Total body water, total exchangeable sodium and related variables in the Ghanaian

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Summary

1. Standard radioisotope dilution techniques employing [3H]water and [22Na]sodium chloride have been used to determine the total body water and total exchangeable sodium of 20 male and 10 female normal Ghanaians (Africans) aged 19–25 years.

2. Lean body mass and total body fat are calculated as a percentage of body weight; the total exchangeable sodium values have been expressed in relation to lean body mass.

3. Comparison of the data for Ghanaian subjects with published figures for Caucasian subjects of similar age shows that the Ghanaian men have much less total body fat and the women a little less total body fat than their Caucasian counterparts.

4. Total exchangeable sodium expressed in terms of lean body mass shows close agreement in both men and women.

Key words: exchangeable sodium, lean body mass, total body fat, total body water.

Introduction

We undertook this study to obtain baseline data, hitherto unavailable on the normal Ghanaian, so as to form a basis of comparison for similar information in various disease states in the West African and also to compare values in the West African with similar values in Caucasians. We report here data on total body water, total exchangeable sodium and other variables that relate to these in the normal Ghanaian. The measurements were made with standard radioisotope dilution techniques with [3H]water and [22Na]sodium chloride.

Method

We studied 30 normal young Ghanaian adults: 20 men aged 19–25 years, and 10 women, aged 19–23 years. All were medical students living in a students’ hostel, and all ate the same diet in similar quantities.

Stock solutions of [3H]water and [22Na]sodium chloride were diluted with distilled water and isotonic sodium chloride solution respectively to provide working solutions containing 50 µCi of [3H/ml and 2 µCi of [22Na/ml. Diluted standards were prepared by making up 5 ml of these working solutions to 1 litre, with tap water and isotonic sodium chloride solution respectively. A dose for oral administration was prepared consisting of exactly 5 ml of each of the two working solutions, each dose containing 250 µCi of [3H and 10 µCi of [22Na.

After the dose, all urine was collected into polythene bottles for 24 h. The volume of the pooled urine was recorded and a 5 ml portion was saved for the determination of the [22Na content. Six hours after the dose venous blood was sampled,
plasma being used to determine the equilibrium $^3$H concentration. At 24 h 10 ml of blood was withdrawn into a heparinized bottle, which was centrifuged immediately. A portion (2 ml) of the plasma was transferred into a polythene bottle for the determination of total sodium concentration by flame photometry. Another 2 ml of plasma was used to determine the equilibrium $^{22}$Na concentration. A detailed record was kept of all food and drink taken in during the 6 h after the dose; from this the fluid intake during that period was estimated.

In the first six cases studied, the 6 h plasma samples were distilled at atmospheric pressure in a 50 ml capacity still to yield plasma water. In all the others, the 6 h plasma samples were heated in a water bath at 100°C for 10 min to coagulate the plasma proteins and then filtered through Hemmings filters at 4000 $g$ for 10 min to yield a protein-free filtrate.

The $^3$H radioactivities in the plasma water and diluted standard were assayed by mixing 1 ml of each with 10 ml of a commercial scintillation cocktail and measuring in a three-channel automatic liquid-scintillation spectrometer system. The results were corrected for quenching by the channels ratio method. The $^{22}$Na radioactivities in the plasma, urine and diluted standards were determined by measuring 2 ml portions in an automatic well-type Nal spectrometer system. Counts of at least 10 000 were recorded for all samples and standards. The contribution from $^{23}$Na was negligible in all $^3$H measurements.

**Calculations.** Total exchangeable sodium, total body water and the derived variables were calculated as in standard texts (Haxhe, 1971) except that the final values of total body water have been corrected by subtracting the estimated water intake during the 6 h equilibrium time.

**Results**

The results are presented in Table 1, in which the mean values of the various variables are compared for Ghanaian men and women with values for Caucasians of the same mean body weight as calculated from Moore's regression equations for either sex for the age range 16–30 years (Moore, Olsen, McMurrey, Parker, Hall & Boyden, 1963), namely: total body water ($l$) = 13.26 + 0.404 body weight (kg) and total exchangeable sodium (mmol) = 14.14 + 21.08 body weight (kg) (males); total body water = 11.63 + 0.318 body weight (kg) and total exchangeable sodium = 12.08 + 18.02 body weight (kg) (females). (The individual data from which the mean values were calculated have been deposited as Clinical Science and Molecular Medicine Table no. 77/22 with the Librarian of the Royal Society of Medicine, 1 Wimpole Street, London W1M 8AE, from whom copies can be obtained on request.)

In view of the fact that Moore's regression equations do not accurately predict values for the Ghanaian subjects, other equations have been derived to describe our results. These are: total body water = 1.96 + 0.667 body weight and total exchangeable sodium = 323.8 + 42.27 body weight (males); total body water = 9.44 + 0.396 body weight (females); total body weight = 9.44 + 0.396 body weight (males); total body weight = 9.44 + 0.396 body weight (females).

### Table 1. Comparison of data for males and females from the present study (Ghanaian) with values obtained from regression equations* for age range 16–30 years (Moore et al., 1967) in Caucasians

<table>
<thead>
<tr>
<th>Variable</th>
<th>Males</th>
<th>Females</th>
<th>Significance of differences (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ghanaian (n = 20)</td>
<td>Caucasian (n = 10)</td>
<td></td>
</tr>
<tr>
<td>BW (kg)</td>
<td>59.2</td>
<td>54.7</td>
<td></td>
</tr>
<tr>
<td>TBW (ml)</td>
<td>41 430</td>
<td>37 180</td>
<td></td>
</tr>
<tr>
<td>TBW (ml/kg BW)</td>
<td>700.2 ± 41.3</td>
<td>572.4 ± 47.9</td>
<td>&lt;0.002 &lt;0.01 &lt;0.001</td>
</tr>
<tr>
<td>TBW (ml/1.73 m$^2$)</td>
<td>41 820 ± 3330</td>
<td>34 180 ± 2170</td>
<td>&lt;0.001 &lt;0.05 &lt;0.001</td>
</tr>
<tr>
<td>LBM (kg)</td>
<td>56.6</td>
<td>42.4</td>
<td>&lt;0.002 &lt;0.01 &lt;0.001</td>
</tr>
<tr>
<td>TBF (% BW)</td>
<td>4.4 ± 5.6</td>
<td>21.8 ± 6.5</td>
<td>&lt;0.001 &lt;0.05 &lt;0.001</td>
</tr>
<tr>
<td>TENa (mmol)</td>
<td>2827</td>
<td>2347</td>
<td>&lt;0.001 &lt;0.01 &lt;0.001</td>
</tr>
<tr>
<td>TEna (mmol/kg BW)</td>
<td>47 80 ± 2.85</td>
<td>43 13 ± 2.46</td>
<td>&lt;0.001 &lt;0.01 &lt;0.001</td>
</tr>
<tr>
<td>TEna (mmol/kg LBM)</td>
<td>50 10 ± 3.72</td>
<td>55 35 ± 3.34</td>
<td>&lt;0.005 &lt;0.1 &lt;0.001</td>
</tr>
</tbody>
</table>

* TBW = 13.26 ± 0.404 BW, TENa = 1414 ± 21.01 BW (males); TBW = 11.63 ± 0.318 BW, TENa = 1208 ± 18.02 BW (females).
body weight and total exchangeable sodium = 
519.3 + 33.42 body weight (females). These 
equations have correlation coefficients of 0.87,  
0.86, 0.83 and 0.93 respectively.

Discussion

The differences between the sexes in both the 
young Ghanaians and Caucasians are similar for 
all the quantities measured. Although the total 
exchangeable sodium was decidedly higher in the 
Ghanaian subjects, both men and women, than in 
their Caucasian counterparts, good agreement is 
obtained when these are related to lean body mass 
as emphasized by various authors (Haxhe, 1971; 
Moore et al., 1963). The differences between the 
Ghanaian and Caucasian males are much greater 
than the corresponding differences between the 
females. In terms of these variables, therefore, 
Ghanaian and Caucasian females are more alike 
than are Ghanaian and Caucasian males.

The various differences may be attributed, in 
part, to obvious differences in diet.

The use of $^{22}$Na instead of the short-lived $^{24}$Na 
was dictated by logistic difficulties. This resulted in 
an average whole-body absorbed radiation dose of 
about 190 mrad, as compared with the 17 mrad 
delivered by the same amount of $^{24}$Na (Vennart & 

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