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Evaluation of bio-electrical impedance as a clinical tool in prospective nutritional assessment in paediatrics

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We have compared the use of bio-electrical impedance analysis (BIA) to anthropometry in the prediction of changes in total body potassium (TBK) counting in a group (n=26) of children with cystic fibrosis. Linear regression analysis showed that the change in TBK in each subject had a significant correlation with the change in BIA, the change in weight and the change in height, but not with the change in fat-free mass (FFM) (determined by skinfold thicknesses). The children were divided into two groups; those who had normal accretion of TBK (Group A) and those who had suboptimal accretion of TBK (Group B). Group t-tests showed that there was a significant difference between the changes in BIA that occurred in Groups A and B but not in the changes in weight, height, FFM, weight Z score and height Z score. The results of this study suggest that serial BIA measures may be useful as a predictor of progressive under nutrition and poor growth in children.

Introduction

Bio-electrical impedance analysis (BIA) has attracted much recent interest as a possible portable, inexpensive, and rapid technique for the measurement of body composition. Many cross sectional studies have shown strong correlations between BIA and other measures of body composition (deuterium dilution, anthropometry, densitometry, total body potassium), across a wide range of age in both healthy and diseased patients. Such correlations however are of little use in assessing the precision and accuracy of estimates of body composition based on BIA.

BIA has been suggested as a possible measure of Total Body Water (TBW) and fat-free mass (FFM)[1]. However the precision and accuracy of BIA for predicting body composition in individual subjects and the sensitivity of BIA in detecting changes in body composition have received little attention, particularly in pediatrics. A number of studies have indicated that BIA is a poor predictor of changes in FFM but these studies have been restricted to short-term studies in healthy or obese adults[2].

We have conducted a prospective evaluation of BIA in the prediction of changes in body composition in children with cystic fibrosis (CF), compared with other direct and indirect measures of body composition. We have used Body Cell Mass (BCM) as determined by Total Body Potassium (TBK) counting as the reference standard because it is a direct measure of body composition. BCM is the active work performing, energy utilizing and in children the growing body component[3].

Methods

Twenty-six CF patients aged 5.7 – 16.3 years participated in the study. Informed consent was obtained from parents/guardians and individual patients where appropriate. This study was approved by the ethics committee at the Royal Children's Hospital.

TBK was measured in a whole body counter adapted and calibrated for children (Canberra, Accuscon, Boston, Mass., USA). BIA was measured at 50kHz using 200μA current using a tetra polar bio-impedance meter (SEAC, Brisbane, Australia). Procedures for electrode placement and BIA measurement were as described previously[1]. BIA values were expressed as (Height)^2/ Resistance. Skinfold thickness measurements at four sites were used to calculate body fat and the FFM according to published equations[4,5]. Measurements of weight, height FFM, BIA and TBK were repeated at 0.4 to 1.8 years after the initial measurements and the children were divided into two groups, Group A (n=16) children with normal TBK (defined here as >5 g/year) accumulation and Group B (n=10) children with sub optimal TBK accumulation (<5 g/year).

Linear regression analysis was used to provide a linear equation relating TBK to other measures and this equation of best fit was used to calculate TBK values based on the other measures. This enables the comparison of BIA with anthropometry in predicting TBK in individual patients, using the estimated limits of agreement procedure[6]. This uses the standard deviation of the mean difference between the measured TBK and the calculated TBK values. Linear regression analysis was also used to examine the relationship between the changes in TBK that occurred in each subject with the changes in weight, height, FFM and BIA. Group t-tests were

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used to compare the changes in TBK, weight, height, weight Z scores, height Z scores, FFM and BIA between patients in Group A and patients in Group B.

Results

Strong linear regressions were found between TBK and all other measures with regression coefficients >0.9. The estimated limits of agreement procedure show that measures of body weight, height, FFM and BIA were all similar in their precision of predicting values of TBK in individual patients (Table 1). Significant linear correlations were seen between changes in TBK with changes in BIA, body weight and height, but not with changes in FFM ($P<0.001$ & $r = 0.65$; $P<0.05$ and $r = 0.44$; $P<0.05$ and $r = 0.44$; $P>0.05$ and $r = 0.42$, respectively). Significant differences in the changes in the change in TBK and BIA were detected between Group A and Group B but not for any anthropometric measures (Table 2).

Table 1. Standard deviation of mean difference between measured TBK and calculated TBK based on weight, height, FFM and BIA.

Weight	7.0%
Height	5.7%
FFM	6.6%
BIA	5.0%

(Expressed as a percentage of measured TBK.)

Table 2. Change in repeat measures per year.

Measure	Group A ($n = 16$)	GroupB ($n = 9$)	
TBK (g)	13 ± 8	−1 ± 4	$P<0.001$
BIA (m^2/ohm)	2.8 ± 3.5	−0.62 ± 3.4	$P<0.01$
Wt (kg)	2.6 ± 1.9	2.4 ± 2.5	ns
Ht (cm)	4.6 ± 2.0	4.4 ± 1.9	ns
Wt Z	−0.11 ± 0.35	−0.11 ± 0.5	ns
Ht Z	−0.01 ± 0.31	−0.13 ± 0.37	ns
FFM (kg)	0.42 ± 2.93	0.38 ± 2.86	ns

Discussion

This study confirms and extends previous evaluations of BIA as a measure of body composition. The strength of the correlations between BIA and TBK are similar to that reported previously in a pediatric population[1]. The estimated limits of agreement procedure however suggest that BIA is not better than anthropometric measures in predicting TBK in individual patients.

Measurements of body composition in CF are important in the early detection of nutritional problems and in assessing the effect of nutritional therapy[7]. Total body potassium counting is a well-established and widely accepted measure of body composition and is a sensitive measure of nutritional status[3]. However, this technique is not practical for clinical use because it requires specialized facilities that are expensive and not portable. BIA has the potential to provide a portable and inexpensive measure of body composition but the results of this study indicate that it is not a reliable or accurate predictor of BCM in individual patients, despite the strong correlation between the two measures.

The ability of BIA to predict changes in body composition in pediatric patients has not previously been examined. The results of this study demonstrate that BIA is superior to anthropometric measures in predicting changes in TBK. This contradicts previous studies in adults where BIA was shown to be insensitive to changes in body composition[2]. These studies, however, were all short term and confined to the prediction of loss of lean body mass with dieting and exercising in healthy or obese adults. The results of this study suggest that BIA may be sensitive to body composition changes in the medium to long term. Serial BIA measures may be useful in CF and other diseases as a predictor of progressive under nutrition and poor growth. The ability of BIA to predict changes in BCM in a shorter time frame (eg <6 months) remain to be determined. Given the magnitude of error in the prediction of TBK values from BIA data it would not be surprising if BIA was insensitive to change in TBK over this period.

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