Body composition assessment

There is increasing recognition and awareness of the inability of classical measures of growth and development to meet the requirements of modern clinical medicine and biological research. Measurements such as weight and length provide useful but incomplete data relating to the growth or nutritional status of a child. Thus, more detailed assessment of body composition is being sought by those interested in paediatrics, nutrition, growth, and development.

There are numerous techniques that are used to assess body composition, the majority of which use a two compartment model: that is to divide the body into fat and fat free masses. Nevertheless, many such techniques are not easily applied in children because of either practical or ethical considerations. For example, underwater weighing to assess body density and hence body fat mass is clearly not applicable to young children. However, there are numerous approaches that can be used to assess body composition in the paediatric population each with their own advantages and disadvantages. The range of the technology utilised and the complexity of the various techniques is wide. Some of these techniques are described below.

Anthropometry

Estimates of body composition based upon simple straightforward anthropometric measurements have been available for many years. The majority of these methods rely on the ability of measurements of subcutaneous fat folds or skinfolds at selected sites to predict accurately total body fatness. It has never been thought that this approach was perfect and there are many problems associated with the model that are not easy to overcome. It has been shown that it is not possible in infants to predict total body fatness from the measurement of skinfold thicknesses to an appropriate level of accuracy, and the equations derived for use in childhood and adolescents are often extremely population specific.

Bioelectrical impedance

This technique has become extremely popular in recent years. It is based upon the fact that the electrical resistance to a flow of current of 50 kHz in the human body is related to the amount of total body water and hence fat free mass. As the technique is non-invasive, simple, precise, and relatively cheap it would seem to be an ideal body composition tool for use in paediatrics. There have been a number of validations of the technique and in contrast with anthropometric methods bioelectrical impedance seems to be much less population specific. However, problems have been reported with its use in the neonatal period but these may be associated with the difficulty of validation in this population rather than the model itself. As the technique theoretically predicts total body water care should be taken in assuming that the same degree of precision can be applied to derived estimates of fat free mass. The conversion of body water to measures of fat free mass assumes a constant level of hydration in lean tissue. Even so the correlation between bioelectrical impedance and estimates of body cell mass via the measurement of total body potassium has been shown to be high. Current research in this area indicates that a dual frequency or multifrequency current might enable both intracellular and extracellular water to be measured. Users of bioelectrical impedance apparatus should, however, ensure that the equations built into any associated software supplied with the equipment are appropriate for children.

Assessment of total body water

It is of course possible to measure total body water rather than use prediction equations. The most straightforward approach is to use an isotope of either hydrogen or oxygen in the form of water and apply a standard dilution principle. Tritiated water ($^3$H$_2$O) is not normally used in children because of the radioactive nature of the isotope but deuter-
ated water (\(\text{H}_2\text{O}\)) and \(\text{H}_2\text{O}^{18}\) can be used. The latter isotope is extremely expensive and thus the use of deuterated water is the most common method of assessing total body water via stable isotopes. The major drawback in the use of this isotope is that there is exchange of the isotope with non-aqueous hydrogen in the body. This exchange is probably variable and possibly population specific. However, an assumption that the measured deuterium dilution space is 3% greater than true body water is a reasonable adjustment.

**Dual energy x ray absorptiometry**

A potentially exciting advance in the assessment of body composition is the use of dual energy x ray absorptiometry otherwise known as DEXA or more recently DXA. This technique consists of the use of two x ray beams of differing energies (usually 40 and 80 keV). The x rays are attenuated to different degrees as they pass through the body dependent upon the quantity and nature of the tissue. It is therefore possible to not only assess the quantity of the fat and fat free masses but also measure bone mineral content. Moreover, segmental body composition analysis can be undertaken with this system. The radiation dose incurred is sufficiently small to be ethically acceptable for use in children. Dual energy x ray absorptiometry has now been extensively used in adults although little work has been carried out in children. There are some concerns that the differences in the size, shape, and body geometry of children may require important changes to be made in the calibration procedures and in the mathematical computations involved in the technique. DXA is never likely to be a widespread ‘bedside’ technique but should enable less expensive and more accessible techniques to be validated with greater ease and accuracy.

The future for body composition research in the paediatric population will undoubtedly involve a move away from the traditional two compartment models described. It is likely that greater accuracy and precision will be obtained using three or even four compartment models. The techniques described above may then be used together to derive estimates of fat mass, body water, mineral content, and protein content. It has been shown that three and four compartment models have at least theoretical advantages over a two compartment model in that variations in the relationship between components such as mineral, non-mineral, and water are associated with smaller errors in the final estimate of body composition. Such advances will be welcome by all working in the field.

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