BIOIMPEDANCE AND DXA TOTAL BODY WATER ESTIMATIONS IN THE ELDERLY: A DEUTERIUM OXIDE COMPARISON

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ABSTRACT

Bioimpedance techniques have the ability to estimate total body water (TBW) and include single frequency bioimpedance (BIA), bioimpedance spectroscopy (BIS), and multiple-frequency bioimpedance (MFBIA). In addition, dual-energy X-ray absorptiometry (DXA) can predict TBW by using fat-free mass and a constant hydration status of 0.737%. However, the validity of the aforementioned methods has not been established in a healthy elderly population. PURPOSE: Compare BIA, BIS, MFBIA, and DXA TBW estimations in elderly men and women to a criterion deuterium oxide (D_2O) TBW measurement. METHODS: Thirty-four women and twenty-four men over the age of sixty-five participated in the study (71 +/- 5yr, 68.8 +/- 12.0kg, 167.0 +/- 8.5 cm). Subjects reported to the lab in a fasted state and provided a urine sample before ingesting approximately 11 grams of D_2O. Four hours later the subjects provided another urine sample for the calculation of TBW using a standard isotope dilution method. During the four hour equilibration period the subjects had TBW measured using BIA, MFBIA, BIS, and DXA in no particular order. RESULTS: For men, all methods produced similar and high r values (0.89-0.95) as well as low standard error of the estimate (SEE) values (1.26-1.52 L) with BIA producing the only non-significant mean difference (0.29 L, p=0.31). The MFBIA produced the largest mean difference between D_2O and over predicted TBW by 3.43 L. DXA and BIS also both significantly over predicted TBW with mean differences of 1.74 and 2.10 L respectively (p<0.001). For women, all methods produced nearly identical and high r values (0.90-0.91) as well as low standard error of the estimate (SEE) values (0.94-1.02 L). All methods significantly (p<0.001) over estimated TBW, but mean differences were low for DXA (0.92 L) and BIA (0.89 L) compared to BIS (2.37 L) and MFBIA (2.47 L). CONCLUSIONS: The added frequencies used in the MFBIA and the complex Cole models of the BIS did not increase the validity of TBW estimation in elderly men and women as the BIA outperform both devices and uses a single frequency of 50 kHz. However, all methods demonstrated high r values and low SEE values and have the potential to accurately estimate TBW in the current population. However, based on the current results the BIA method used in the current study resulted in the most valid estimations of TBW for elderly men and women compared to D_2O.

INTRODUCTION

Total body water has been measured by various techniques for more than 40 years. Total body water can be applied to many areas, including the estimation of lean body mass and hydration status. The principle of this technique is based on the belief that water is equally distributed in all parts of the body with the exception of fat. Deuterium Oxide is a non-radioactive isotope that equilibrates in the body after ingestion (≈ 4 hours), after which the amount of D_2O can be measured from a urine sample using a continuous flow isotope ratio mass spectrometer. By comparing the pre- and post-values of D_2O from the raw D_2O sample and urine, an accurate measure of TBW can be assessed [1]. Additionally, several past investigations have used the D_2O method for measuring total body water [1-5].

Other methods have been developed for measuring TBW. Bioimpedance is one commonly used method, which involves flowing one (BIA) or multiple (BIS, MFBIA) frequencies of electrical current through body tissues and measuring the opposition of the tissue to this flow. Tissues with higher amounts of water (fat-free mass) will be more conductive, and tissues with less water (fat) will be less conductive. Many of the bioimpedance devices are small and portable, which allows for use in a variety of contexts, such as on the field or even during competition. Since D_2O is a time-consuming, laboratory-based method, it cannot be applied in many contexts, making other methods necessary. Additionally, DXA is a device that is commonly used for measuring body composition. By measuring fat-free mass, TBW can be estimated with a constant hydration status of 0.737%. Estimating TBW from a DXA scan could be useful in studies where body composition is being measured via DXA already, thereby avoiding the addition of another time-consuming measurement (D_2O). However, the validity of the aforementioned methods has not been established in a healthy elderly population. Therefore the purpose of this study was to compare BIA, BIS, MFBIA, and DXA TBW estimations in elderly men and women to a criterion deuterium oxide TBW measurement.

METHODS

Variables measured:

1. TBW using D_2O
   - Measured from urine in triplicate
2. Body Composition – BIA, BIS, MFBIA, DXA

Precision Balance S213

Procedures

1.Anthropomorphic measurements, including height and weight

2.TBW using deuterium oxide (D_2O) ingestion

(1) Subjects were asked to enter a private bathroom and urinate into an 8 fluid ounce cup, filling it with at least 100 mL of urine.

(2) Subjects were asked to drink a solution containing 11mL of D_2O, rinse the cup sides while filling and drink another 50-100 mL of water.

(3) Immediately after ingestion, a 4-hour timer was activated.

(4) Four hours later the subjects provided another urine sample for the calculation of TBW using a standard isotope dilution method.

3. During the four hour equilibration period the subjects had TBW measured using BIA, MFBIA, BIS, and DXA in no particular order.

4. TBW Calcualtions:

. BIS: Cole Model

. BIA: Manufacturers Equation

. MFBIA: Manufacturers Equation

. DXA: FFM (soft tissue + Bone) x 0.737

handheld refractometry CLX-1

ImpediMed DF50 (BIA)

InBody 720 (MFBIA)

ImpediMed SFB7 (BIS)

DXA

Subject Characteristics

	N	Age (yrs)	Height (cm)	Weight (kg)
Total	58	71 +/- 5	167.0 +/- 8.5	68.8 +/- 12.0
Men	24	71.3 +/- 5.4	161.2 +/- 5.0	61.2 +/- 7.0
Women	34	71.8 +/- 5.3	175.2 +/- 5.3	79.5 +/- 8.9

RESULTS

Table 1. Validation of methods for predicting TBW compared with the D2O method in male (N=24).*

	Mean (L)	SD	r	SEE	TE	CE (L)	CE P	2SD of CE	Upper Limits	Lower Limits	Trend	Trend P
D2O	40.91	3.99										
BIS	43.01	4.58	0.94	1.37	2.60	-2.10	<0.01	3.09	0.99	-5.19	-0.14	0.06
BIA	40.61	4.22	0.95	1.32	1.38	0.29	0.31	2.69	2.98	-2.40	-0.06	0.41
MFBIA	44.33	4.57	0.93	1.52	3.82	-3.43	<0.01	3.37	-0.06	-6.79	-0.14	0.10
DXA	42.65	3.96	0.95	1.26	2.12	-1.74	<0.01	2.44	0.70	-4.18	0.01	0.91

*SD=standard deviation; SEE=standard error of estimate; TE=total error; CE=constant errors; CE Sig= p-value of CE; 2SD of CE=1.96×SD of CE; Upper Limits=CE+2SD; Lower Limits=CE-2SD; Trend=trend slope; Trend Sig= p-value of TE.

Table 2. Validation of methods for predicting TBW compared with the D2O method in female (N=34).*

	Mean (L)	SD	r	SEE	TE	CE (L)	CE P	2SD of	Upper	Lower	Trend	Trend P
D2O	26.75	2.25										
BIS	29.13	2.84	0.91	0.94	2.66	-2.37	<0.01	2.40	0.03	-4.77	-0.25	<0.01
BIA	27.64	2.41	0.90	1.01	1.38	-0.89	<0.01	2.09	1.21	-2.98	-0.07	0.39
MFBIA	29.22	2.70	0.89	1.02	2.75	-2.47	<0.01	2.39	-0.08	-4.86	-0.19	0.03
DXA	27.67	2.33	0.90	1.00	1.37	-0.92	<0.01	2.02	1.11	-2.94	-0.04	0.65

*SD=standard deviation; SEE=standard error of estimate; TE=total error; CE=constant errors; CE Sig= p-value of CE; 2SD of CE=1.96×SD of CE; Upper Limits=CE+2SD; Lower Limits=CE-2SD; Trend=trend slope; Trend Sig= p-value of TE.

CONCLUSIONS

The added frequencies used in the MFBIA and the complex Cole models of the BIS did not increase the validity of TBW estimation in elderly men and women as the BIA outperform both devices and uses a single frequency of 50 kHz. However, all methods demonstrated high r values and low SEE values and have the potential to accurately estimate TBW in the current population. However, based on the current results the BIA method used in the current study resulted in the most valid estimations of TBW for elderly men and women compared to D_2O.

In groups of apparently healthy older men and women who have regular FFM hydration ratio's, all four methods should accurately predict TBW. However, all methods may over- or under-predict TBW compared to D2O by as much as 2-3.4 L at the individual level. Caution should be used when using any of the above methods to measure a single individual.

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