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Body Composition Assessment

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Mammals, including man, consist of water, protein, fat, and mineral matter. The assessment of this composition can be direct or indirect. Few studies exist on the direct assessment of body composition of man. Analyses of bodies donated for medical research have been published.[1,2] A total of eight such analyses are available. They were done using gravimetric analysis methods, with discrete tissue samples held to be representative of the whole body. Gravimetric methods are those that directly measure the water content of the sample as the difference in sample weight before and after drying. Fat content is difference in tissue weight before and after solvent extraction of the sample. Mineral content (ash content) is the weight of the sample after combustion in a muffle furnace. Protein content is the amount of nitrogen in the sample multiplied by 6.25 under the assumption that most samples are 16% protein. The results of these studies are shown in Table 29.1.

Direct body composition methods are unwieldy for large animals. There is considerable sampling error because of difficulty in preparing a homogeneous body mixture for sampling. In some instances dissection data (Table 29.2) have been accumulated.[3] Direct analysis is possible for small species, i.e., rodents, but even with these species there are difficulties attributed to the preparation of a whole body homogenate and sampling errors associated with nonhomogeniety.

The indirect methods for assessing body composition are more practical. These are listed in Table 29.3. These methods do not require the death of the donor, and can be used at intervals to determine whether a given treatment has an effect on certain body components. For example, bone mass and density (the mineral component of the body) can be assessed using an instrument called a dual energy x-ray absorptiometry (DXA). This machine passes an x-ray through the body and compares the strength of the excitement of the electrons with a known excitement base. The difference in signal strength is attributed to the density of the bone through which the x-ray passes. Changes (losses) in bone mass/density can occur with age, especially in females. Interventions that interfere with this age-related loss are desirable and can be documented using DXA. For example, Deng

TABLE 29.1

Proximate Body Composition of Adult Humans

% Water	50–70
% Fat	4–27
% Protein	14–23
% Mineral	4.6–6

TABLE 29.2

Size and Body Composition of Adult Men and Women

	Men	Women
Age	57 ± 22	76 ± 15
Height (cm)	170 ± 9	158 ± 6
Weight (kg)	64 ± 14	57 ± 11
Skin (kg)	3.9 ± 1.1	3.2 ± 0.6
Adipose (kg)	13.0 ± 7.3	20.8 ± 10.0
Muscle (kg)	25.3 ± 6.7	16.4 ± 3.8
Bone (kg)	10.2 ± 1.5	7.6 ± 1.3
Residual (kg)	11.6 ± 3.5	9.3 ± 5.5
Body mass index (kg/m^2)	21.9 ± 3.7	23.2 ± 4.6

Source: Clarys JP, Martin AD, Martell-Jones MJ, et al. *Am J Hum Biol* 11: 167; 1999 (with permission).

TABLE 29.3

Indirect Methods for Determining Body Composition

Total body water: dilution of heavy water
Muscle mass: dilution of labeled creatine
Lean body mass: body content of K^{40} (requires use of whole body counter)
% Body fat: specific gravity (weight of body in air versus under water)

% Body fat, calculated: $\frac{2.118 - 1.354 - 078}{\text{density}} \times$(% total body water/body weight)

% fat = (5.548 – 5.044)/specific gravity
% fat = 100 – total body water/0.732

et al.[4] have reported that the effectiveness of hormone replacement therapy is associated with vitamin D and estrogen receptor genotypes. They documented this association with periodic DXA determinations of bone mass.

Body fat content can be calculated using either DXA or computer-assisted tomography.[5] Investigators have used this technology and compared it with the measurement of skinfold thickness, and have found a good correlation. Skinfold thicknesses are measured using calipers at designated places in the body. The most frequent are the skinfold under the upper arm, the fold over the iliac crest, and the abdominal fold. Using equations (Table 29.4), body fat stores can be estimated.

The body minus its fat store is defined as the lean body mass. This is an arbitrary designation that assumes that the fat store is not metabolically active, but it is not a correct assumption from a metabolic point of view. The adipose tissue is a very active tissue,

TABLE 29.4

General Formulas for Calculating Body Fatness from Skinfold Measurements

Males:

% Body Fat = $29.288 \times 10^{-2}(X) - 5 \times 10^{-4}(X)^2 + 15.845 \times 10^{-2}$ (Age)

Females:

% Body Fat = $29.699 \text{ X } 10^{-2}(X) - 43 \times 10^{-5}(X)^2 + 29.63 \times 10^{-3}(\text{Age}) + 1.4072$

X = sum of abdomen, suprailiac, triceps, and thigh skinfolds; age is in years.

Source: Jackson, A. S. and Pollack, M. L. 1985. *Phys Sports Med* 13: 76-90 (with permission).

having a role in the control of energy balance and a role in the food intake regulatory system. However, from the body composition point of view, these roles are ignored. Lean body mass (LBM) can be estimated if one assumes that the fat-free body has a water content of 72%. The total body water can be measured using heavy water (deuterium) as a diluent. This water distributes itself throughout the total body and through the application of the formula $C_1V_1 = C_2V_2$ the total body water can be calculated. C_1 is the concentration of the deuterium in the infusate; V_1 is the volume of the infusate. C_2 is the concentration of deuterium in the volume of blood withdrawn after a fixed interval (usually 30 minutes). One then solves for V_2, which is the volume of the total body water. The LBM is then calculated:

$$\text{LBM} = \text{total body water}/0.72$$

The details of body composition measurement have been published, and the reader is referred to these sources for further information.[6-8]

References

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