多頻生物電阻抗在兒科的評估

Evaluation of multiple frequency bio-electrical impedance analysis in paediatric subjects

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The efficacy of multiple frequency bio-electrical impedance analysis (MFBIA) at discrete frequencies in predicting body cell mass, total body water, and fat-free mass compartments was investigated in healthy (n=30) and diseased (n=40) paediatric populations. Correlation coefficients achieved by comparing MFBIA with reference techniques using Deming's regression analysis were in excess of 0.9, but were not superior to those achieved comparing reference techniques with the traditional BIA application at 50 kHz. Applying the 95% limits of agreement procedure to the results showed that the agreement between the techniques was not sufficient for the technique to be of value in individual body composition assessments. The use of MFBIA at discrete frequencies does not improve the accuracy of estimations of body compartment sizes in paediatric subjects compared with those obtained with BIA at 50 kHz.

Introduction

Malnutrition has a major influence on morbidity, mortality and growth patterns in paediatric patients. The understanding and clinical management of malnutrition would be more effective if body composition measurements could be made simply and accurately.

Bio-electrical impedance analysis (BIA) has been used widely to assess body composition in population studies. This safe, simple, non-invasive and portable technique uses impedance of the body to the flow of an applied 50 kHz alternating electric current to estimate body compartment sizes. It is a simple practical technique, but has been rejected for use in individuals because of relative inaccuracy.

Because of the capacitive effect of cell membranes, electrical impedance produced by a biological tissue is dependent on the frequency of the applied current (see Fig. 1). Application of BIA at frequencies other than 50 kHz has yet to be widely investigated, although as yet there is no evidence that 50kHz is the ideal frequency at which to apply the technique. If the accuracy of BIA measurements could be improved by using multiple frequencies, the technique would be a practical clinical tool.

This study aimed to establish the limitations and potential advantages of multiple frequency BIA (MFBIA) over single frequency BIA in estimating fat-free mass, intracellular mass and total body water in children. This encompassed evaluating the effects of disease and disturbance of body water balance by applying it to diseased children.

Subjects and methods

Participation in the study was on an informed consent basis. The subjects were aged between 4 and 16 years and were divided into two groups; Group A consisting of 30 healthy children, and Group B consisting of 40 children suffering from cystic fibrosis. Groups A and B were matched for age and sex. Multifrequency bio-electrical impedance (MFBIA) was measured at six frequencies (1.0, 3.25, 10.0, 32.5, 50 and 100 kHz) in both groups using a tetrapolar bioimpedance device (model MFBIA, SEAC, Brisbane) attached to the body with skin electrodes at the wrist and contralateral ankle according to the procedure of Lukaski[1] et al.

The impedance readings obtained were compared with body cell mass (BCM), fat-free mass (FFM) and total body water (TBW) estimates. BCM estimates were obtained from a 40-minute whole body potassium (TBK) count using the established counting procedure at the Royal Children's Hospital, Brisbane[2]. FFM estimates were obtained using anthropometry. The equations of Brook[3] and Slaughter[4] were used to calculate FFM using skinfold measurements performed using a Harpenden (John Bull) spring-actuated calliper at biceps, triceps, subscapular and surprailiac locations[5]. TBW was estimated by performing a deuterated water dilution, using deuterium concentration in background and 6-hour urine samples, and the equation of Fusch and Moeller[6].

Demings regression analysis[7] was used to relate height^2/impedance to each reference technique for all six frequencies measured and each study group. Separate regressions were performed for males and females within the study groups. Correlation coefficients and standard errors of the estimate were calculated for these regression lines. To establish whether the agreement between impedance and TBW and BCM measures was acceptable, a variation of Bland and Altman's limits of agreement (LOA) procedure was performed[8], where the difference between the techniques is

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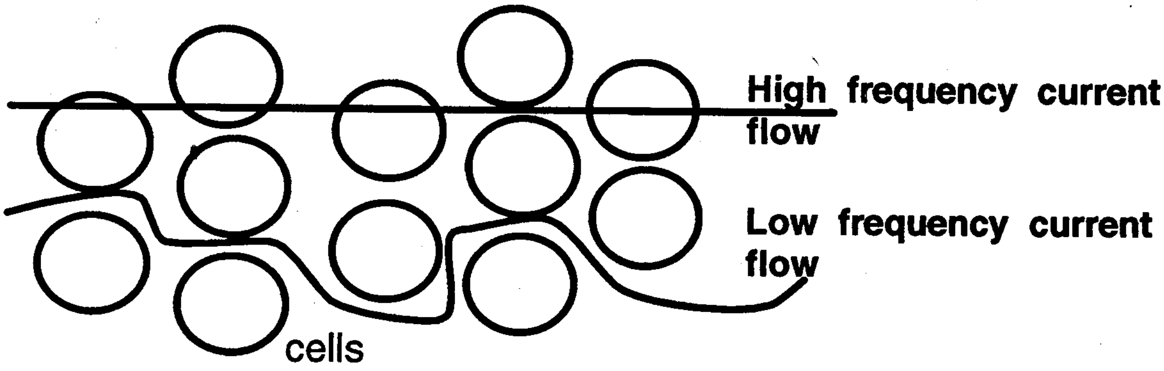

Figure 1. Principles of biological current flow.

expressed as a percentage of the mean and is plotted against the mean of an individual sample.

Results

Although correlations between multiple frequency impedance and reference techniques were good (r > 0.9), the results were equivalent to those achieved using single frequency measurements at 50 kHz (see Table 1).

BIA correlated more closely with BCM than LBM or TBW (Tables 1,2 and 3). TBW by deuterium dilution provided the poorest correlation with BIA at these frequencies.

Standard errors of the estimate (SEE) and LOA results for the two study groups were not significantly different for any of the three reference techniques used (Tables 2 and 3).

Table 1. MFBIA results compared to TBK, TBW and FFM estimates.

Frequency	1.0	3.25	10.0	32.5	50.0	100.0
Ave SEE						
for 1 TBK	2.6	2.6	2.5	2.6	2.5	2.5
2 TBW	4.5	4.3	4.4	4.3	4.3	4.2
3 FFM	3.1	2.9	3.0	3.0	2.8	3.0
Ave LOA						
for 1 TBK	17.7%	17.7%	17.5%	17.6%	16.9%	16.9%
2 TBW	26.9%	26.0%	26.5%	26.4%	260.%	26.1%

Table 2. Comparison by Groups

Average SEE	Group A	Group B
TBK	2.68	2.43
TBW	3.93	4.75
FFM	2.97	2.95

Table 3. Agreement between impedance and TBK, TBW by groups

Average LOA	Group A	Group B
TBK	16.5%	18.1%
TBW	25.6%	27.0%

Discussion

This study suggests that the use of bio-electrical impedance at multiple fixed frequencies to predict FFM, BCM and TBW offers no advantage over a single frequency measurement at 50 kHz. The SEE and LOA results were not significantly different between the six frequencies for either reference technique. The best result achieved was 11.5% for the 95% LOA (for BCM and BIA), which is in excess of the clinically significant range. The technique accuracy therefore remains the factor limiting the widespread application of the technique.

Investigation of subjects suffering from cystic fibrosis showed that impedance provided equally good predictions of body composition in subjects with this disease as in normal children, although the 95% limits of agreement were in excess of 17%, rendering the method of limited value for assessment of body composition in individuals in either study group.

Of the body compartments used for comparison, BIA was most closely related to the BCM compartment, although this may reflect the accuracy of the whole body potassium count technique used to calculate BCM rather than a relationship between impedance and BCM.

Conclusion

This study indicates that in healthy children and cystic fibrosis sufferers, BIA measurements at 1, 3.25, 10, 32.5 and 100 kHz do not provide better predictions of body cell mass, total body water and fat-free mass than BIA performed at 50 kHz.

Further investigations using a more sophisticated computerized swept frequency impedance device which is capable of measuring resistance and capacitive reactance components of impedance over a broader spectrum of frequencies would allow determination of the ideal or characteristic frequency for application of the bioimpedance technique whilst the Cole-Cole method of data analysis will theoretically provide predictors of extra-cellular water and TBW water[9].

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