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

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running title: Stem cell transplant and impedance

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Contribution of Authors

Yun-Chi Hung contributed to the conception and design of the study; generation, collection, assembly, analysis and interpretation of data; drafting of the manuscript; and approval of the final version of the manuscript. Judith Bauer contributed to the conception and design of the study; revision of the manuscript; and the approval of the final version of the manuscript. Pamela Horsley contributed to the conception and design of the study; and the approval of the final version of the manuscript. Leigh Ward contributed to the analysis of the data; revision of the manuscript; and the approval of the final version of the manuscript. John Bashford contributed to the conception and design of the study; and the approval of the final version of the manuscript. Elisabeth Isenring contributed to the conception and design of the study; revision of the manuscript; and the approval of the final version of the manuscript.

Conflicts of Interest

Author Ward consults to 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.
Abstract

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

Methods: Forty-four adult haematological cancer patients undergoing PBSCT completed both BIS and ADP assessment at pre-admission and at three months post-transplantation. Body composition was assessed using BIS (ImpSFB7, Impedimed, Brisbane, Australia) and ADP (BOD POD, COSMED, Concord, CA, USA). A subsample (n=11) were assessed by DXA (Hologic, QDR 4500A fan-beam scanner, MA, USA) at post-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 to 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 (> ±6kg). 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 at a group level, however, changes at an individual level should be interpreted with caution due to wide limits of agreement.

Key Words: Body composition, stem cell transplantation, cancer, air-displacement plethysmography, bioelectrical Impedance, spectroscopy
Introduction

Unintentional weight loss and a decline in nutritional status are frequently reported amongst cancer patients 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 be variable depending on the type and stage of disease. Impaired FFM needs to be identified because unfavourable 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 conducted by the authors [3], reduced nutritional status was accompanied by a concurrent loss of LBM, and reduced quality of life after a group of cancer patients underwent 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 and relatively inexpensive. This technology provides accurate results amongst healthy subjects [4, 5] but a limited number of studies have examined its validity amongst the cancer population and the inter-changeability 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 amongst critically-ill patients.

In this study, the body composition of adult cancer patients treated with peripheral blood stem cell transplantation (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 three months post-PBSCT.

Methods
Stem cell transplant and impedance

Subjects were haematological cancer patients treated with PBSCT at a single transplant centre, the Haematology and Oncology Clinics of Australia, The Wesley Hospital, Brisbane, Australia. Sixty-five subjects were scheduled to complete ADP and BIS assessment up to two weeks before PBSCT (pre-admission), and at three months post-PBSCT; 44 subjects completed assessments at both time points; 11 out of the 44 subjects completed a once-off DXA scan. Ethical approval was granted by the Multidisciplinary Ethics Committee of the hospital (Ref: 1107, and Ref: 1017) and Medical Research Ethics Committee of The University of Queensland (HMS10/0306.r1 and HMS11/2405).

All subjects 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-300A, Tanita Inc, Tokyo, Japan). BIS, followed by ADP measurements were completed within a 15-minute 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 which 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 to 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
Stem cell transplant and impedance

resistivities of intra- and extracellular water, a body proportion correction factor (Kb), body density (Db) and lean tissue hydration fraction to predict body fat-free mass from the predicted TBW [8]. Body composition estimates from BIS data are therefore dependent upon 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 default parameters provided with the instrument, those of: de Lorenzo et al. [7] and Matthie et al. [10]; Moissl et al. [11]; and 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 as an alternative to underwater weighing; it is based on the two compartment model which 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 by Siri [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, while 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 less than a minute.
Stem cell transplant and impedance

Dual energy X-ray (DXA) absorptiometry

Body composition was assessed with whole-body DXA scan (Hologic, QDR 4500A fan-beam scanner, 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. Body composition was calculated by algorithms provided by the manufacturer (Bioimp, software version 5.3.1.1) [17].

Participants wore light clothing; all metal objects were removed (i.e. jewellery, glasses, zips). Participants were instructed to remain still for up to 7 minutes 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 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 ± two standard deviations 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 subjects were included in this study; 44 subjects (52.3% male) who completed both baseline and follow-up assessment at three-month post-transplantation were analysed.

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

Median age was 56.5 years-old (range 22-75 y), and median BMI was 28.0 kg/m$^2$ (range 16.4–47.6 kg/m$^2$); 36.4% of the subjects 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% was underweight (BMI <18.5 kg/m$^2$)[21]. Results of ADP showed FFM (kg) was higher amongst males ($p < 0.001$). In the sub-group of participants (n=11/44) who underwent DXA examination, both FFM and FM predicted by DXA relative to ADP was not significantly different ($\text{FFM}_{\text{DXA-ADP}} = -0.91\text{kg} \pm \text{LOA 4.2, } p = 0.186$; $\text{FM}_{\text{ADP-DXA}} 1.39\text{kg} \pm \text{LOA 4.2, } p = 0.055$).

Mean weight loss amongst obese subjects (-7.1 ± 4.9 kg) was significantly higher than normal or underweight subjects (-2.9 ± 3.4 kg) ($p = 0.032$) but similar to overweight subjects (-4.3 ± 4.3 kg) ($p = 0.235$); there was no difference in weight loss between males and females ($p = 0.275$), and 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 irrespective of the prediction method used. This is explored further below.
Agreement of absolute values

Since the alternative predictive equations performed similarly, results in Table 2 are shown for default instrument and Moissl et al. [11] methods only.

Although the results predicted by Ward et al. [12] (i.e. difference FFM -2.2 kg (CI95% -3.6, -0.8), p = 0.003) and Moissl et al. [11] (i.e. difference FFM -1.2 kg, CI 95% -2.3, -0.2, p = 0.021) at baseline, and Ward et al. [12] prediction at post-transplant (i.e. difference FFM -1.4 kg, CI 95% -2.8, 0.0, p = 0.045) were significantly different to ADP, the agreement relative to ADP were better compared to the instrument’s default setting. Results predicted by De Lorenzo et al. [7] method were not significantly different relative to ADP at both time points.

Results predicted by the BIS alternative predictive equations agreed well (all p > 0.05) with DXA, whereas results predicted by the default setting was significantly different (all p ≤ 0.001).

Limits of agreement were wide for all comparisons (i.e. LOA ± 7 to LOA ±11 kg for both FFM and FM).

Agreement of detected changes (Δ) before and after transplantation

Predicted ΔFFM and ΔFM (Table 2) by ADP and all BIS methods were similar but limits of agreement were wide. The method by Moissl et al. [11] performed the best (mean bias ΔFFM = 0.29 kg, LOA ± 6.4 kg, p = 0.547), followed by Ward et al. [12] (mean bias ΔFFM = 0.75 kg LOA ± 6.6 kg, p = 0.138), De Lorenzo et al. [7] (mean bias ΔFFM = 0.91 kg, LOA ± 8.4 kg, p = 0.160), and lastly the default setting (mean bias ΔFFM = 0.92 kg, LOA ± 7.2 kg, p = 0.101).
Stem cell transplant and impedance

Correlation

The strength of correlation between results measured by BIS and ADP was based on the criteria proposed by McBride et al. [22]. Absolute FFM, and FM measured by the default setting correlated poorly (all strength < 0.90) with ADP; in contrast, absolute FFM and FM measured by the alternative BIS predictive equations correlated moderately (strength 0.90-0.95) to substantially (strength 0.95-0.99), but poorly for percentage FM (strength <0.90).

Correlations for ΔFFM, ΔFM, and Δ%FM were poorer for all methods (strength 0.16-0.61).

Bland-Altman plots

Bland-Altman plots of absolute value at pre-admission and three months post-transplantation were similar. For ease of presentation, only the plots for pre-admission comparison are presented for the BIS default setting and Moissl et al. [11] method. Figure 1a shows the default setting overestimated FFM relative to ADP and bias increases as FFM increases. Figure 1b shows the Moissl et al. [11] method overestimated FFM slightly but the trend of increase or decrease in bias towards extreme ends of FFM is less pronounced.

Similar trends were observed for FM (plots not shown). Figure 2a and Figure 2b are Bland-Altman plots showing ΔFFM detected by the default setting and Moissl et al. [11] method compared to ADP. Regardless of the direction of change, disagreement between the default setting and ADP tended to increase as the magnitude of change increased. Mean bias was slightly improved when results were re-analysed with the Moissl et al. [11] method but a similar trend of increase in bias was observed for increased changes in FFM. Bland-Altman plots showed similar systematic variation for the bias ΔFM for both methods (plots not shown).
This study is the first to examine the agreement of body composition methods amongst cancer patients treated with PBSCT. This study found a portable device such as BIS was sensitive enough to detect changes in body composition comparable to that assessed by ADP amongst cancer patients who experienced moderate weight loss at three months after PBSCT. Agreement at a group level (mean bias) for detected changes in FFM was clinically acceptable (<1 kg) although limits of agreement were wide as observed in other studies [23-27].

Relative to ADP and DXA, the agreement of absolute values predicted by the default setting was poor. Similar findings were reported in other cancer studies that examined cross-sectional results [28, 29].

No cancer studies which examined the agreement between predicted changes in longitudinal studies could be identified in the literature. However, studies on overweight or obese subjects (without cancer) demonstrated that portable methods such as bioimpedance devices can accurately measure changes in the body composition parameters after weight loss regardless of large discrepancies between cross-sectional results [24-27, 30, 31].

Absolute results of FFM tend to be overestimated by the BIS default setting which was similar to studies examining healthy subjects [32, 33], overweight or obese subjects, [24, 31, 34] and subjects with clinical conditions [23, 28]. When BIS results were re-analysed with the methods by De Lorenzo et al. [7], Ward et al. [12], and Moissl et al. [11], the agreements
of absolute results relative to ADP improved substantially. Bland-Altman plots showed the systematic variation in the bias of FFM relative to ADP observed for the BIS default setting (Figure 1a) was reduced when BIS results were re-analysed using the method by Mossil et al. [11] (Figure 1b). A similar effect was observed for FM (plots not shown).

For the agreement in ΔFFM (Figures 2a and 2b) however, the method of Moissl et al. [11] did not reduce the systematic variation in the bias of ΔFFM observed in the BIS default setting. Changes in body hydration or altered composition of FFM may explain the increase in discrepancy as weight loss or weight gain increases [35]. The BIS method, unlike empirically-derived prediction equations, predicts body water volumes based on fundamental equations incorporating the resistivity of body fluids (ECW and ICW) [7, 8]. However, transformation of TBW to FFM assumes a hydration fraction and is therefore prone to error when hydration state changes. At the time of study, the participants were nutritionally stable and unlikely to be dehydrated. Other variables (i.e. disproportion loss of FFM or FM) specific to our population may be present.

The limits of agreement for ΔFFM or ΔFM in this study were 2 to 4 kg wider than some reported in the literature [24, 25, 27]. These differences may be due to sample characteristics as subjects in these studies were younger, healthy participants undergoing intentional weight loss program; three of these studies were composed of females only while one analysed by gender separately. For each of the BIS methods, we examined bias and limits of agreement separately by gender, age group (≥ 60 y and < 60 y) and BMI
Stem cell transplant and impedance categories. Results were not significantly different for the Moissl et al. [11] method, however, results predicted by the default setting, Ward et al. [12] and De Lorenzo et al. [7] became significantly different to ADP for female subjects (p<0.05), and younger subjects ≤60 years old (p<0.05). Results showed Moissl et al. [11] method is more suitable for the assessment of samples with mixed characteristics (i.e. gender, age, and BMI) than the other BIS methods in this study. Owing to wide limits of agreement, ADP and BIS are not interchangeable; routine assessments on the same individual should be conducted with the same method consistently.

There is currently no population-specific resistivity coefficient or recommendation on the type of BIS equation suitable for the assessment of body composition of patients treated with PBSCT. Results of this study showed the default setting is not optimal for assessing the PBSCT population since alternative predictive equations produced better agreement with the reference method. Absolute (i.e. cross-sectional) results should be interpreted with caution as results vary greatly with the choice of predictive equations and the characteristics of the subjects being assessed [36]. Notably, for example in the present study, BIS prediction, when analysed using the method of Moissl et al. [11] performed significantly better than when the BIS default settings were used. The Moissl et al. [11] approach specifically takes account of the variation of impedance-based predictions of body composition with BMI; our population was skewed toward subjects who were either overweight (36.4%) or obese (29.5%).
Stem cell transplant and impedance

There are no similar studies amongst the cancer population; most studies compared cross-sectional results only. This study has highlighted that the accuracy of BIS for prediction of absolute body composition is dependent upon the choice of appropriate values for coefficients in the predictive equations; the default settings of BIS cannot be relied upon. It should be noted, however, that these settings may be changed by the user. Considering changes in body composition parameters have more clinical meaning than results collected at a single time point, it would be of great interest for future studies to compare more thoroughly the validity of detected changes in body composition rather than the agreement of cross-sectional results alone. Different predictive equations should be explored. In this regard, all BIS methods were observed in the present study to predict similarly change in body composition both in direction and magnitude; these predictions were also similar to those determined by ADP. Further studies are needed to confirm the sensitivity of BIS in tracking body composition changes relative to other laboratory methods, as well as amongst other clinical populations with varying degrees of weight loss.

Strengths and limitations

This study provides new information as it is the first to examine the agreement of body composition methods amongst PBSCT patients. Our study had a moderate sample size considering studies examining detected body composition changes had sample sizes of less than 60 [25-27, 30, 31]; these studies included healthy overweight subjects participating in weight loss programs whereas our subjects were cancer patients; it is more challenging to obtain large sample in prospective studies particularly amongst the cancer populations.
A limitation of this study was that DXA could only be performed at one time point amongst a small number of participants because the instrument was located at a different site; the distance of travel had an effect on compliance. The 32% (n=21/65) of patients who were not included in this study due to incomplete body composition data may bias the results if they had different degree of FFM and FM change compared to patients included in this study.

Conclusion

Amongst patients treated with PBSCT, the BIS approach to prediction of FFM and FM, particularly the Moissl method [11], was highly correlated with body composition determined by ADP although the bias and limits of agreement were large for the SFB7 default method. The Moissl method [11] was in closer agreement with ADP but the relatively large limits of agreement may preclude its use in individuals. With respect to changes in FFM and FM, changes predicted by BIS were similar to those determined by ADP at a group level, however, agreement at an individual level should again be interpreted with caution due to wide limits of agreement.

Conflict of interest

Author Ward has consulted to 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 declare no conflict of interest.
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Table 1 Body composition parameters (mean ±SD) measured at pre-admission and at three months after peripheral blood stem cell transplantation N=44.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-admission</th>
<th>Post-PBSCT</th>
<th>Detected change</th>
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<tr>
<td>Weight (kg)</td>
<td>81.5 ± 19.7</td>
<td>76.8 ± 18.1</td>
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<td>FFM (kg)\text{ADP}</td>
<td>49.4 ± 10.9</td>
<td>48.4 ± 10.9</td>
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<td>FFM (kg)\text{BIS}</td>
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<td>FFM (kg)\text{BIS}</td>
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<td>FM (kg)\text{BIS}</td>
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Stem cell transplant and impedance

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<th>Parameter</th>
<th>Unit</th>
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<tr>
<td>FM (kg)</td>
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<td>%FM</td>
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1. De Lorenzo et al. [7]
2. Ward et al. [9]
4. N=11
5. p < 0.05, difference compared to ADP, paired t-test
6. p < 0.001, difference compared to ADP, paired t-test

Abbreviations: ADP, air displacement plethysmography; BIS, bioimpedance spectroscopy; DXA, dual-energy X-ray absorptiometry; FFM, fat free mass; FM, fat free mass, NM, not measured; PBSCT, peripheral blood stem cell transplantation.
Stem cell transplant and impedance

Table 2 Mean bias (95%CI) and limits of agreement for fat free mass (kg), fat mass (kg), and percentage (%) fat mass, at pre-admission, and at three months after peripheral blood stem cell transplantation as measured by bioimpedance spectroscopy relative to air-displacement plethysmography, and dual-energy X-ray absorptiometry N=44.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Bias (95%CI)</th>
<th>Limits of Agreement</th>
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<td>FFM (kg) (_{ADP-BIS})</td>
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<td>FM (kg) (_{ADP-BIS})</td>
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<td>± 9.8</td>
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</tr>
<tr>
<td>FM (%) (_{ADP-BIS})</td>
<td>7.3 (5.7, 8.8)</td>
<td>± 10.2</td>
<td>0.63</td>
</tr>
<tr>
<td>FFM (kg) (_{ADP-BIS})</td>
<td>-1.2 (-2.3, -0.2)</td>
<td>± 6.8</td>
<td>0.95</td>
</tr>
<tr>
<td>FM (kg) (_{ADP-BIS})</td>
<td>1.2 (0.2, 2.3)</td>
<td>± 6.8</td>
<td>0.97</td>
</tr>
<tr>
<td>FM (%) (_{ADP-BIS})</td>
<td>1.2 (0.0, 2.4)</td>
<td>± 7.9</td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Post-transplantation</strong></td>
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<td></td>
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<tr>
<td>FFM (kg) (_{ADP-BIS})</td>
<td>-5.6 (-7.0, -4.2)</td>
<td>± 9.1</td>
<td>0.84</td>
</tr>
<tr>
<td>FM (kg) (_{ADP-BIS})</td>
<td>5.7 (4.3, 7.1)</td>
<td>± 9.2</td>
<td>0.82</td>
</tr>
<tr>
<td>FM (%) (_{ADP-BIS})</td>
<td>6.9 (5.4, 8.4)</td>
<td>± 10.0</td>
<td>0.65</td>
</tr>
<tr>
<td>FFM (kg) (_{ADP-BIS})</td>
<td>-0.9 (-2.1, 0.2)</td>
<td>± 7.3</td>
<td>0.95</td>
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<tr>
<td>FM (kg) (_{ADP-BIS})</td>
<td>1.0 (-0.1, 2.1)</td>
<td>± 7.5</td>
<td>0.95</td>
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<tr>
<td>FM (%) (_{ADP-BIS})</td>
<td>1.1 (-0.4, 2.5)</td>
<td>± 9.6</td>
<td>0.87</td>
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<tr>
<td>FFM (kg) (_{DXA-BIS})</td>
<td>-5.9 (-8.7, -3.0)</td>
<td>± 8.4</td>
<td>0.81</td>
</tr>
<tr>
<td>FM (kg) (_{DXA-BIS})</td>
<td>5.1 (2.4, 7.8)</td>
<td>± 8.0</td>
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<tr>
<td>FM (%) (_{DXA-BIS})</td>
<td>6.3 (3.1, 9.5)</td>
<td>± 9.5</td>
<td>0.33</td>
</tr>
<tr>
<td>FFM (kg) (_{DXA-BIS})</td>
<td>-1.5 (-3.2, 0.1)</td>
<td>± 4.9</td>
<td>0.96</td>
</tr>
<tr>
<td>FM (kg) (_{DXA-BIS})</td>
<td>0.7 (-0.7, 2.2)</td>
<td>± 4.3</td>
<td>0.96</td>
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</table>
Stem cell transplant and impedance

<table>
<thead>
<tr>
<th></th>
<th>FM (%)_{DXA - BIS}</th>
<th>0.9 (-1.3, 3.1)</th>
<th>± 6.7</th>
<th>0.79</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Detected changes</th>
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</thead>
<tbody>
<tr>
<td>ΔFFM (kg)_{ADP - BIS}</td>
<td>0.92 (-0.19, 2.02)</td>
<td>± 7.2</td>
<td>0.45</td>
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<tr>
<td>ΔFM (kg)_{ADP - BIS} SFB7 default</td>
<td>-0.76 (-1.87, 0.35)</td>
<td>± 7.3</td>
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<tr>
<td>ΔFM (%)_{ADP - BIS}</td>
<td>0.40 (-1.68, 0.87)</td>
<td>± 8.4</td>
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<tr>
<td>ΔFFM (kg)_{ADP - BIS}</td>
<td>0.29 (-0.68, 1.27)</td>
<td>± 6.4</td>
<td>0.50</td>
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<tr>
<td>ΔFM (kg)_{ADP - BIS} Moissl et al.¹</td>
<td>-0.22 (-0.68, 1.27)</td>
<td>± 6.3</td>
<td>0.61</td>
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<tr>
<td>ΔFM (%)_{ADP - BIS}</td>
<td>-0.16 (-1.32, 0.99)</td>
<td>± 7.6</td>
<td>0.37</td>
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</tr>
</tbody>
</table>

¹Moissl et al. [11]
²n = 11
³p < 0.05, difference between methods, paired t-test
⁴p < 0.001, difference between methods, paired t-test
⁵Lin’s concordance correlation coefficient

Abbreviations: ADP, air displacement plethysmography; BIS, bioimpedance spectroscopy; DXA, dual-energy X-ray absorptiometry; FFM, fat-free mass; FM, fat-free mass; Δ, change between baseline and post-transplantation.
Figure 1. Bland-Altman plot of absolute fat free mass in kg (FFM) at pre-admission as predicted by (a) bioimpedance spectroscopy default setting (BIS default), and (b) Moissl et al. method, relative to air displacement plethysmography (ADP). Mean bias (solid line) and ±2SD (dashed lines).

Figure 2. Bland-Altman plot of change in fat free mass in kg (ΔFFM) between pre-admission and three months after stem cell transplantation as predicted by (a) bioimpedance spectroscopy default setting (BIS default), and (b) by Moissl et al. method, relative to air displacement plethysmography (ADP). Mean bias (solid line) and ±2SD (dashed lines).
\[
\Delta \text{FFM ADP} - \Delta \text{FFM Moissl} = \frac{\Delta \text{FFM ADP} + \Delta \text{FFM Moissl}}{2}
\]

- Female
- Male