg/m² (SD of ± 1.77 kg/m²), for women the mean value of FFMI is 14.81kg/m² (SD of ± 2.31 kg/m²).

Three out of fifteen (20%) patients with COPD have been hospitalized in the last twelve months: two because of pneumonia and one because of an umbilical hernia. Five out of seven (71.43%) patients with lung cancer have had surgery and two out of seven (28.57%) have had radiotherapy.

Table 2 contains the mean results of the measurements of the DEXA and the BIA.

Table 1: demographic and anthropometric parameters in patients with Chronic Obstructive Pulmonary Disease (COPD) and lung cancer.

Characteristics	COPD and lung cancer average ± SD or n (%total)	Lung cancer average ± SD or n (%total)	COPD average ± SD or n (%total)
Total n=22	22	7 (31.82)	15 (68.80)
Sex M	13 (59.09)	2 (28.57)	11 (73.33)
F	9 (40.91)	5 (71.43)	4 (26.67)
Age (years)	64.45 ± 6.36	61.43 ± 7.46	65.87 ± 5.49
Total body mass (kg)	71.07 ± 18.18	64.43 ± 24.57	74.17 ± 14.30
Height (cm)	166.74 ± 6.07	164.29 ± 5.74	167.89 ± 6.07
BMI (kg/m²)	25.51 ± 6.06	23.80 ± 7.21	26.33 ± 5.18
FFMI (kg/m²)	17.61 ± 3.08	15.94 ± 3.72	18.38 ± 2.22
Waist circumference(cm)	90.23 ± 16.44	88.71 ± 20.36	90.93 ± 15.05
Hip circumference (cm)	98.27 ± 11.28	95.71 ± 9.67	99.47 ± 12.08
Waist-hip-ratio (cm)	0.91 ± 0.11	0.91 ± 0.13	0.91 ± 0.10

BMI = Body Mass Index. FFMI = Fat Free Mass Index

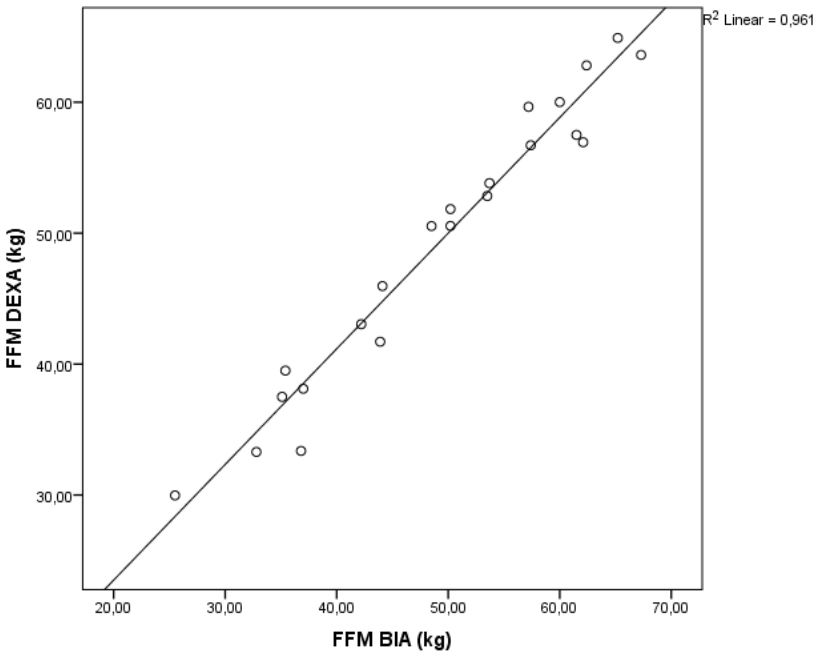
Table 2: The average values of the body composition of the 22 patients with Chronic Obstructive Pulmonary Disease (COPD) and lung cancer.

	DEXA (average ± SD or median (Q1-Q3))	BIA (average ± SD or median (Q1-Q3))
FFM (kg)	49.28 ± 10.75	49.18 ± 11.93
FM (kg)	20.12 ± 11.08	21.89 ± 9.50
%FM (% of weight)	26.60 (23.55 - 33.97)	29.15 (25.60 - 34.95)

FFM= Fat free mass, FM = Fat mass and Fat percentage (%FM)

Correlation between BIA and DEXA

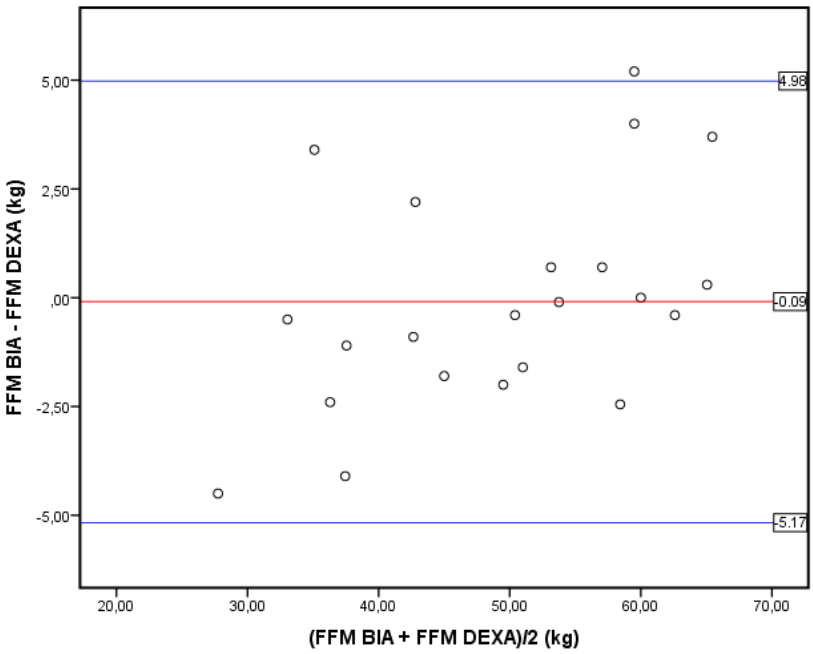
The normality of FFM and %FM measured by DEXA and BIA was confirmed by the Kolmogorov-Smirnov test. The FM was not normally divided in the BIA group ($p<0.05$) (Appendix Table 3). The Pearson correlation test showed a strong correlation between BIA and DEXA for measuring FFM r=0.980 and for %FM r=0.801 which you can see in fig 1. The spearman's correlation was applied for FM and showed a correlation between BIA and DEXA of r=0.923 ($p<0.01$).



<u>Fig 1:</u> Pearson correlation of Fat Free Mass (FFM) by Bioelectrical impedance analysis (BIA) and Dual energy x-ray absorptiometry (DEXA) in kg.

Agreement between BIA and DEXA

Bland and Altman analysis showed similar results between BIA and DEXA for FFM (mean difference -0.09kg; limits of agreement +4.88kg and -5.07kg), FM (mean difference 1.11kg; limits of agreement (+6.45kg and -4.23kg) and %FM (mean difference 1.73%; limits of agreement (11.33% and -7.87%)(Fig 2 and Fig 3).



<u>Fig 2:</u> Bland and Altman: Fat free mass (FFM) differences between Dual energy x-ray absorptiometry (DEXA) and Bioelectrical impedance analysis (BIA) compared with the average of these measurements ((BIA+DEXA)/2) in 22 patients with lung cancer or COPD. (Mean difference of -0.09kg ; limits of agreement +4.88kg and -5.07kg)

Discussion

The purpose of this study was to measure the criterion validity of the BIA by comparing the results of FFM measured by the BIA to those measured by the DEXA. Results gave a high correlation (r=0.980) and a small difference of -0.09kg when compared the reference method DEXA. Though we should notice the limits of agreement of +4.88kg and -5.07kg. Therefore BIA might be useful in the future for the estimation of FFM in most cases but for diagnostic purpose of weight loss, the BIA is not recommended because of its variability.

Bland and Altman analysis.

Although the Pearson Correlation test showed a strong correlation between the DEXA and BIA and a small difference between the methods (bias) by the Bland and Altman, the limits of agreement (error) were relatively large (+4.88kg and -5.07kg). According to the study Kyle et al., a prediction error of 2.0-2.5kg in men and 1.5-1.8kg in women is considered as ideal. A prediction error of less than 3.0kg for men and 2.3kg for women would be considered very good (Kyle et al. 2004).

These results are comparable with a previous study where FFM was estimated in 58 COPD patients by the BIA and compared with DEXA results. In this study, BIA shows a meanly underestimation of 0.72kg with limits of agreement: +7.20kg and -5.68kg which are higher than the recent results (Steiner et al. 2002). In another study, BIA gave a mean difference of -0.61kg with limits of agreement between +4.90kg and -6.15kg which are about the same as in the current study (Lerario et al. 2006).

Other studies about patients with cancer gave similar results. In the first study they compared BIA and DEXA in 24 patients with histologically confirmed head and neck carcinoma. This study found a mean FFM of ± 56kg with a mean difference of 0.7kg with limits of agreement of +4.46kg and -3.04k, which are about the same as in the current study. Furthermore, in this study the same trend is noticeable: an underestimation when FFM<55kg and a overestimation when FFM>50kg (Jager-Wittenaar et al. 2014).

In the second study about 132 consecutive incurable cancer patients with solid tumors, they compared DEXA with Bioelectrical Spectroscopy (BIS) which shows a mean bias of 7.85kg (DEXA-BIS) with a SD of ± 5.35kg (Ellegard et al. 2009). Those findings are not comparable to

the current study, probably due to the use of a BIS. A BIS uses mathematical modeling and mixture equations (Kyle et al. 2004).

Patients characteristics

From the sample size of 22 patients there were only seven patients with lung cancer, the other fifteen subjects were diagnosed with COPD. This means that the COPD patients took the majority of the group with 68.18%.

Five out of the 22 subjects included for the study have a BMI higher than 30 kg/m². One in the lung cancer group (38.20 kg/m²) and four in the COPD group (31.30, 39.20, 30.30 and 32.50 kg/m²). Two patients out of 22 have a BMI below 18.5kg/m² (respectively 15.8kg/m² and 18.2 kg/m²). A BMI higher than 30 kg/m² is categorized as obese, a BMI lower than 18.5kg/m² is seen as underweight. It is known that an increased fat mass can affect the measurement of FFM with the BIA. (Jager-Wittenaar et al. 2014). In the current study a small trend is noticeable of a general underestimation when FFM is lower than 50,00kg and an overall overestimation when the mean FFM is higher than 50,00kg.

The isolated use of a BMI value cannot indicate which compartment, FFM or FM, is more affected. An excess of fat tissue may maintain the normal weight while the muscle compartment is depleted.

In the present study, six out of nine women have a FFMI below 15.4 kg/m², three men have a FFMI below 18.4kg/m² and three men have a FFMI around 18.4kg/m². According to Schutz et al., the median FFMI in healthy men between 55-74y old is 19.4kg/m² (range 25th-75th percentile: 18.4kg/m² and 20.3kg/m²) and in women 16.2kg/m² (range 25th-75th percentile: 15.4kg/m² and 17.4kg/m²) (Schutz, Kyle, and Pichard 2002). Based on these reference values we can conclude that 12 out of 22 patients have a FFMI below average, which means that more than 50% of the patients have muscle depletion. These findings are similar with other studies. In Lerario et al., the mean FFMI in men is 18.3 (SD of ± 2.0 kg/m²) and in women 15.1 (SD of ± 1.5 kg/m²)(Lerario et al. 2006). In a second study, the mean FFMI in men is 17.0 kg/m² (SD of ± 1.9 kg/m) and in women 14.4kg/m² (SD of ± 1.4kg/m). The overall prevalence of nutritional depletion was 49% (Steiner et al. 2002).

Limitations of the study

The BIA relies on the estimation of total body water from measurement of whole body impedance. FFM is measured using a prediction equation derived from a comparison with a reference method. Incorrect assumptions about the hydration of the lean tissue of patients with lung cancer or COPD can lead to errors.

A second limitation is that all patients were only measured one time with the DEXA and one time with the BIA. A better option would have been to measure every patient several times to calculate an average of these results. This would have made the measurement more precise.

Also, it can be noted that all patients were put together and that no distinction was made in the severity of the disease state, sort of lung cancer, or level of COPD. Someone who is already suffering from a disease for a long period of time will have another body composition than someone who is recently diagnosed.

Conclusion

The Pearson correlation test between the FMM measured by the BIA and DEXA resulted in a correlation of r=0.980. Bland and Altman analysis showed a mean difference of -0.09kg with limits of agreement between 4.98kg and -5.17kg.

BIA is a quick, easy, portable and relatively inexpensive device with no risks in use. It is considered as a valid measurement tool for the general screening of patients with lung cancer and COPD. To accurately investigate the FFM for diagnostic purposes, we recommend to use another measuring instrument because the disparity of the limits of agreement.

Reference List

Cuijpers-Schroyen. 2016. 'Thesis part I '.

Dasarathy, S. 2016. 'Cause and management of muscle wasting in chronic liver disease', *Curr Opin Gastroenterol*, 32: 159-65.

Dumler, F., and C. Kilates. 1999. 'Nutritional status assessment and body composition analysis in pre-end stage renal disease patients', *Miner Electrolyte Metab*, 25: 397-9.

Ellegard, L. H., M. Ahlen, U. Korner, K. G. Lundholm, L. D. Plank, and I. G. Bosaeus. 2009. 'Bioelectric impedance spectroscopy underestimates fat-free mass compared to dual energy X-ray absorptiometry in incurable cancer patients', *Eur J Clin Nutr*, 63: 794-801.

Ellis, K. J. 2000. 'Human body composition: in vivo methods', *Physiol Rev*, 80: 649-80.

Engelen, M. P., A. M. Schols, W. C. Baken, G. J. Wesseling, and E. F. Wouters. 1994. 'Nutritional depletion in relation to respiratory and peripheral skeletal muscle function in out-patients with COPD', *Eur Respir J*, 7: 1793-7.

Jager-Wittenaar, H., P. U. Dijkstra, C. P. Earthman, W. P. Krijnen, J. A. Langendijk, B. F. van der Laan, J. Pruim, and J. L. Roodenburg. 2014. 'Validity of bioelectrical impedance analysis to assess fat-free mass in patients with head and neck cancer: an exploratory study', *Head Neck*, 36: 585-91.

Kyle, U. G., I. Bosaeus, A. D. De Lorenzo, P. Deurenberg, M. Elia, J. M. Gomez, B. L. Heitmann, L. Kent-Smith, J. C. Melchior, M. Pirlich, H. Scharfetter, A. M. Schols, C. Pichard, and Espen Working Group Composition of the. 2004. 'Bioelectrical impedance analysis--part I: review of principles and methods', *Clin Nutr*, 23: 1226-43.

Lerario, M. C., A. Sachs, M. Lazaretti-Castro, L. G. Saraiva, and J. R. Jardim. 2006. 'Body composition in patients with chronic obstructive pulmonary disease: which method to use in clinical practice?', *Br J Nutr*, 96: 86-92.

Schutz, Y., U. U. Kyle, and C. Pichard. 2002. 'Fat-free mass index and fat mass index percentiles in Caucasians aged 18-98 y', *Int J Obes Relat Metab Disord*, 26: 953-60.

Steiner, M. C., R. L. Barton, S. J. Singh, and M. D. Morgan. 2002. 'Bedside methods versus dual energy X-ray absorptiometry for body composition measurement in COPD', *Eur Respir J*, 19: 626-31.

Tisdale, M. J. 2010. 'Cancer cachexia', *Curr Opin Gastroenterol*, 26: 146-51.

Vestbo, J., S. S. Hurd, A. G. Agusti, P. W. Jones, C. Vogelmeier, A. Anzueto, P. J. Barnes, L. M. Fabbri, F. J. Martinez, M. Nishimura, R. A. Stockley, D. D. Sin, and R. Rodriguez-Roisin. 2013. 'Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary', *Am J Respir Crit Care Med*, 187: 347-65.

Wouters, E. F., and A. M. Schols. 1993. 'Prevalence and pathophysiology of nutritional depletion in chronic obstructive pulmonary disease', *Respir Med*, 87 Suppl B: 45-7.

www.cancer.gov.

Appendices

Tables of SPSS statistical analysis.

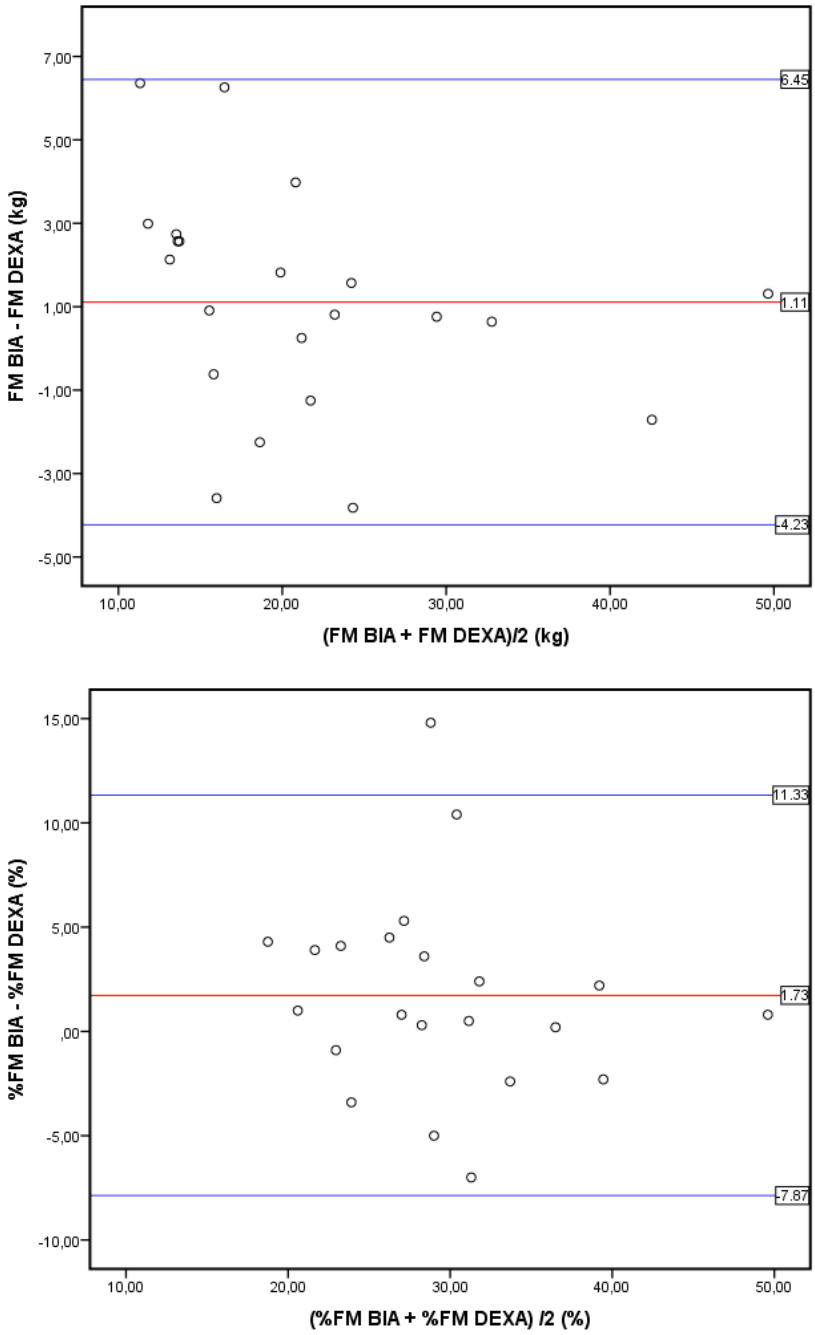
Table 3: Normality test by Kolmogorov-Smirnov. Fat Free mass (FFM), Fat mass (FM) and Fatmass percentage (%FM) sig (p<0.05).

Test of normality			
	Kolmogorov-Smirnov		
	Statistics	Df	Sig.
FFM DEXA	,137	22	,200*
FFM BIA	,119	22	,200*

Test of normality			
	Kolmogorov-Smirnov		
	Statistics	Df	Sig.
FM DEXA	,171	22	,092
FM BIA	,201	22	,021

Test of normality			
	Kolmogorov-Smirnov		
	Statistics	Df	Sig.
%FM DEXA	,147	22	,200*
%FM BIA	,103	22	,200*

Charts of SPSS statistical analysis.



<u>Fig 3:</u> Bland and Altman: Fat free mass (FFM) differences between Dual energy x-ray absorptiometry (DEXA) and Bioelectrical impedance analysis (BIA) compared with the average of these measurements ((BIA+DEXA)/2) in 22 patients with lung cancer or COPD. (FM mean difference: 1.11kg (6.45kg and -4.23kg) %FM mean difference +1.73% (11.33% and -7.87%)).

Auteursrechtelijke overeenkomst

Ik/wij verlenen het wereldwijde auteursrecht voor de ingediende eindverhandeling:
The validity of Bioelectrical Impedance Analysis for estimating fat free mass in patients with lungcancer and COPD

Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
Jaar: **2017**

in alle mogelijke mediaformaten, - bestaande en in de toekomst te ontwikkelen - , aan de Universiteit Hasselt.

Niet tegenstaand deze toekenning van het auteursrecht aan de Universiteit Hasselt behoud ik als auteur het recht om de eindverhandeling, - in zijn geheel of gedeeltelijk -, vrij te reproduceren, (her)publiceren of distribueren zonder de toelating te moeten verkrijgen van de Universiteit Hasselt.

Ik bevestig dat de eindverhandeling mijn origineel werk is, en dat ik het recht heb om de rechten te verlenen die in deze overeenkomst worden beschreven. Ik verklaar tevens dat de eindverhandeling, naar mijn weten, het auteursrecht van anderen niet overtreedt.

Ik verklaar tevens dat ik voor het materiaal in de eindverhandeling dat beschermd wordt door het auteursrecht, de nodige toelatingen heb verkregen zodat ik deze ook aan de Universiteit Hasselt kan overdragen en dat dit duidelijk in de tekst en inhoud van de eindverhandeling werd genotificeerd.

Universiteit Hasselt zal mij als auteur(s) van de eindverhandeling identificeren en zal geen wijzigingen aanbrengen aan de eindverhandeling, uitgezonderd deze toegelaten door deze overeenkomst.

Voor akkoord,

Cuijpers, Femke **Schroyen, Bo**