Total Body Water Measured by Electromagnetic Resonant Cavity Perturbation

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We recently demonstrated a novel method for determining human total body water (TBW) intended for patients suffering abnormal hydration using an electromagnetic resonant cavity perturbation (RCP) approach [1]. RCP relies on asking a volunteer to lie in a large cavity resonator and changes in its resonant frequency, f_{res}, are observed due to the consequent perturbation of the dielectric properties. Utilising the relationship that water content correlates to these dielectric properties at radio frequencies, it has been shown that the measured response of these parameters enables determination of body water [2]. Measurements are made using an automated network analyser operating in the transmission mode (measuring S_{21} or S_{12}). The sensitivity can be demonstrated by asking a volunteer to drink a small amount of liquid between measurements, and is better than one litre. Although the sensitivity varies from subject to subject, we have shown that by fitting a second-order polynomial to the variation of the gradient versus the mass-to-height ratio, we are able to develop a prediction equation applicable to a wide range of ages and body types. Moreover, we have validated these equations by conducting a cross-validation study using three reference methods; our predictions of TBW have been shown to compare favourably.

Method: A rectangular electromagnetic screened room is utilised as an R.F cavity, which resonates at 59 MHz when energy is coupled into the room. Two monopole probes are mounted on the ceiling of the room and couple to the required vertical E-field (TE_{101} mode). Twenty-nine healthy volunteers were recruited and asked to lie in the centre of a screened room at York University, UK, before and after drinking 1.25–2 litres of water and isotonic fluid. For the cross-validation study, a further eighteen volunteers were invited to participate in a series of experiments at the Centre for Bone and Body Composition at the Leeds General Infirmary, UK. TBW for each volunteer was measured using three existing techniques; isotope dilution, dual X-ray absorptiometry and bio-impedance analysis. These volunteers were also measured in the screened room at York University.

Results: A combination of the isotope dilution data and the corresponding measurements of Δf_{res} taken in the screened room at York have been used to cross-validate the RCP prediction equations. Although a Bland and Altman plot was used to correct a -2 litre drift in the data, agreement between the results is highly significant ($r = 0.95$, $p < 0.001$). Precision is also encouraging; the standard deviation of 37 paired measurements is 2.6 KHz, whilst resolution for the validation group ranges from 350–800 ml.

Conclusions: Predictions of TBW using electromagnetic RCP are favourable compared with reference methods; data is accurate and repeatable, and furthermore, resolution is better than 1 litre. This leads to confidence in the integrity of the proposed technique.

REFERENCES

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