Body composition of Chinese compared with data from North America

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A multiple tracer dilution method measuring total body water (TBW) and extra cellular water (ECW) was used to study body composition. Healthy Chinese were compared to a group of healthy Americans evaluated by similar dilutional methods. Compared to the American subjects, Chinese subjects were less heavy (body weight was 62.1± 2.0 kg vs 72.5± 4.1, $P<0.05$), leaner (body fat was 19.6.± 1.8% of body weight vs 25.8± 1.9, $P<0.005$), wetter (total body water was 58.9± 1.3% vs 54.3± 1.4, $P<0.005$) and had a greater percentage of body cell mass (50.9± 1.7% vs 44.2± 1.4, $P<0.001$). The multidilution method using deuterium oxide and sodium bromide to assess body composition is accurate but expensive and laborious. Therefore, equally precise but more economical bedside methods are needed for routine compositional analysis.

Introduction

Body compositional data obtained from healthy North American subjects studied with various techniques are widely available. The effect of disease on intercompartmental relationships has been studied in main western societies[1–3]. Less is known about body composition of Asian populations such as the Chinese or Japanese. The genome of Oriental people is derived from a different 'genetic pool', and Asian people have different dietary customs compared to North Americans. The principal energy source in China is rice or wheat which contains much less fat calories than the usual American diet[4]. Since food intake influences body composition, long-term differences in dietary intake may be reflected in differences in body composition. Although it is acknowledged that Chinese people have a lower mean body weight and less fat compared to North American Caucasians, it is not known whether all body compartments are proportionally decreased. A group of Chinese subjects in Taiwan studied using densitometric and anthropometric methods showed lower fat percentages compared to Americans.

In the present study, body composition data were obtained from a group of healthy male and female individuals and from surgical patients in the Beijing area of China. These data were then compared to compositional data previously obtained in a North American population[1].

Subjects and methods

Subjects

The healthy Chinese group consisted of 22 subjects; physical examinations and routine laboratory tests showed no abnormalities.

The protocol was approved by the Academic Committee of the Peking Union Medical College Hospital serving as the Institutional Review Board for the hospital. Consent to participate in the study was obtained from all subjects. The American data (n = 10) had been reported in a publication from authors at the Harvard Medical School[1].

Methods

If a known amount of a substance ('tracer') is injected into the body and allowed to equilibrate within the compartment in which the tracer is known to distribute exclusively, the volume of this compartment can be calculated from a venous blood sample. Multiple tracers were simultaneously injected and allowed to equilibrate in various body fluid compartments. The concentrations of these tracers were then determined and the volume of the various compartments calculated[1–14].

Tracers. 1. Pyrogen–free deuterium oxide (D_2O, 99.6% purity, 40–50 ml, autoclave sterilized solution, Sigma, St Louis, MO, USA) was used for measurement of total body water. 2. Pyrogen–free sodium bromide (4% NaBr, 20ml, autoclave sterilized solution, GR grade E. Merck, Germany) was used for extracellular water (ECW) measurement.

Sampling procedure. Deutrium oxide and sodium bromide were simultaneously injected intravenously within a 15–minute time period using a syringe pump. The volume of the tracers injected was determined by subtracting the weight of the empty syringes from the original weight of the syringes containing the tracers (Mettler Balance, Model AE 163, Basle, Switzerland).

For TBW venous blood samples (2 ml) were taken at two

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and three hours after injection of the D_2O. The serum samples underwent double vacuum distillation at –70 °C to obtain the pure water fraction. The content of D_2O in this sample was determined using the 'falling drop technique' as described by Schloerb[5]. A 125–litre thermal static water bath was used while the temperature variation was kept within ± 0.0 005 °C . The accuracy of the 'falling drop method' is ± 0.5%. The error of repeated determination of TBW is 2.2%[6].

For ECW blood samples (4 ml) were taken at two and three hours after injection of NaBr. Serum was heated in a nickel cruicible at 600 °C for a half hour to remove the organic matter which could interfere with the bromide determination as described by Hunter[7,8]. The method is based on the conversion of bromide into tetrabromorosaniline, which is measured calorimetrically. The accuracy is ± 1%; the total error of repeated determination is ± 2.3%[2].

Abbreviations. BW = Body weight; TBW = Total body water; ECW = Extracellular water; ICW = Intracellular water; TBF = Total body fat; LBM = Lean body Mass; V = Volume (tracer); V' = Volume (measured compartment); C= Concentration; C' = Concentration in blood.

Data analysis. Personal computers (Macintosh) using standard statistical software (StatView) were used to analyse data. Student t-tests were applied to evaluate differences between groups. Significance was accepted at the $P<0.05$ level. The results were expressed as means ± sem.

Results

When body composition in the healthy Chinese males and females were examined, most of the compartments were larger in males than in females (Table 1). In contracts, when the percent of body fat was calculated, the males were lower compared to the females (TBF %BW = 19.6± 1.8 vs 25.5± 1.4, $P<0.05$). Also, the relative ECW was significantly lower in males than in females (23.3± 0.5% vs 25.6± 0.7, $P<0.05$). The relative plasma volume was not statistically different between groups.

Table 2 shows data of healthy Chinese males, as well as data on American males published by Moore[1]. The groups were similar with respect to age (35.7 yrs vs 36.8). Chinese males were lighter (BW was 62.1±2.0kg vs 72.5± 4.1, $P<0.05$), wetter (TBW was 58.9± 1.3% vs 54.3± 1.4, $P<0.05$) and leaner (TBF was 19.6± 1.8% vs 25.8± 1.9, $P<0.05$). Since ECW was not different between the two groups, the difference in TBW was due to an expansion of the ICW (35.6± 1.2% vs 30.9± 3.0, $P<0.0$ 1).

Similar results were found with Chinese and American females (Table 3). Chinese females were lighter (BW was 46.4± 1.8kg vs 59.3± 3.1, $P< 0.01$) and wetter (54.6± 1.1% vs 48.6± 1.5, $P<0.01$) than their American peers. Unlike the males, the difference in TBW was composed of both ICW and ECW. Healthy Chinese females had less fat (25.5± 1.4% vs 33.6± 2.0, $P<0.01$).

Table 1. Comparison of healthy Chinese males and females.

	Male Chinese (n=15)	Female Chinese (n=7)	*P*
Age (yr)	36±3	26±5	=0.05
Height (cm)	170±1	155±1	<0.001
Body weight (kg)	62.1±2.0	46.4±1.8	<0.001
TBW (l)	36.4±1.0	25.4±1.3	<0.001
TBW (% BW)	58.9±1.3	54.6±1.1	<0.05
ECW (l)	14.4±0.5	11.8±0.4	<0.005
ECW (% BW)	23.3±0.5	25.6±0.7	<0.02
ECW (% TBW)	39.7±0.9	47.1±1.8	<0.001
ICW (l)	22.0±0.8	13.5±1.1	<0.001
ICW (% BW)	35.6±1.2	29.0±1.4	<0.005
ICW (% TBW)	60.3±0.9	52.9±1.8	<0.001
BCM (kg)	31.4±1.1	19.3±1.5	<0.001
BCM (% BW)	50.9±1.7	41.4±2.0	<0.01
LBM (kg)	49.7±1.4	34.6±1.8	<0.001
LBM (%BW)	80.4±1.8	74.5±1.4	<0.05

Table 2. Differences between healthy Chinese and American males.

	Chinese (n=15)	American (n=10)	*P*
Age (yr)	36±3	37±4	=0.9
Body weight (kg)	62.1±2.0	72.5±4.1	<0.02
TBW (l)	36.4±1.0	39.0±1.8	=0.2
TBW (% BW)	58.9±1.3	54.3±1.4	<0 .05
ECW (l)	14.4±0.5	16.8±0.8	<0.02
ECW (% BW)	23.3±0.5	23.4±0.7	=0.9
ECW (% TBW)	39.7±0.9	43.1±0.7	<0.02
ICW (l)	22.0±0.8	22.2±1.1	=0.8
ICW (% BW)	35.6±1.2	30.9±3.0	<0.01
ICW (% TBW)	60.3±0.9	56.9±0.7	<0.02
BCM (kg)	31.4±1.1	31.8±1.6	=0.8
BCM (% BW)	50.9±1.7	44.2±1.4	<0.01
LBM (kg)	49.7±1.4	53.3±2.5	=0.2
LBM (%BW)	80.4±1.8	74.2±1.9	<0.05

Table 3. Comparison between healthy Chinese and American females.

	Chinese (n=7)	American (n=10)	*P*
Age (yr)	26±.5	34±3	=0.2
Body weight (kg)	46.4±1.8	59.3±3.1	<0.01
TBW (l)	25.4±1.3	28.5±0.9	=0.06
TBW (% BW)	54.6±1.1	48.6±1.5	<0.01
ECW (l)	11.8±0.4	13.4±0.5	<0.05
ECW (% BW)	25.6±0.7	22.7±0.6	<0.01
ECW (% TBW)	47.1±1.8	46.9±0.5	=0.9
ICW (l)	13.5±1.1	15.1±0.5	=0.2
ICW (% BW)	29.0±1.4	25.9±1.0	=0.01
ICW (% TBW)	52.9±1.8	53.1±0.5	=0.9
BCM (kg)	19.3±1.5	21.6±0.7	=0.2
BCM (% BW)	41.4±2.0	37.0±1.4	=0.1
LBM (kg)	34.6±1.8	38.9±1.3	=0.06
LBM (%BW)	74.5±1.4	66.4±2.0	<0.01

Discussion

In this study, various fluid compartments were measured using a multitracer dilution method. Results were used to calculate relatively 'solid' compartments such as fat. However, the standard for determining absolute composition is the use of direct analytical techniques following cadaver desiccation. All other methods use various assumptions and therefore introduce potential errors which may eventually generate inaccurate compositional data. Equations derived from animal studies or healthy populations[1] should be ideal in predicting body composition in corresponding populations. However, these equations may not be applicable in other (patient) populations. Deuterium oxide is a naturally occurring isotope of water[14] and is considered an accurate dilution

indicator for the measurement of TBW. After intravenous or oral administration, D_2O equilibrates with all body water after two hours[15]. Although the 'falling drop' method to measure D_2O is accurate, it is time consuming and therefore not the ideal method. Recently nuclear magnetic resonance (NMR) has proven to be an accurate and rapid method of measurement of D_2O concentrations in body fluids[16]. Sodium bromide is also a nonradioactive substance and used as a dilutional indicator to measure the extracellular phase of body water[17]. The multitracer dilution method used in this study is accurate but time consuming and laborious. More inexpensive and precise methods are needed so that compositional analysis can be applied as a clinical tool.

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中國人的身體組成並與北美數據相比較

摘要

作者用一種多示踪物稀釋法測定全身水份（TBW），細胞外液來研究身體組成。用相似稀釋法評估了一組健康中國人和健康美國人。與美國人比較，中國人體重較少（中國人體重爲 62.1±2.0 公斤；而美國人爲 72.5±4.1 公斤，$p<0.05$）、較瘦（中國人體脂佔體重 19.6±1.8%；而美國人體脂佔體重 25.8±1.9%，$p<0.05$）、較濕潤（中國人全身水份爲 58.9±1.3%；而美國人爲 54.3±1.4%，$p<0.05$）、身體細胞質量佔較大的百份率（中國人爲 50.9±1.7%；而美國人爲 44.2±1.4%，$p<0.05$）。

用重水和溴化鈉多稀釋法來評估身體組成是準確的，但較昂貴和花費精力。因此，同樣精確但經濟的其它常規身體成份分折法是需要的。