Nutrition 30 (2014) 1000–1006

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Body composition following stem cell transplant: Comparison of bioimpedance and air-displacement plethysmography

Yun-Chi Hung BHlth.Sci. [a,*], Judith D. Bauer Ph.D. [a,b], Pamela Horsely Grad.Dip.Dietetics. [c], Leigh C. Ward Ph.D. [d], John Bashford R.A.C.P. [e], Elisabeth A. Isenring Ph.D. [a,f]

[a] *Centre for Dietetics Research, School of Human Movement Studies, The University of Queensland, Brisbane, Queensland, Australia*
[b] *The Wesley Research Institute, Brisbane, Queensland, Australia*
[c] *Nutrition Services Department, The Wesley Hospital, Brisbane, Queensland, Australia*
[d] *School of Chemistry and Molecular Biosciences, The University of Queensland, St Lucia, Queensland, Australia*
[e] *Haematology & Oncology Clinics of Australia, The Wesley Medical Centre, Brisbane, Queensland, Australia*
[f] *Department of Nutrition & Dietetics, Princess Alexandra Hospital, Brisbane, Queensland, Australia*

ARTICLE INFO

Article history:
Received 8 August 2013
Accepted 29 January 2014

Keywords:
Body composition
Stem cell transplantation
Cancer
Air-displacement plethysmography
Bioelectrical impedance
Spectroscopy

ABSTRACT

Objective: The aim of this study was to assess the agreement between detected changes in body composition determined by bioimpedance spectroscopy (BIS) and air-displacement plethysmography (ADP) among patients with cancer undergoing peripheral blood stem cell transplantation (PBSCT); and to assess the agreement of absolute values of BIS with ADP and dual energy x-ray (DXA).

Methods: Forty-four adult hematologic cancer patients undergoing PBSCT completed both BIS and ADP assessment at preadmission and at 3 mo after transplantation. A subsample (n = 11) was assessed by DXA at 3 mo after transplantation. Results were examined for the BIS instrument's default setting and three alternative predictive equations from the literature. Agreement was assessed by the Bland-Altman limits of agreement analysis while correlation was examined using the Lin's concordance correlation.

Results: Changes in body composition parameters assessed by BIS were comparable with those determined by ADP regardless of the predictive equations used. Bias of change in fat-free mass was clinically acceptable (all <1 kg), although limits of agreement were wide (more than ±6 kg). Overall, the BIS predictive equation accounting for body mass index performed the best. Absolute body composition parameters predicted by the alternative predictive equations agreed with DXA and ADP better than the BIS instrument's default setting.

Conclusion: Changes predicted by BIS were similar to those determined by ADP on a group level; however, agreement of predicted changes at an individual level should be interpreted with caution due to wide limits of agreement.

Introduction

Unintentional weight loss and a decline in nutritional status frequently are reported in patients with cancer due to a combination of treatment side effects or the disease itself. Change in the proportion of fat mass (FM) and fat-free mass (FFM) can vary depending on the type and stage of disease. Impaired FFM needs to be identified as unfavorable body composition changes are associated with adverse clinical outcomes such as mortality [1], reduced functioning, and poorer quality of life [2]. In a previous study [3], reduced nutritional status was accompanied by a concurrent loss of lean body mass, and reduced quality of life

The Wesley Research Institute funded this study. Y-CH contributed to the conception and design of the study; generation, collection, assembly, analysis, and interpretation of data; and drafting of the manuscript. JDB and EI contributed to the conception and design of the study and revision of the manuscript. PH contributed to the conception and design of the study. LW contributed to the analysis of the data and revision of the manuscript. JB contributed to the conception and design of the study. All authors approved the final version of the article. LW is a consultant for ImpediMed Ltd., a manufacturer of impedance devices. ImpediMed Ltd had no involvement in the design, execution of this study, or the preparation of this manuscript. Other authors have no conflicts of interest to report.

* Corresponding author: Tel.: +61 7 3365 6313; fax: +61 7 3365 6877.
E-mail address: yui.hung@uqconnect.edu.au (Y.-C. Hung).

0899-9007/$ - see front matter © 2014 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.nut.2014.01.017

after a group of cancer patients underwent peripheral blood stem cell transplantation (PBSCT).

Bioimpedance technology such as bioimpedance spectroscopy (BIS) is a portable, computerized technology for body composition assessment that is non-invasive and easy to operate. It is also relatively inexpensive. This technology provides accurate results in healthy subjects [4,5] but a limited number of studies have examined its validity in the cancer population and the interchangeability of BIS with other laboratory measures. How portable devices such as BIS compare with laboratory methods such as dual-energy x-ray absorptiometry (DXA), and air-displacement plethysmography (ADP) is of interest because compliance to routine assessments requiring complex procedures or low convenience (i.e., need to travel) can be challenging for critically ill patients.

In this study, the body composition of adults with cancer treated with PBSCT was examined. The aims of this study were to compare the agreement of absolute values estimated by BIS relative to ADP and DXA; and changes in body composition detected by BIS relative to ADP at 3 mo post-PBSCT.

Methods

Participants were hematologic cancer patients treated with PBSCT at a single transplant center, the Haematology and Oncology Clinics of Australia, The Wesley Hospital, Brisbane, Australia. Sixty-five patients were scheduled to complete ADP and BIS assessment up to 2 wk before PBSCT (preadmission), and at 3 mo post-PBSCT; 44 patients completed assessments at both time points; 11 of the 44 completed a one-off DXA scan. Ethical approval was granted by the Multidisciplinary Ethics Committee of the hospital (Ref no. 1107 and Ref no. 1017) and Medical Research Ethics Committee of The University of Queensland (HMS10/0306.r1 and HMS11/2405.R1).

All participants wore a tight-fitting, one-piece Lycra suit and a Lycra cap provided by the lab. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, and weight was measured to the nearest 0.1 kg (TBF-300 A, Tanita Inc, Tokyo, Japan). BIS, followed by ADP measurements were completed within a 15-min period.

Bioimpedance spectroscopy

Participants were assessed with whole-body BIS (ImpSFB7, Impedimed, Brisbane, Australia). The theories and principles of bioimpedance techniques have been detailed previously [6]. In short, body composition is derived from impedance that measures the decrease in voltage of an applied electric current due to resistance in the human body (i.e., non-conductive tissues such as fat). For each assessment, this BIS device obtains impedance data across a spectrum of 256 frequencies between 3 and 1000 kHz. Prediction of body composition was performed by fitting the impedance data to the Cole-Cole model to determine resistance at zero and infinite frequencies using manufacturer's software. These resistance values were then applied to Hanai mixture theory equations to predict total body water, FFM, and FM [6,7]. Hanai mixture theory equations require the input of values for resistivities of intra- and extracellular water, a body proportion correction factor (Kb), body density (Db) and lean tissue hydration fraction to predict body FFM from the predicted total body weight [8]. Body composition estimates from BIS data are therefore dependent on the values chosen for these parameters. For SFB7, the coefficient of variation for repeated measures has been determined as <0.5% [9]. Estimates of body composition were predicted using the instrument's default parameters (Bioimp, software version 5.3.1.1), alternative equations used by De Lorenzo et al. [7] and Matthies [10], Moissl et al. [11] and equation produced by the authors in an independent study [12]. The electrode configuration for whole-body assessment has been described previously [6].

Air-displacement plethysmography

ADP was conducted using a BOD POD unit (COSMED, Concord, CA, USA). ADP is considered an alternative to underwater weighing. It is based on the two-compartment model that separates the body into two distinct chemical components composed of FFM and FM [13]. The principles of ADP have been detailed elsewhere [14]. FFM and FM can be derived from volume, density, and weight using the equation for the general population [15]. Predictive thoracic gas volume inbuilt in the BOD POD software was used.

The system is composed of a fibreglass chamber that measures body volume and an external electronic scale that measures weight. The chamber volume is calibrated daily, whereas the scale is calibrated fortnightly; calibration is performed using the manufacturer-provided calibration cylinder (50.099 L) and calibration weights (20 kg), respectively. Two to three repeated measurements were conducted for each participant as instructed by the computer. Participants remained still for each measurement, which lasted <1 min.

Dual energy x-ray absorptiometry

Body composition was assessed with whole-body DXA scan (Hologic, QDR 4500 A fan-beam scanner, Bedford, MA, USA) and adult software version 13.3. Daily calibration was performed with phantom spine, and steps provided by the manufacturer. The theories and principles of DXA have been detailed previously [16]. In summary, body composition is determined through the measurement of mass attenuation coefficients, the ratio values, image processing, and soft tissue distribution models [17].

Participants wore light clothing; all metal objects were removed (i.e., jewelry, glasses, zippers). Participants were instructed to remain still for up to 7 min during the scan.

Statistical analyses

Statistical analysis was performed using SPSS version 20.0.0 (IBM SPSS statistics, Chicago, IL, USA). Normality was tested with Shapiro-Wilk's test. Descriptive statistics were calculated for baseline characteristics (age and body mass index [BMI]), and body composition parameters at different time points. Paired *t* test was used to assess the mean differences between body composition parameters measured by BIS relative to ADP or DXA. Bland-Altman approach was used to assess the agreement between ADP and BIS; limits of agreement (LOA) were calculated as ±2 SD of bias [18]. Correlation between results of the methods was assessed with Lin's concordance correlation [19]. Statistical significance was reported at the conventional $P < 0.05$ level (two-tailed). A clinically acceptable difference for FFM between the methods was defined a priori as ≤1 kg [20].

Results

Sixty-five participants were included in this study; 44 patients (52.3% men) who completed both baseline and follow-up assessment at 3 mo post-PBSCT were analyzed.

Non-completion of assessments was mainly due to inconvenience of traveling to the hospital in the desired time frame.

Median age was 56.5 y (range 22–75 y), and median BMI was 28 kg/m^2 (range 16.4–47.6 kg/m^2); 36.4% of the participants were overweight (BMI 25 to <30 kg/m^2), 31.8% were of normal weight (BMI 18.5 to <25 kg/m^2), 29.5% were obese (BMI >30 kg/m^2), and 2.3% were underweight (BMI <18.5 kg/m^2) [21]. Results of ADP showed FFM (kg) was higher among men ($P < 0.001$). In the subgroup of participants (n = 11) who underwent DXA examination, both FFM and FM predicted by DXA relative to ADP was not significantly different ($FFM_{DXA-ADP} = -0.91$ kg ± LOA 4.2, $P = 0.186$; $FM_{ADP-DXA}$ 1.39 kg ± LOA 4.2, $P = 0.055$). Mean weight loss among obese patients (−7.1 ± 4.9 kg) was significantly higher than normal or underweight participants (−2.9 ± 3.4 kg; $P = 0.032$) but similar to those who were overweight (−4.3 ± 4.3 kg; $P = 0.235$); there was no difference in weight loss between men and women ($P = 0.275$), and the younger or older group (age ≤60 and >60 y; $P = 0.272$).

Different BIS prediction methods produced different absolute values for FFM and FM (Table 1). Results obtained using the alternative BIS predictive equations were generally in agreement, e.g., predicted FFM at baseline varied by only 3.2%, whereas the default instrument predictions were in poorer agreement with ADP values and those obtained using the alternative BIS predictive equations. Notably, however, the changes in body composition from baseline to post-PBSCT measured by BIS were similar regardless of the prediction method used. This is explored further later in the article.