脂肪與無脂肪組織的測量：臨床意義和限制因素

Measuring fat and fat-free mass: clinical significance and limitations

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Measuring body composition is part of clinical nutritional assessment. Simultaneous measurements of fat mass, and fat-free mass, or, preferably, the components of fat-free mass, will yield the most clinical information, but may be limited by laboratory availability. In obese subjects, measurements of fat mass and fat distribution is complemented by a simultaneous assessment of cell mass or total body protein, since management will involve following changes in all of these parameters. Similarly, in osteoporosis, assessment of fat mass and distribution at the same time as bone mass and density, where hormonal replacement therapy has been instituted is a necessary part of the total management of the patient. Since fat distribution has been recognised as an important indicator of health risk, it has become increasingly important to know how to quantify risk and risk change in individuals with abdominal fat distribution. Little information is available about this, or the risks peculiar to peripheral fat distribution. As compartmental models of body composition become more complex, changes in these compartments in various illnesses are becoming clearer. The use of IVNAA for measuring total body protein changes in haemodialysis, and alcoholic cirrhosis, and the recent development of multifrequency BIA to assess extracellular water provide good examples. Although many hospitals clinics now have DEXA and BIA available, body composition laboratories per se are still a rarity, limiting clinical measurements to anthropometry. The errors involved in measurement using the various techniques mentioned still do not allow assessment of short-term changes in fat mass, or the components of fat-free mass.

Measuring body composition is part of nutritional assessment. From a clinical view point, the assessment of the individual is often of most immediate importance, the data being considered in the context of the appropriate epidemiological setting for the patient.

A wide variety of techniques are able to measure aspects of body composition (see Table 1), although their availability is limited. Many hospitals now have been access to anthropometry, bio-electrical impedance (BIA) and dual-energy X-ray absorptiometry (DEXA), a combination of which will allow extensive body composition measurement.

Table 1. Techniques for the measurement of fat mass and fat-free mass.

Anthropometry using skinfold thicknesses, diameters
Bioelectrical impedance analysis (BIA)
D_2O dilution for total body water
Whole body gamma counting (^{40}K) for body cell mass
Underwater hydrodensitometry (DEXA) for fat mass and bone mineral mass
Magnetic resonance imaging (MRI) principally for intra-abdominal fat volume

Heymsfield[1] listed an anatomical hierarchy of levels at which body composition can be assessed, which allows, if access is available, a rational choice for the most appropriate technique, but, for the clinician, a functional classification of body compartments is the most useful (Table 2).

Table 2. Anatomical and functional classification of body compartments.

Anatomical measurement of body compartments	Functional assessment of body compartments
Atomic	
Molecular	Fat mass (total, central, peripheral) Fat-free mass (total water, extra/intracellular water, protein, bone minerals, (glycogen)
Cellular	Cell mass
Tissue-system	
Whole body	Weight, height, diameters

Simultaneous measurement of compartments

Simultaneous measurement of fat mass (FM) and fat-free mass (FFM) or, preferably, the components of FFM will yield the most clinical information. Changes in one compartment are usually accompanied by changes in other body compartments. In obese subjects, measurement of FM and fat distribution is complemented by simultaneous measurement of cell mass, or total body protein (TBP). The increased fat mass of obesity is accompanied by an increased muscle mass, best assessed by cell mass or TBP, and preservation of muscle mass during fat loss is ideal, although some loss is obligatory. Measurement of TBP (by neutron activation analysis as nitrogen) can be limited by the thickness of the fat mass through which the neutrons must pass, so that a measurement

over the abdomen gives an answer not necessarily reflective of the TBP (Table 3)[2].

Table 3. Measurements of TBP (nitrogen) at two sites in three groups.

Subjects	W/HR	Abdomen (mean ± SD)	Thigh (mean ± SD)	*P*
Males (n =11)	>0.90	2.10 ± 0.25	2.45 ± 0.24	0.0032
Females (n =7)	<0.85	1.26 ± 0.28	1.35 ± 0.22	0.52
Females (n =22)	>0.85	1.43 ± 0.27	1.71 ± 0.34	0.0042
P		0.16	0.014	

Although central fat distribution is now generally accepted to be a risk factor, perhaps pathogenetic, for a variety of illnesses[3,4], little information is available on the health risks, if any, which are specific to a peripheral fat distribution, which, of course, has a cosmetic effect as well. However, these risks are population-based, and, from a clinical perspective, individual risk, how it may be quantified, and altered by management strategies is most important. Again, little information is available about such individual risk. In any case, the error of the body composition methods is such, that it may not always be possible to detect the small changes which are likely to be clinically relevant.

In the management of osteoporosis, simultaneous assessment of FM and fat distribution as well as FFM, at the same time that bone mineral density or mineral mass is measured, is a necessary part of the total management of the patient[5]. This is especially so where hormonal replacement therapy is to be instituted.

Alterations in body composition in disease

As it becomes possible to measure body compartments in more detail, it will be more possible to recognize alterations in the relative and absolute size of the compartments, with earlier institution and adjustment of therapy.

In alcoholic cirrhosis, as severity of liver disease increases, there is usually an increase in body weight, due to the increase in total body water associated with oedema. This increase in water obscures a decline in TBP, which occurs in a significant number of such patients before the serum albumin declines. Anthropometric and BIA measurements are insensitive to these changes. Measurement of TBP or cell mass by 40K counting may be sufficiently sensitive[6].

In haemodialysis patients, TBP is usually reduced, especially in males, the degree of reduction being significantly correlated with total dose of steroids received during renal transplant rejection phases, although other factors such as duration of renal replacement therapy, duration of haemodialysis, and number of previous failed transplants are also correlated. Again, arm muscle circumference and body mass index are poor predictors of likely reduction in TBP[7].

BIA represents the most portable and least expensive technology for assessing body composition, since even bedside anthropometry can be difficult in a seriously ill or bed-ridden patient. It is however, limited by its insensitivity to changes in the hydration state of the FFM, so that the variety of formulae which exist, to convert resistance and reactance to FFm and FM, become inappropriate. Of special interest in this field is the recent development of multifrequency BIA, and its potential to measure extracellular water volume. It is possible to estimate the hydration state of the FFM using a combination of other body composition techniques, so that, in time, lists of hydration states for groups with different disorders affecting water status should become available, allowing much greater sensitivity for BIA.

Limitations, and measurement errors in body composition assessment

Clinical limitations of body composition assessment relate to lack of availability of laboratories, and lack of sensitivity of the simpler, more portable methods.

Measurement errors may be due to the observer, the instrument or to biological variation. Since the kinds of change which are being sought, often over relatively short time frames, lie close to or within error limits, it can be difficult to measure the small changes which are of clinical significance. To keep matters in perspective, it is fair to record that the kinds of observer error or instrument error associated with most body composition technologies are often smaller than the errors associated with frequently ordered biochemical tests let alone clinical assessments. Biological variation in body composition can be due to variation within and between populations, gender, age, activity, ethnicity and culture, among others. Very few of these kinds of data currently exist.

The clinical interpretation of body composition requires an appreciation of these factors in any individual, in order to evaluate the contribution of interaction between body composition change and health or disease.

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