TOTAL BODY WATER ESTIMATIONS USING BIOIMPEDANCE IN THE ATHLETIC YOUNG ADULTS: A DEUTERIUM OXIDE COMPARISON

Chih-Yin Tai, Brandon D. Spradley, Sutthanuch Wiriyapinit, Amber Magner, Bill Price, Enrico N. Esposito, Paul H. Falcone, Laura R. Carson, Michael P. Kim, Eric R. Serrano, and Jordan R. Moon

Presented By : Chih-Yin Tai– edison@musclepharm.com - MusclePharm Sports Science Research Institute

ABSTRACT

Bioimpedance techniques have the ability to estimate total body water (TBW) using a single frequency prediction equation (BIA), using hundreds of frequencies in complex Cole models (BIS), as well as using multiple-frequencies and prediction equations (MFBIA). However, the ability of the above methods to estimate TBW in athletic populations has not been investigated. **PURPOSE**: Compare BIA, BIS, and MFBIA estimations in athletic males and females to a criterion deuterium oxide (D2O) TBW measurement. **METHODS:** Twenty-seven females and fifty-one males between the ages of 14 and 30 participated in the study (19.15 +/- 3.42yr, 66.50+/- 11.26kg, 172.94+/- 9.28cm). Subjects reported to the lab in a fasted and hydrated state and provided a urine sample before ingesting approximately 11 grams of D2O. 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 TBW was measured using BIA, MFBIA, and BIS in no particular order. **RESULTS:** For males, all methods produced nearly identical and high r values (0.869-0.878) as well as low standard error of the estimate (SEE) values (2.96-3.06 L) with BIA producing the only significant mean difference (2.66 L, $p < 0.001$). Neither MFBIA or BIS were significantly different than D2O with mean overestimations as low as 0.92 and 0.24 L ($p > 0.05$). For females, all methods produced similar and high r values (0.82-0.85) as well as nearly identical and low standard error of the estimate (SEE) values (1.31-1.42 L). BIS significantly ($p = 0.041$) under estimated TBW (0.793 L) while BIA (0.737 L) and MFBIA (1.27 L) significantly ($p < 0.02$) over estimated TBW compared to D2O. However, BIS and BIA mean difference, although significant, were less than 1 L. **CONCLUSIONS:** The added frequencies and complex Cole models of the BIS appeared to improve the validity of TBW estimations compared to D2O in athletic males and females ages 14-30 years. 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 BIS method used in the current study demonstrated the most valid estimations of TBW for athletic males and females compared to D2O.

INTRODUCTION

Total Body Water (TBW) has been measured by various techniques for more than 40 years. TBW is a very useful measurement to estimate lean body mass. The principle of the technique is based on the belief that water is equally distributed in all parts of the body with the exception of fat. Deuterium Oxide (D2O) is a non-radioactive isotope that equilibrates in the body after ingestion (≈ 4 hours), after which the amount of D2O can be measured from a urine sample using a Europa Hydra continuous flow isotope ratio mass spectrometer. By comparing the pre- and post-values of D2O from the raw D2O sample and urine, an accurate measure of TBW can be assessed [1]. Additionally, several past investigations have used the D2O method for measuring total body water [1-10].

METHODS

Variables measured:

1. TBW using D20
   - Measured from urine in triplicate
2. Body Composition – BIA, BIS, MFBIA

Precision Balance S213

Procedures

1.Subjects basic body composition measurement, included height and weight.

2.Measuring TBW using deuterium oxide (D2O) 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 D2O, rinse the cup sides while filling and drink another 50-100 mL of water.

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

(4) Subjects were required to wait until the 4-hour timer has expired and were asked to urinate into a cup again following the same procedures as before.

3. MFBIA-Inbody 720 measurement.

4. BIA-ImpediMed DF50.

5. BIS-ImpediMed SFB7.

handheld refractometry CLX-1

ImpediMed DF50 (BIA)

Z: impedance
Ph: phase
R: resistance
Xc: reactance

InBody 720 (MFBIA)

Total Body H_2O (L)
Weight (kg)
Intracellular & Extracellular H_2O (L)

ImpediMed SFB7 (BIS)

Total Body H_2O (L)
Extracellular H_2O (L)
Intracellular H_2O (L)
Fat Mass %
Z at zero
Z at infinite

Subject Characteristics

	N	Age (yrs)	Height (cm)	Weight (kg)
Total	78	19.15 ± 3.42	172.94 ± 9.28	66.50 ± 11.26
Men	51	18.67 ± 4.29	176.84 ± 8.19	73.01 ± 15.11
Women	27	19.19 ± 2.91	166.57 ± 6.50	61.77 ± 8.15

RESULTS

Table 1. Validation of methods for predicting TBW compared with the D2O method in male (N=51).*

	Mean (kg)	SD	r	SEE	TE	CE	CE Sig	2SD of CE	Upper Limits	Lower Limits	Trend	Trend Sig
D2O	44.261	6.121										
BIA	41.600	5.984	0.869	3.064	4.066	2.661	0.000	6.087	8.748	-3.426	0.024	0.751
BIS	44.496	7.026	0.878	2.963	3.342	-0.235	0.620	6.599	6.364	-6.835	-0.147	0.049
MFBIA	45.184	6.874	0.876	2.987	3.417	-0.924	0.053	6.511	5.588	-7.435	-0.124	0.098

*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=27).*

	Mean (kg)	SD	r	SEE	TE	CE	CE Sig	2SD of CE	Upper Limits	Lower Limits	Trend	Trend Sig
D2O	32.40	2.41										
BIA	31.67	2.69	0.81	1.42	1.71	0.74	0.02	3.08	3.82	-2.35	-0.12	0.35
BIS	33.20	3.28	0.82	1.42	2.04	-0.79	0.04	3.76	2.97	-4.55	-0.34	0.01
MFBIA	33.67	3.24	0.85	1.31	2.14	-1.27	0.00	3.45	2.18	-4.72	-0.32	0.01

*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 and complex Cole models of the BIS appeared to improve the validity of TBW estimations compared to D2O in athletic males and females ages 14-30 years. 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 BIS method used in the current study demonstrated the most valid estimations of TBW for athletic males and females compared to D2O.

ACKNOWLEDGEMENTS

This study was funded by MusclePharm, Inc. (Denver, CO).

REFERENCES

1.Scrimgeour, C.M., et al., A simplified method for deuterium/hydrogen isotope ratio measurements on water samples of biological origin. Biological Mass Spectrometry, 1993. 22: p. 383-387.

2.Fields, D.A., et al., Comparison of the BOD POD with the four-compartment model in adult females. Med Sci Sports Exerc, 2001. 33(9): p. 1605-10.

3.Fuller, N.J., et al., Four-component model for the assessment of body composition in humans: comparison with alternative methods, and evaluation of the density and hydration of fat-free mass. Clin Sci (Lond), 1992. 82(6): p. 687-93.

4.Pace, N. and E.N. Rathbun, Studies on body composition. III. The body water and chemically combined nitrogen content in relation to fat content. Journal of Biological Chemistry, 1945. 158: p. 685-691.

5.Peterson, M.J., S.A. Czerwinski, and R.M. Siervogel, Development and validation of skinfold-thickness prediction equations with a 4-compartment model. Am J Clin Nutr, 2003. 77(5): p. 1186-91.

6.Price, W.F., et al., Reproducibility of body composition measurements in a single individual. J Lab Clin Med, 1969. 74(4): p. 557-63.

7.Silva, A.M., et al., Body fat measurement in adolescent athletes: multicompartment molecular model comparison. Eur J Clin Nutr, 2006. 60(8): p. 955-64.

8.Wang, Z., et al., Hydration of fat-free body mass: review and critique of a classic body-composition constant. Am J Clin Nutr, 1999. 69(5): p. 833-41.

9.Wang, Z., et al., Multicomponent methods: evaluation of new and traditional soft tissue mineral models by in vivo neutron activation analysis. Am J Clin Nutr, 2002. 76(5): p. 968-74.

10.Wang, Z.M., et al., Six-compartment body composition model: inter-method comparisons of total body fat measurement. Int J Obes Relat Metab Disord, 1998. 22(4): p. 329-37.