NUTRITION AND DIGESTION

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Contents

Summary

Four elements—oxygen, carbon, hydrogen and nitrogen (O, C, H, and N)—account for over 95% of body mass and together with an additional seven—sodium, potassium, phosphorous, chloride, calcium, magnesium, and sulphur (Na, K, P, Cl, Ca, Mg, and S)—they comprise over 99.5% of body mass. In order to optimize physiological body functions humans need a total of over 40 nutrients. As no single food contains all the essential nutrients, dietary recommendations encourage people to fulfil their energy requirements with a variety of foods. A positive energy balance partly due to increasingly sedentary lifestyles has made obesity the main nutritional problem in Western countries; whereas the imbalance caused by a shortage in food supply still leads to malnutrition in the developing countries. Simple anthropometric measures—weight, height, and body mass index (BMI) —are still good indicators of nutritional adequacy in a population, but more accurate methods, also suitable for epidemiological studies, are being developed for the assessment of adiposity. These include bioelectrical impedance analysis and waist circumference. Food energy is derived through the digestive processes in the gastrointestinal tract largely controlled by the nervous and endocrine systems. The mouth and stomach perform the physical and start the chemical digestion of foods thus passing it to the small intestine, the main site

for digestion and absorption. The large intestine with its microflora plays an essential role in fiber digestion and serves as the site for final resorption of water and electrolytes and some of the remaining products of digestion. In the future, ways to control and manipulate the intestinal microflora may promote both therapeutic and preventive medicine, and the use of genetic information may enable us to develop more individually tailored diets and foods with specific nutritional effects.

1. Nutrition

This chapter provides an introduction to the topics of human body composition assessment and the nutritional requirements to maintain optimal body function. The fate of food as it enters the human gastrointestinal tract is discussed in principle, however, leaving out the metabolism of the different nutrients. This chapter and the associated articles touch upon new developments and current topics in nutrition research and practice. Topics include obesity prevention and food security, the vast possibilities of molecular genetics in supporting good nutrition, and the health impacts of intestinal microflora and its connection to nutrition.

1.1. Body Composition

The human body composition can be divided into five distinct levels of increasing complexity: atomic, molecular, cellular, tissue system, and whole body. From the atomic perspective four elements—O, C, H, and N—account for over 95% of body mass and together with an additional seven—Na, K, P, Cl, Ca, Mg, and S—comprise over 99.5% of body mass. About 50 of the 106 elements found in nature are also found in the human body, and many of these are required by humans for growth and health maintenance.

Molecular level compounds comprise five main groups: water, proteins, lipids, carbohydrates, and minerals. Some commonly applied rules are that 16% of protein is nitrogen, 77% of fat is carbon, and approximately two thirds of excess body weight in adults is fat. There are also relatively stable associations with other elements and with components at higher levels. Several of these associations are (kg/kg): S/N = 0.062; N/protein = 0.16; C/triacylglycerol = 0.77; K/intracellular water = 150 mmol/liter; and H/body weight = 0.10. These known relationships allow development of body composition models for estimating unknown components, such as protein = measured N/0.16 or N x 6.25.

Estimation of body composition with some of the available methods, models and equations, such as the concentration of potassium in intracellular water, are relatively reliable in healthy individuals but prone to error in connection with disease states with altered fluid and electrolyte balance. In nutrition research, the estimation of body composition most often takes place either according to the two-compartment model (for estimation of fat mass and fat free mass), or the three-compartment model (fat + water + residual, i.e. glycogen, minerals and protein), or the four-compartment model in which minerals are separated from the residual (Figure 1).

The most recent methods for the estimation of body components include bioelectrical impedance analysis (measuring impedance to an electrical current) and dual energy X-ray absorptiometry, DXA, (attenuation of X-rays), the first being more feasible for field studies. At the tissue level, in clinical settings, the methods of choice to distinguish between subcutaneous, visceral, yellow marrow and interstitial subcomponents are computerized axial tomography (CT) and magnetic resonance imaging (MRI). While the above mentioned methods are more accurate, the simple anthropometric measurements of weight and height to derive body mass index (BMI), waist and hip circumferences and their ratio have been shown to provide the most feasible and relatively valid estimates of body composition, and adiposity in particular.

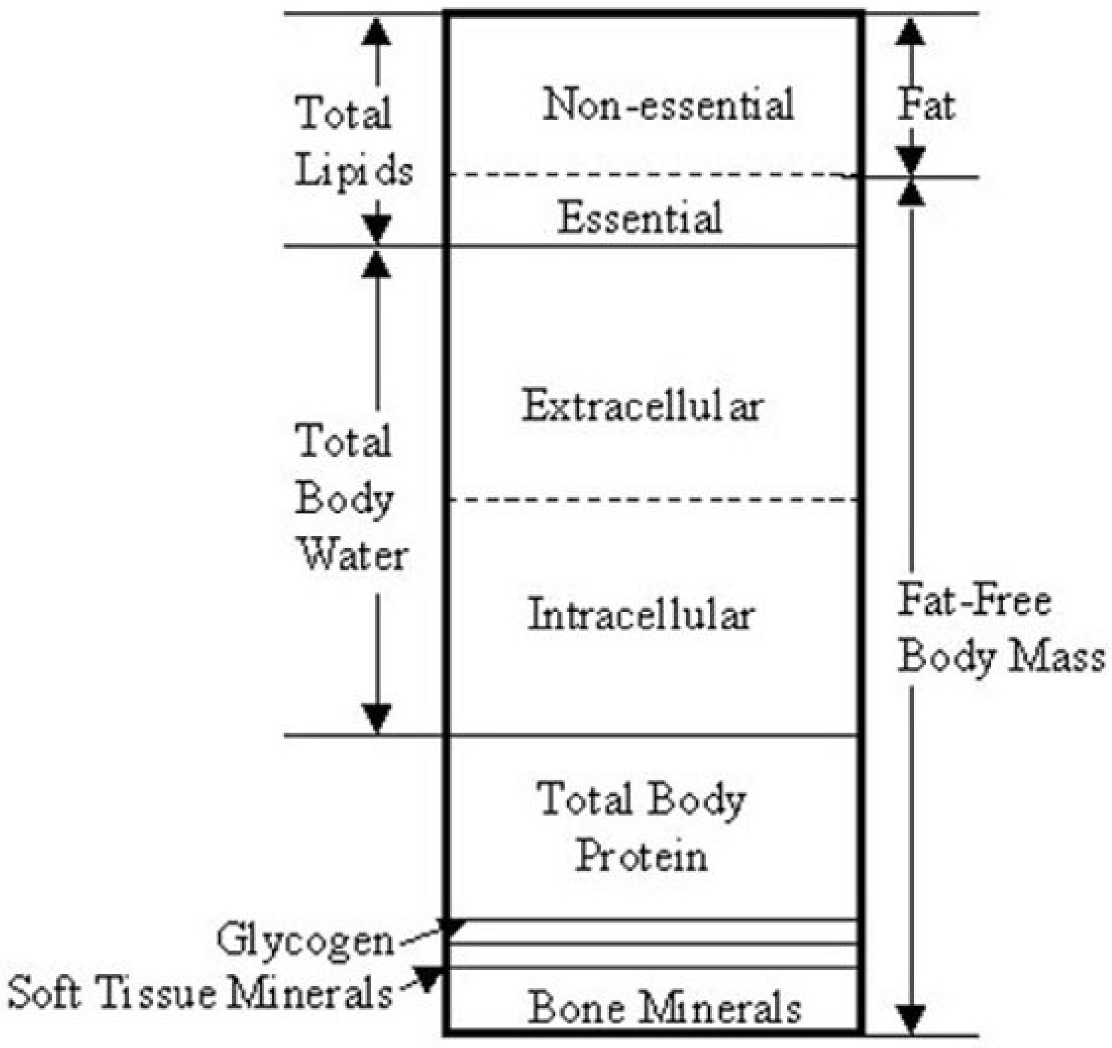

Figure 1. Body composition adapted from Heymsfield *et al*, 1997.

1.2. Nutritional Needs

Man needs oxygen, water and enough food (energy), 10 or more indispensable amino acids in proteins, essential fatty acids, e.g. linoleic acid, small amount of carbohydrate, 13 vitamins, and 18 elements scattered across the upper half of the periodic table (in addition to hydrogen, carbon, nitrogen, and oxygen). Together they add up to over 40 nutrients.

Approximated daily requirements for essential nutrients are: water (1 kg), available carbohydrate (50-100 g), protein (50 g), Na, Cl, K, and essential fatty acids (1-5 g), Ca, P (1 g), Mg (300 mg), vitamin C (50 mg), niacin, vitamin E, Zn, Fe (15 mg), Mn, pantothenate (5 mg), vitamin A, thiamin, riboflavin, vitamin B6, F, Cu (1-2 mg), folate, Mo (200 µg), biotin, I (100 µg), vitamin K, Se (50 µg) and vitamin D, vitamin B12, Cr (2-10 µg).

No single food contains all the essential nutrients. Hence a healthy diet contains foods from different food groups such as bread and cereals, fruits and vegetables, milk and milk products, meat and alternatives. The four groups are intended to minimise deficiency of important nutrients—protein, calcium, vitamin C, etc. In affluent countries, however, more disease is probably caused by too much fat, salt, and alcohol and not enough carbohydrate or fiber.

Research has demonstrated that nutrition plays a crucial role in the prevention of chronic diseases, as most of them can be related to diet. Generous intakes of saturated fat raise the plasma cholesterol concentration and contribute to coronary heart disease, and too much food energy leads to obesity. People with high salt intakes have more hypertension.

The key recommendations concerning macronutrients in developed countries are the reduction of total fat intake to 30% of total energy intake (%E) with a more severe restriction of saturated fats (to 10% of energy intake); increase of carbohydrate intake to 55% of total energy intake (with a reduction of sugars to 10% of total energy intake), increased intake of polysaccharides, and reduced intake of salt. The remaining 10-15%E is recommended to come from protein, with the usual consumption pattern of 2/3 from animal and 1/3 from vegetable sources. Supplementary use of any specific amino acid is not encouraged.

There is growing evidence that a number of micronutrients provide benefits beyond the prevention of deficiency diseases, the one traditionally considered. These benefits relate to the optimal development and maintenance of physiological functions and/or the prevention of certain degenerative diseases such as coronary heart disease, cancer and osteoporosis. The actions of mechanisms include, for example, antioxidative effects, effects on biotransformation, cell formation and differentiation, and metabolism.

The energy requirement of an individual is difficult to predict due to substantial differences in basal needs and physical activity. Hence Average Intakes for groups have been calculated as the mean + 15% variation, as discussed in *Nutritional Needs*. Average intakes for groups are based on extensive data relating to the basal metabolic rate of individuals of different ages but on very limited information on the average and range of physical activity patterns. Reference values for macro and micronutrient intakes and energy intakes are presented in *Nutritional Needs*.

1.4. Over and Undernutrition

Nutritional goals and guidelines are set to prevent the social and pathological consequences of both energy deficit and excess. In Western countries, the principal concern in relation to energy is overweight and obesity rather than that of underweight and malnutrition common in developing countries. Excess weight is associated with increased mortality and morbidity, and it increases risk of arthrosis, gallbladder disease, diabetes, coronary heart disease, hypertension, stroke and increased risk of some cancers. The risk can be avoided, if energy intakes and expenditure are matched within a desirable weight range. This has been defined as equivalent to a body mass index (BMI) of about 20-25.

Micronutrient malnutrition has been virtually eliminated or taken under control in the Western world and Europe, although deficiencies of many nutrients still remain public health problems in the developing world, e.g. lack of iodine, iron and vitamin A. One must, however, keep in mind that especially elderly people may have unbalanced diets in all countries due to reasons such as poor appetite, limited physical or mental capacity or access to food stores. Variability among individuals is also great.

Maintaining physical fitness promotes well-being and helps to prevent chronic diseases such as coronary heart disease, osteoporosis and muscle wasting in old age. Based on World Health Organization (WHO) recommendations, maintenance of good physical health that promotes overall health status requires regular exercise for about half an hour per day or more demanding exercise such as bicycling, jogging or ball games for 20-25 minutes at least three times per week.

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Biographical Sketches

Anna-Liisa Rauma was born in 1958 in Mikkeli, Finland. She obtained her MSc in Nutrition in 1983, at the University of Helsinki, Finland, and a PhD in Nutrition in 1996, from the University of Kuopio, Finland. She has won additional academic distinctions—advanced studies in microbiology, general toxicology and education.

Her master's research involved the determination of nutrient content of sprouted beans and seeds and in the doctoral research she studied pure vegetarians, their nutritional status and biotransformation. After her masters degree she worked for five years as a registered dietetian. After that she has made an academic career in university life, first as a PhD researcher and then as an associate professor in home economics. Currently she works as a professor at the Department of Education at the University of Joensuu, Savonlinna, Finland, her research focusing on nutrition education and nutrition ecology.

Irja Haapala was born in 1961 in Helsinki, Finland. She obtained her M.S. in Clinical Nutrition in 1992 from the University of Kuopio, Finland and a Ph.D. in Nutrition in 2001, from Pennsylvania State University. Additional diplomas: Teacher's Certification in 1995, the Vocational Teacher Education College of Jyväskylä, Finland, and Secretarial Diploma in 1983 from the the International Business College in El Paso, Texas, USA.

Her master's research involved the assessment of the nutritional status and nutritional intake of Finnish high school athletes. As a Fulbright fellow at the Pennsylvania State University, she focused her research interest on the pedagogical and didactic aspects of nutrition education. In her doctoral research, she compared the effectiveness of face-to-face and computer-mediated cooperative learning in teaching food safety internationally and nationally in the U.S.A.

Currently she works as assistant professor at the Department of Public Health and General Practice at the University of Kuopio, Finland, her research focusing on nutrition education campaigns and interventions using interactive technology and on nutrition epidemiology.