European Journal of Clinical Nutrition
https://doi.org/10.1038/s41430-018-0129-7

BRIEF COMMUNICATION

Longitudinal validity of abdominal adiposity assessment by regional bioelectrical impedance

José Ramón Alvero-Cruz[1] · Jerónimo C. García-Romero[1] · Margarita Carrillo de Albornoz-Gil[1] · Manuel Jiménez[2] · Lorena Correas-Gomez[1,3] · Piero Peñaloza[1] · Iván López-Fernández[3] · Elvis A. Carnero[3,4]

Received: 13 November 2017 / Revised: 24 January 2018 / Accepted: 4 February 2018

Abstract

The main goal of this study was to analyze the longitudinal agreement between changes in trunk and abdominal adiposity variables assessed by DXA and portable bioimpedance device (ViScan). A total of 44 women, enrolled in a 4-month exercise intervention, were included in this analysis. Trunk/abdominal compartments were assessed by ViScan and DXA. Adjusted correlations for age and FM at first assessment (pre) were utilized to perform concurrent validation among methods and completed with an agreement analysis. We observed significant differences between the changes detected by DXA and ViScan for %TFM (difference = −1.41%; $p < 0.05$), and proportional bias (Kendall's Tau = 0.53; $p < 0.0001$). Changes in abdominal adiposity were similar (difference = −0.1037 *z*-score units, $p = 0.53$), although there was proportional bias (Kendall's Tau = −0.24, $p < 0.022$). ViScan has a limited capability to evaluated changes in trunk and abdominal adiposity, at least for clinical purposes in adult women.

Introduction

Direct measurements of subcutaneous adipose tissue (SAT) and intraabdominal (IAT) have been limited to magnetic resonance imaging (MRI) or computed tomography (CT); additionally, dual X-ray absorptiometry (DXA) offer partial measurements of abdominal adipose compartments [1] and models to estimate the total IAT and SAT [2]. However, all the previous methods are not always suitable for bedside use or other field settings (for example, sport facilities) and alternative techniques such as bioelectrical impedance analysis (BIA) seem to be able to estimate SAT and IAT [3].

An automated BIA system has been developed to evaluate adiposity in the abdominal region [4]. ViScan device provides estimations of abdominal adipose tissue and VAT (designated as visceral fat level (VFL_{ViScan})) and it has been reported to have good correlations with MRI measurements [5, 6]. Nevertheless, validations with DXA and/or MRI evaluations in patients with obesity shown larger differences between methods [7] and its sensibility to assess changes must be a main concern. To our knowledge, there are not studies that analyze the ability of ViScan to track changes of abdominal adiposity (longitudinal validity), so it is not clear whether ViScan could be a useful tool to assess the changes in abdominal adipose tissue compartments after nutritional, lifestyle, and exercise interventions.

The main goal of this study was to analyze the longitudinal agreement between changes in trunk and abdominal adiposity variables assessed by DXA and ViScan in a subsample of healthy women enrolled in an exercise intervention.

Methods

A total of 44 healthy women were included in this analysis. They belonged to a larger sample size who were enrolled in a 4-month exercise training study. Additionally, we have

✉ Elvis A. Carnero
Elvis.carnero@flhosp.org

[1] Facultad de Medicina, Andalucía Tech. Escuela de Medicina del Deporte, Universidad de Málaga Campus de Teatinos, s/n, 29071 Málaga, Spain

[2] Departamento de Didactica de la Educacion Fisica y Salud, Universidad Internacional de La Rioja, Logrono, Spain

[3] Facultad de Ciencias de la Educación, Andalucía Tech. Laboratorio de Biodinámica y Composición Corporal, Universidad de Málaga, Campus de Teatinos, s/n, 29071 Málaga, Spain

[4] Translational Research Institute for Diabetes and Metabolism, Florida Hospital Sanford Burnham Prebys Medical Discovery Institute, 301 East Princeton Street, Orlando, FL 32804, USA

included only participants with two simultaneous DXA and ViScan assessments (mid-point and post).

Assessments were performed consecutively at the mid-point of the intervention (pre) and at the end (post). Participants were accepted to participate after informed consent was signed. All procedures were approved by the Ethics Committee of the Faculty of Medicine of the University of Málaga (ref: EMEFYDE 003-15).

Body composition assessments

A BIA assessment in the abdominal region was performed with a specific device (AB-140 ViScan, Tanita, Japan). Briefly, participants were lying down with their hands over the chest and a belt impedance (4-electrodes system) was placed over the skin (previously wet) of the abdominal region (height = 10 cm) to register the bioimpedance. The center of the impedance belt was aligned with the navel by a laser system localized inside the main unit of the device following the indications of the manufacturer; then, the data were collected by the main unit and transformed in trunk fat mass percent (%TFM = (total trunk mass/trunk fat mass) × 100)) and VFL_{ViScan}. Intra-day coefficients of variation in our laboratory following this protocol were 0.70% and 2.61% for %TFM and VFL, respectively.

A whole-body DXA scan was performed in each participant (Hologic Explorer; Hologic, USA) and fat mass (FM) and fat free mass (FFM) were obtained. In addition, a regional analysis of the trunk region was carried out as described elsewhere [8] and trunk FM (TFM, kg), %TFM, abdominal fat mass ($AbFM_{DXA}$), and $\%AbFM_{DXA}$ were obtained. Differences between pre and post were calculated (Δ).

Statistical analysis

Simple and adjusted (age and mid-point FM) correlations analyses were used to explore associations between DXA and ViScan variables, and concordance correlation coefficient (CCC) to perform concurrent validation between both methods for changes in body composition. Complementarily, an agreement analysis, one sample *T*-test, and Kendall's tau coefficient correlation were used to confirm the systematic and proportional bias. Δ abdominal adiposity variables were treated in *z*-score units.

Results

A total of 44 women (42.9 ± 8.6 years) were included in this analysis (Table 1). There were only significant differences between waist circumference (WC) measured by ViScan (mean differences = −2.18 ± 7.1, $p < 0.05$).

Regarding association analysis between DXA and ViScan Δ variables, both Δ $\%TFM_{ViScan}$ ($r = 0.47$, $p < 0.01$) and VFL_{ViScan} ($r = 0.36$, $p < 0.05$) were significantly correlated with ΔDXA. Adjusted correlations for age and mid-point %FM values did not modify correlation coefficients. The low CCC ($CCC_{\%TFM} = 0.465$ and $CCC_{visceral} = 0.307$) confirmed results from weak simple and adjusted correlation coefficients.

Table 1 Sample characteristics and body composition variables at mid-point evaluation and after an exercise training program period sample ($n = 44$)

	Pre	Post	
Variable	Mean ± SD	Mean ± SD	*p*
Age (years)	40.06 ± 8.7		
Weight (kg)	67.95 ± 12.6	67.25 ± 12.6	0.41
BMI (kg/m^2)	25.57 ± 4.74	25.46 ± 4.8	0.25
%FM (%)	37.02 ± 8.4	36.70 ± 9.9	0.87
FFM (kg)	42.79 ± 10.6	42.52 ± 12.5	0.91
WC_{ViScan} (cm)	93.04 ± 13.8	95.27 ± 13.1	0.048
$\%TFM_{DXA}$ (%)	31.93 ± 9.92	31.66 ± 9.8	0.24
$\%TFM_{Viscan}$ (%)	34.65 ± 10.5	35.50 ± 9.9	0.14
$\%AbFM_{DXA}$ (%)	34.01 ± 10.2	34.08 ± 10.3	0.85
VFR_{ViScan}	7.26 ± 3.49	7.78 ± 3.67	0.09

WC_{ViScan} waist circumference from ViScan, *post* indicate variables after 85 days of an exercise training program, *TFM* trunk fat mass, % $AbFM_{DXA}$ abdominal fat mass as measured by DXA, VFR_{ViScan} visceral fat ratio-ViScan

The agreement analysis of mid-point-evaluation data showed a significant difference between %TFM assessed by DXA and ViScan (mean difference = 2.69%; $p = 0.001$ from paired sample *t*-test; agreement limits %TFM = −4.64% to 9.86%), but not proportional bias ($\tau = 0.099$, $p = 0.3469$).

As observed for mid-point-evaluation analysis, there were significant differences between the changes detected by DXA and ViScan for %TFM (mean difference = −1.41%, $p = 0.0047$), and proportional bias was also confirmed (Kendall's Tau = 0.53, $p < 0.0001$; Fig. 1a).

Regarding to the changes in abdominal adiposity, VFL index and AbFM *Z*-score units were similar (mean difference = −0.1037, $p = 0.53$), nevertheless proportional bias was observed (Kendall's Tau = −0.24, $p < 0.022$; Fig. 1b).

Discussion

The main goal of this work was to analyze the validity of ViScan to assess changes in %TFM and the visceral adiposity marker (VFL) provided by ViScan device. Regarding %TFM our results indicated a significant but low CCC between Viscan and DXA changes, furthermore, there was a significant difference in changes evaluated with both equipments. Additionally, a deeper analysis showed that ViScan overestimates reductions and underestimates gains of %TFM, which indicated a proportional bias. These

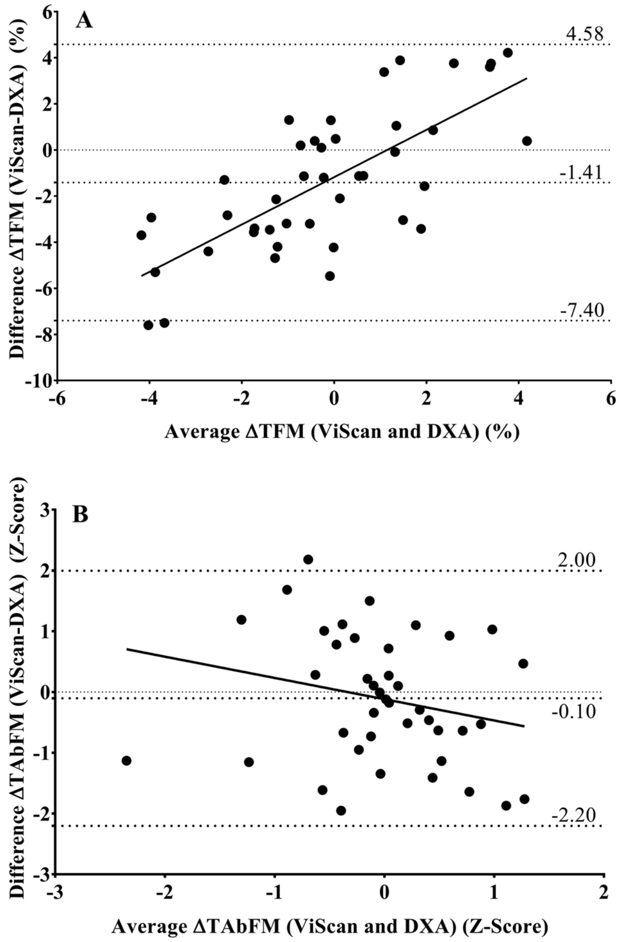

Fig. 1 Bland and Altman plot for the analysis of longitudinal agreement between assessment of changes in %TFM (**a**) or abdominal adiposity (**b**) performed with ViScan (regional abdominal bioelectrical impedance) and DXA (dual X-ray absorptiometry). Values in **b** are *Z* values (standard deviation units); VFR visceral adiposity index determined by ViScan, AbFM total abdominal fat mass by DXA

results may be influenced by the fact that ViScan sensor covers mainly the abdominal area, which is the region with the most percentage of FM and DXA provides the actual total TFM. *Z*-values for changes in abdominal adiposity were not significantly different between methodologies, which may suggest that when evaluation covers a similar area, results from both techniques should reflect a similar effect size of change. Nevertheless, ViScan may underestimate gains of AbFM (proportional bias).

These discrepancies may be related with limitations of the bioimpedance to differentiate changes of heterogeneous molecular compartments inside the abdominal cavity. So, a high interindividual variability must be dependent of abdomen dimensions and particular conductive properties, which has been confirmed in studies of people with obesity, where ViScan underestimate either total or TFM [9].

Our study is not exempt from limitations, we only included women in our analysis and it has been described that correlations between ViScan variables and CT are more variable in men [10].

In summary, the main contribution of this study was our analysis of longitudinal concurrent validation, which showed ViScan has a limited capability to evaluated changes in trunk and abdominal adiposity, at least in adult women. In the meantime, the precision of this bioimpedance device may be still useful in epidemiological research for cross-sectional studies.

Acknowledgements We thank participants for committing with all assessments and training program in good mood and collaborative way. We also appreciate the support of Irina Postrilla and Maria Ayuso for their help with the logistic at the gym. This study was supported by the University of Malaga (Campus of International Excellence Andalucıa Tech).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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