Clinical Nutrition ESPEN 10 (2015) e167–e173

Contents lists available at ScienceDirect

Clinical Nutrition ESPEN

journal homepage: http://www.clinicalnutritionespen.com

Original article

Validity of anthropometry- and impedance-based equations for the prediction of total body water as measured by deuterium dilution in Cameroonian haemodialysis patients

Gabriel Nama Medoua [a, *], Véronique J. Essa'a [a], Colman T. Tankou [b], Anne Christine A. Ndzana [a], Henriette T. Dimodi [a], Patricia M. Ntsama [a]

[a] Centre for Food and Nutrition Research, IMPM, P O Box 6163, Yaoundé, Cameroon
[b] Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, Cameroon

ARTICLE INFO

Article history:
Received 9 January 2015
Accepted 29 May 2015

Keywords:
Bioelectrical impedance
BIA equation
Anthropometric equation
Total body water
Deuterium dilution
Cameroonian haemodialysis patients

SUMMARY

Background & aims: There is no available information on the validity of anthropometry- and impedance-based equations for predicting total body water (TBW) in Cameroonian haemodialysis patients. This study aimed to validate and develop predictive equations of TBW for Cameroonian haemodialysis patients.
Method: TBW in 40 Cameroonian haemodialysis patients (28 men and 12 women) was measured by deuterium dilution and compared with the one predicted by 7 anthropometric and 9 BIA equations. Multiple linear regression analysis was used to develop an equation for predicting TBW as measured by deuterium, from anthropometric parameters.
Results: Pure errors in predicting TBW showed unacceptable value for all equations tested. In all the cases, unacceptable discrepancies at individual level for clinical purposes were noted. The following equation was developed and showed a better agreement with the deuterium dilution method: $TBW = 13.8994 + 0.0017 \times Age + 0.3190 \times Weight + 1.8532 \times Sex$.
Conclusion: Further development and cross-validation of anthropometric and BIA prediction equations specific to African heamodialysis patient are needed. Meanwhile, the equation developed in this study which provided a better agreement with the isotope dilution could be use for Cameroonian haemodialysis patients.

1. Introduction

Malnutrition occurs in a high percentage of patients with renal failure, as various studies shown signs of malnutrition in 23–76% of haemodialysis patients [1,2]. Precise evaluation of nutritional status and body composition in this population is important because malnutrition increase morbidity and mortality [3,4].

Measurement of Total Body Water (TBW) is often done to assess body composition and nutritional status in healthy subjects and renal failure patients. In the latter, assessing TBW is also important to prescribe and check the treatment, as it is directly related to urea kinetic modeling [5,6].

Isotope dilution is the most precise method to measure TBW, but it is difficult to apply the in clinical setting as it is expensive and not widely available. Therefore, cheap and simple methods are needed for routine clinical practice and epidemiologic field studies, especially in developing countries. In this regard, anthropometry and bioelectric impedance analysis (BIA) have drawn attention as inexpensive, simple to use, and portable techniques. However, these are indirect methods based on prediction equations developed in a population in which the method was validated against a reference method, and are therefore population-specific [7].

Since the validity of anthropometry and BIA prediction equations in African haemodialysis patients has not yet been demonstrated, the aims of this study were to compare the results of the deuterium dilution technique with those of the more convenient anthropometry and multifrequency BIA methods in Cameroonian haemodialysis patients, and to develop a new equation for predicting TBW as measured by deuterium dilution. In this study, TBW

* Corresponding author. Tel.: +237 697 39 28 42.
E-mail address: gmedoua@yahoo.fr (G.N. Medoua).

http://dx.doi.org/10.1016/j.clnesp.2015.05.006
2405-4577/

was predicted using 7 anthropometry equations and 9 BIA equations.

2. Materials and methods

2.1. Subjects

During the first 2 weeks of the study, all haemodialysis patients attending the haemodialysis unit of the Yaoundé Teaching Hospital, who agreed to sign the consent form, were included in the study. Forty patients, men (n = 28) and women (n = 12), participated in the study, and the protocol was approved by the IRB of IMPM. Patients, between 23 and 70 years old, were on haemodialysis for at least three months and in a stable state of hydration at the time of assessment without overt edema. All measurements were performed about 30 min after dialysis, at a room temperature of 23 ± 5 °C. The dose of deuterium was administered just after anthropometric and BIA measurements. Thus, the hydration status of a subject was likely to have remained the same throughout the measurement period.

2.2. Anthropometry

Anthropometric measurements were performed using standard procedures [8]. Weighed was measured to nearest 0.01 kg using an electronic scale (Seca 882, Seca, Hamburg, Germany). Height was measured to the nearest millimeter using a portable gauge (Seca 225, Seca, Hamburg, Germany). Body mass index (BMI) was calculated as weight (kilograms) per height (meters) square. Mid-upper, waist and hip circumferences were measured to the nearest 0.1 cm using a non-elastic metric measuring tape. Skinfold measurements at the triceps, biceps, subscapular, and suprailiac sites were made to the nearest millimeter on the opposite side of the dialysis vascular access using a Holtain skinfold caliper (Holtain Ltd., Crosswell, Crymmych, Dyfed, UK).

2.3. Bioelectrical impedance analysis

A multi-frequency impedance analyzer (Bodystat, QuadScan 4000, Douglas, Isle of Man, UK) was use to get impedance (Z) data at 5, 50, and 100 kHz; a tetrapolar electrode placement on the right hand, wrist, foot, and ankle was used with the subject in supine position (dialysis vascular access was through central venous catheter or Arterio-Venous Fistula in the left side). The impedance index was calculated as height^2/Z (cm^2/Ω). Height^2/Z_5 is assumed to reflect the ECW and height^2/Z_{100} the TBW; their ratio was used as a simple index of the ECW/TBW ratio.

2.4. Reference method: deuterium oxide dilution

The deuterium oxide dilution method used has been described in detail previously [9]. In brief, a dose (30 g) of deuterium oxide (99.8% purity; Cambridge Isotope Laboratories, Inc., Andover, MA, USA) was orally administrated to each subject and saliva samples (2 mL) were collected before and after administering the dose at 4, 6, 8, 17, and 19 h respectively.

The enrichment of deuterium in saliva samples was measured in the range of 2300–2900 cm^{-1} using a Fourier transformed infrared spectrophotometer (IRAffinity-1, Shimadzu, Kyoto, Japan) with a calcium fluoride cell with a cell thickness of 10^{-4} m, and a software (Isotope) developed by the Medical Research Council (Human Nutrition Research, Cambridge, UK).

2.5. Total body water calculation

2.5.1. From deuterium oxide dilution

TBW (kg) was calculated from deuterium enrichment at time zero, assuming that dilution space of deuterium (V_D) is 4.1% higher than TBW due to exchange of hydrogen with non-aqueous hydrogen in the body [10].

$$TBW = \frac{V_D}{1.041}$$

where $V_D(kg) = \frac{Dose\ of\ deuterium\ (mg)}{Enrichment\ of\ deteurium\ in\ saliva\ (mg/kg)}$

2.5.2. From anthropometry

From the density predicted by using the equations of Durnin and Womersley [11], the body fat (BF) was calculated by using the equation of Brozek [12], the equation of Siri [13] or the black-specific equation developed by Gartner et al. [14] considering the FFM density of 1.106 kg/cm^3 for black women [15] and the fat density of 0.9007 kg/cm^3 for black men [16]:

Siri BF = (4.95/density) − 4.50
Black specific BF = (4. 852285436/density) − 4.387238188
Brozek BF = (4.570/density) − 4.142

TBW was derived from FFM (difference between body weight and body fat) and the hydration constant of 0.732 [17].
The following formulas were also used:
Watson formula [18]:

Male TBW = 2.447 − (0.09156 × age) + (0.1074 × height) + (0.3362 × weight)
Female TBW = −2.097 + (0.1069 × height) + (0.2466 × weight)

Hume formula [19]:

Male TBW = (0.194786 × height) + (0.296785 × Weight) − 14.012934
Female TBW = (0.34454 × height) + (0.183809 × weight) − 35.270121

Slater formula [20]:

TBW = 7.40 × height^3.

Chumlea equations for black subjects [21]:

Male: TBW = −18.37 − (0.09 × age) + (0.34 × weight) + (0.25 × height)
Female: TBW = −16.71 − (0.05 × age) + (0.22 × weight) + (0.24 × height)

2.5.3. From BIA

The 9 impedance-based prediction equations display in Table 1 were used to estimate the TBW of Cameroonian haemodialysis patients (Table 1).

2.6. Statistical analysis

Results were reported as mean ± standard deviation. Statistical analyses were performed by using IBM SPSS Statistics 21. *P* values <0.05 indicated statistical significance. One-way analysis of variance with post-hoc Tukey's B test was used to identify