ETHNIC DIFFERENCES IN BODY COMPOSITION

- The study of body composition relies, to a large extent, on observations in relatively small groups of subjects, and the development of rules and models for generalization on a larger scale. Body fat is the most variable body component among subjects, whereas the fat-free mass (body weight minus body fat) has, from the chemical point of view, a relatively constant composition.
- Carcass analyses in the mid-20^{th} century revealed that the main components of the fat-free mass at the molecular level are water, minerals and protein in relatively constant amounts. This composition forms the basis of many in-vivo methods for body composition that are widely used today, such as densitometry, deuterium oxide dilution, and whole body, radioactive-potassium (^{40}K) counting. These methodologies used constant factors that are assumed to be applicable to all humans.
- Densitometry, deuterium oxide dilution, and ^{40}K counting require instrumentation that is expensive and not easily available in all laboratories. Therefore, many predictive methods have been developed with the general features of being simple, inexpensive and easily applicable to large groups of subjects. Such methods assume a constant relationship between easily measurable body parameters and a method of reference. Some examples are skinfold thickness, body circumference, bioelectrical impedance, and the body mass index (BMI), which are used as surrogate measures of body fatness.
- The development of most body-composition methods has been done in the USA and Europe with Caucasian subjects, and developed models and rules are generally applied to other ethnic groups, assuming similar relationships. But practically, these models and rules require revision before they can be applied to non-Caucasian subjects as there are differences in body composition between ethnic groups.
- **Densitometry:** The basic principle of densitometry is the assumption that the body consists of two components, a fat mass (FM) and a fat-free mass (FFM), each of which has its own constant density of 0.9 kg/l and 1.1 kg/l, respectively. The density of the total body (determined by water displacement, air displacement or underwater weighing) thus reflects the composition in terms of FM and FFM. There are differences

in the composition of the FFM across gender and age groups and also among ethnic groups. It is now generally accepted that African-Americans have a higher bone mineral density and bone mineral content than whites, and that their muscle mass is higher, leading to a higher density of the FFM. The consequence of this is that the Siri formula normally used to calculate the body-fat percentage (BF %) from density underestimates the body-fat percentage significantly. Similarly, Chinese, Malays and Indians (from Singapore) have a different FFM composition relative to that of Caucasians, resulting in under estimations of BF% obtained by density and use of Siri's formula.

- **^{40}Potassium counting:** Whole-body ^{40}K counting assumes that there is a constant proportion of potassium in the FFM, this being determined by gamma emission of naturally abundant ^{40}K. The potassium content of the body among African-Americans is found to be higher than that among Caucasians, leading to biased values for muscle mass, body cell mass or FFM when the normal rules for calculating body composition from ^{40}K are applied.
- **Skinfold thickness:** The skinfold methodology assumes that the thickness of the subcutaneous adipose tissue is representative of the total amount of body fat. Another assumption is, that for a given age and gender, the distribution of the subcutaneous fat layer is constant. However, there are differences in subcutaneous fat patterning among ethnic groups. For example, in blacks and Hispanics, the contribution of truncal skinfolds to total skinfold thickness is higher than that in Caucasians. Recently, small differences between Chinese and Caucasian subjects were also reported. In addition, it is questionable as to whether a prediction equation can be used at all, as the method of reference could be invalid for the group under study. Indiscriminate application of 'Caucasian' prediction equations to other ethnic groups may therefore result in biased estimates of BF%.
- **Waist circumference and waist/hip circumference ratio:** The waist circumference (WC) and the waist/hip circumference ratio (WHR) are used as predictors for body-fat distribution, more specifically as indicators of intra-abdominal (visceral) fat deposition. There are many studies showing that the relationship between these parameters and

the actual amount of intra-abdominal fat differs between groups, and it is now generally believed that African-Americans have less visceral fat than matched (for age, BMI, circumference ratios) Caucasian Americans. In comparing the NHANESIII (National Health And Nutrition Examination Study III) data, a study by Okusun et al. (2000) concluded that, for the same apparent body fatness (BMI), Caucasians have a higher WC than Mexicans and African-Americans. Data from the MONICA (Monitoring trends and determinants in cardio-vascular disease) study suggest that the relationship between WC and risk factors for cardiovascular disease are different among (ethnic) population groups, which indicates, in fact, a different amount of visceral fat for the same WC.

- **Bioelectrical impedance analysis:** The bioelectrical impedance of the body is, to a large extent, determined by the impedance of the limbs. Generally, the length of the conductor affects impedance, and there are clear differences in limb length between ethnic groups at all ages. This is the main reason that prediction formulae based on bioelectrical impedance are ethnically specific, as was found in many studies. Also, the use of so-called 'segmental' impedance measurements (for example foot-to-foot impedance or hand-held impedance) is dependent upon the lengths of the limbs. Differences in validity of predicted BF% using hand-held impedance among different ethnic groups could be explained by differences in relative arm length between the groups. For this reason, there should be careful interpretation of results from studies in which body compositions of different ethnic groups are compared using bioelectrical impedance analysis.
- **Body Mass Index and adipose tissue distribution:** There are clear ethnic differences in BMI and adipose tissue distribution. It is well known that there is a marked difference in regional adipose tissue distribution among various populations worldwide. This ethnic difference also applies to intra-abdominal adipose tissue accumulation. Some populations are more likely to accumulate adipose tissue in the subcutaneous adipose depots whereas other populations are more likely to accumulate adipose tissue in the intra-abdominal cavity, placing them at higher risk of developing obesity-related

complications. It is therefore crucial that public health authorities around the world identify cases of high-risk obesity associated with excess intra-abdominal fat.

- The impact of ethnicity on body fat mass in the U.S. population has been studied by McTigue et al. using the National Longitudinal Survey of Youth 1979, a national U.S. study of 9,179 individuals with over sampling of minority ethnic groups. They observed significant ethnic differences in body weight, with black and Hispanic populations at highest risk of obesity when compared to white populations. Obesity onset was 2.1 and 1.5 times faster for black and Hispanic women respectively when compared to white women. The obesity onset pattern for men was slightly different, with Hispanic men being at highest risk.
- World Health Organization (WHO) expert committee has recommended using body mass index (BMI)—the ratio of weight in kilograms divided by height in meters squared—as an index of relative body weight linked to an increased risk of disease. They proposed a BMI cut-off value of 25 kg/m^2 (but below 30 kg/m^2) to define overweight. They also reported that a substantial proportion of Asian people were at increased risk of type 2 diabetes and cardiovascular disease (CVD) at BMI values lower than the proposed WHO overweight cut-off point of ≥25 kg/m^2.
- Furthermore, a meta-analysis of 32 studies has revealed that mean BMI values (kg/m^2) were 21.3 for Ethiopians, 22.2 for Chinese, 22.4 for Indonesians, 23.0 for Thais, 24.1 for Caucasians, 25.7 for Blacks, and 29.7 for Polynesians. BMI therefore differs significantly among populations of the same age, gender, and body fatness.
- Moreover, in Asian populations, a higher body fat content was reported at a lower BMI when compared to Caucasians. These significant ethnic differences in mean BMI may be explained by differences in energy balance as well as intrinsic differences in body composition. In light of this, the general WHO obesity cut-off point of 30 kg/m^2 can no longer be applied worldwide without taking into account ethnicity. Revised BMI cutoff points to define obesity have been suggested for South Asians, Chinese and Aboriginals. In fact, cut-off BMI values defining obesity in relation to glucose and lipid levels and

blood pressure, three significant CVD risk factors, were found to be much lower for these populations than values traditionally used for people of European origin.

- Marked differences have also been reported regarding susceptibility to abdominal obesity. Available data suggests that Blacks are more prone to subcutaneous fat accumulation for a given BMI than Whites, whereas Asians are especially prone to intra-abdominal fat accumulation. Studies have suggested that genetic predisposition as well as environmental and lifestyle factors may explain differences among various ethnic groups in their susceptibility to abdominal fat accumulation, intra-abdominal fat in particular.
- For a similar level of total body fat, white subjects have been shown to have more intra-abdominal adipose tissue than Blacks. When white and black men with the same total body fat mass are compared, white men have significantly more intra-abdominal (visceral) fat than black men. Black women generally have higher total body fat mass but less intra-abdominal adipose tissue than white women. This means black women are more prone to “subcutaneous obesity” than white women.
- On the other hand, Japanese individuals are more likely to accumulate intra-abdominal fat compared to white individuals, despite the fact that they have substantially less total body fat than their American counterparts. This difference in susceptibility to intra-abdominal adiposity may be one factor behind the high rate of type 2 diabetes in Asia.