A Simplified Method for Calculation of Total Body Volume in Men : with reference to body composition

Yuji TAKASAKI[1], Masahiro YAMASAKI[2] and Akio KAMATAKI[3]

1) Department of Public Health, School of Medicine, Showa University, Hatanodai, Shinagawa-ku, Tokyo, 142 Japan
2) Department of Physiology, Institute of Constitutional Medicine, Kumamoto University, Kuhonji, Kumamoto, 862 Japan
3) Department of Administration Engineering, Fukuoka Institute of Technology, Wajiro, Higashi-ku, Fukuoka, 811-02 Japan

Underwater weighing or potassium counting provides the reliable estimation of body composition, but these procedures are not practical in population studies. Though body composition is often calculated from skinfolds, the technique of skinfold measurement must be standardized. On the other hand, height and weight are typical items of morphological measurements because of their availability and they had been generally obtained in the most of studies. Therefore, if possible, it is meaningful to estimate body composition from these two variables. This estimation has the disadvantage that height and weight take no account of body composition, but they are good items to indicate total body volume. If we get total body volume, body fatness can be calculated. Thus, it is reasonable to begin with constructing a equation for total body volume in order to estimate body composition. The present study was attempted to demonstrate the validity of equations for predicting total body volume from only height and weight.

The date were collected from 30 men, ranged from 19 to 25 years old. The mean values and standard deviations of the height, weight, and total body volume were 171.0 cm, 4.9 cm, 62.97 kg, 8.23 kg, and 58.77 liters, 8.22 liters, respectively. Total body volume was obtained from dividing weight by body density employing underwater weighing technique.

Equations to express total body volume can be constructed by some regressions such as multiple regression equations of variables combining height and weight on total body volume. However, an equation has only to have small error of estimation. From viewpoints of allometry and dimensional analysis, a simple form was expressed as $Y = AH^a W^b$ like a formula for body surface area. Constants of A, a, and b were calculated by applying the equation to the data of 30 subjects whose volume, height, and weight had been measured in the laboratory. As a result, the equation of total body volume on height and weight was calculated as

$$V = 1.5748\,W^{1.0707}/H^{0.1588}$$

where V, W and H are total body volume in liters, weight in kilograms, and height in centimeters, respectively. From the values of a and b on the right side of the equation, calculated dimension 3.0533 was nearly equal to tridimension for

Table 1. Conversion tables of total body volume (lit) from height (cm) and weight (kg).

weight in kg

height in cm	45	46	47	48	49	50	51	52	53	54
155	41.6	42.6	43.6	44.6	45.6	46.6	47.6	48.6	49.6	50.6
156	41.6	42.6	43.6	44.6	45.6	46.6	47.6	48.6	49.6	50.6
157	41.6	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	50.5
158	41.5	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	50.5
159	41.5	42.5	43.4	44.4	45.4	46.4	47.4	48.4	49.4	50.4
160	41.4	42.4	43.4	44.4	45.4	46.4	47.4	48.4	49.4	50.4
161	41.4	42.4	43.4	44.3	45.3	46.3	47.3	48.3	49.3	50.3
162	41.3	42.3	43.3	44.3	45.3	46.3	47.3	48.3	49.3	50.3
163	41.3	42.3	43.3	44.3	45.3	46.2	47.2	48.2	49.2	50.2
164	41.3	42.2	43.2	44.2	45.2	46.2	47.2	48.2	49.2	50.2
165	41.2	42.2	43.2	44.2	45.2	46.2	47.1	48.1	49.1	50.1
166	41.2	42.2	43.2	44.1	45.1	46.1	47.1	48.1	49.1	50.1
167	41.1	42.1	43.1	44.1	45.1	46.1	47.0	48.0	49.0	50.0
168	41.1	42.1	43.1	44.1	45.0	46.0	47.0	48.0	49.0	50.0
169	41.1	42.0	43.0	44.0	45.0	46.0	47.0	47.9	48.9	49.9
170	41.0	42.0	43.0	44.0	44.9	45.9	46.9	47.9	48.9	49.9
171	41.0	42.0	42.9	43.9	44.9	45.9	46.9	47.9	48.8	49.8
172	41.0	41.9	42.9	43.9	44.9	45.8	46.8	47.8	48.8	49.8
173	40.9	41.9	42.9	43.8	44.8	45.8	46.8	47.8	48.8	49.7
174	40.9	41.9	42.8	43.8	44.8	45.8	46.7	47.7	48.7	49.7
175	40.8	41.8	42.8	43.8	44.7	45.7	46.7	47.7	48.7	49.6
176	40.8	41.8	42.8	43.7	44.7	45.7	46.7	47.6	48.6	49.6
177	40.8	41.7	42.7	43.7	44.7	45.6	46.6	47.6	48.6	49.6
178	40.7	41.7	42.7	43.6	44.6	45.6	46.6	47.6	48.5	49.5
179	40.7	41.7	42.6	43.6	44.6	45.6	46.5	47.5	48.5	49.5
180	40.7	41.6	42.6	43.6	44.5	45.5	46.5	47.5	48.4	49.4
181	40.6	41.6	42.6	43.5	44.5	45.5	46.5	47.4	48.4	49.4
182	40.6	41.6	42.5	43.5	44.5	45.4	46.4	47.4	48.4	49.3
183	40.6	41.5	42.5	43.5	44.4	45.4	46.4	47.3	48.3	49.3
184	40.5	41.5	42.5	43.4	44.4	45.4	46.3	47.3	48.3	49.3
185	40.5	41.4	42.4	43.4	44.3	45.3	46.3	47.3	48.2	49.2

weight in kg

height in cm	55	56	57	58	59	60	61	62	63	64
155	51.6	52.6	53.6	54.6	55.6	56.7	57.7	58.7	59.7	60.7
156	51.6	52.6	53.6	54.6	55.6	56.6	57.6	58.6	59.6	60.7
157	51.5	52.5	53.5	54.5	55.5	56.5	57.6	58.6	59.6	60.6
158	51.5	52.5	53.5	54.5	55.5	56.5	57.5	58.5	59.5	60.5
159	51.4	52.4	53.4	54.4	55.4	56.4	57.4	58.4	59.5	60.5
160	51.4	52.4	53.4	54.4	55.4	56.4	57.4	58.4	59.4	60.4
161	51.3	52.3	53.3	54.3	55.3	56.3	57.3	58.3	59.3	60.3
162	51.3	52.3	53.3	54.3	55.3	56.3	57.3	58.3	59.3	60.3
163	51.2	52.2	53.2	54.2	55.2	56.2	57.2	58.2	59.2	60.2
164	51.2	52.2	53.2	54.2	55.2	56.2	57.2	58.2	59.2	60.2
165	51.1	52.1	53.1	54.1	55.1	56.1	57.1	58.1	59.1	60.1
166	51.1	52.1	53.1	54.0	55.0	56.0	57.0	58.0	59.1	60.1
167	51.0	52.0	53.0	54.0	55.0	56.0	57.0	58.0	59.0	60.0
168	51.0	52.0	52.9	53.9	54.9	55.9	56.9	57.9	58.9	59.9
169	50.9	51.9	52.9	53.9	54.9	55.9	56.9	57.9	58.9	59.9
170	50.9	51.9	52.9	53.8	54.8	55.8	56.8	57.8	58.8	59.8
171	50.8	51.8	52.8	53.8	54.8	55.8	56.8	57.8	58.8	59.8
172	50.8	51.8	52.8	53.7	54.7	55.7	56.7	57.7	58.7	59.7
173	50.7	51.7	52.7	53.7	54.7	55.7	56.7	57.7	58.7	59.7
174	50.7	51.7	52.7	53.6	54.6	55.6	56.6	57.6	58.6	59.6
175	50.6	51.6	52.6	53.6	54.6	55.6	56.6	57.6	58.6	59.6
176	50.6	51.6	52.6	53.5	54.5	55.5	56.5	57.5	58.5	59.5
177	50.5	51.5	52.5	53.5	54.5	55.5	56.5	57.5	58.5	59.4
178	50.5	51.5	52.5	53.5	54.4	55.4	56.4	57.4	58.4	59.3
179	50.5	51.4	52.4	53.4	54.4	55.4	56.4	57.4	58.3	59.3
180	50.4	51.4	52.4	53.4	54.3	55.3	56.3	57.3	58.3	59.3
181	50.4	51.3	52.3	53.3	54.3	55.3	56.3	57.3	58.2	59.2
182	50.3	51.3	52.3	53.3	54.2	55.2	56.2	57.2	58.2	59.2
183	50.3	51.3	52.2	53.2	54.2	55.2	56.2	57.2	58.1	59.1
184	50.2	51.2	52.2	53.2	54.2	55.1	56.1	57.1	58.1	59.1
185	50.2	51.2	52.1	53.1	54.1	55.1	56.1	57.1	58.0	59.0

Table 1. Continued

weight in kg

height in cm	65	66	67	68	69	70	71	72	73	74
155	61.7	62.7	63.8	64.8	65.8	66.8	67.8	68.9	69.9	70.9
156	61.7	62.7	63.7	64.7	65.7	66.8	67.8	68.8	69.8	70.9
157	61.6	62.6	63.6	64.7	65.7	66.7	67.7	68.7	69.8	70.8
158	61.5	62.6	63.6	64.6	65.6	66.6	67.6	68.7	69.7	70.7
159	61.5	62.5	63.5	64.5	65.5	66.6	67.6	68.6	69.6	70.6
160	61.4	62.4	63.4	64.5	65.5	66.5	67.5	68.5	69.5	70.6
161	61.4	62.4	63.4	64.4	65.4	66.4	67.4	68.5	69.5	70.5
162	61.3	62.3	63.3	64.3	65.3	66.4	67.4	68.4	69.4	70.4
163	61.2	62.2	63.3	64.3	65.3	66.3	67.3	68.3	69.3	70.4
164	61.2	62.2	63.2	64.2	65.2	66.2	67.2	68.3	69.3	70.3
165	61.1	62.1	63.1	64.1	65.2	66.2	67.2	68.2	69.2	70.2
166	61.1	62.1	63.1	64.1	65.1	66.1	67.1	68.1	69.1	70.2
167	61.0	62.0	63.0	64.0	65.0	66.0	67.1	68.1	69.1	70.1
168	60.9	61.9	63.0	64.0	65.0	66.0	67.0	68.0	69.0	70.0
169	60.9	61.9	62.9	63.9	64.9	65.9	66.9	67.9	68.9	70.0
170	60.8	61.8	62.8	63.8	64.8	65.9	66.9	67.9	68.9	69.9
171	60.8	61.8	62.8	63.8	64.8	65.8	66.8	67.8	68.8	69.8
172	60.7	61.7	62.7	63.7	64.7	65.7	66.7	67.7	68.8	69.8
173	60.7	61.7	62.7	63.7	64.7	65.7	66.7	67.7	68.7	69.7
174	60.6	61.6	62.6	63.6	64.6	65.6	66.6	67.6	68.6	69.6
175	60.6	61.5	62.5	63.5	64.5	65.6	66.6	67.6	68.6	69.6
176	60.5	61.5	62.5	63.5	64.5	65.5	66.5	67.5	68.5	69.5
177	60.4	61.4	62.4	63.4	64.4	65.4	66.4	67.4	68.4	69.4
178	60.4	61.4	62.4	63.4	64.4	65.4	66.4	67.4	68.4	69.4
179	60.3	61.3	62.3	63.3	64.3	65.3	66.3	67.3	68.3	69.3
180	60.3	61.3	62.3	63.3	64.3	65.3	66.3	67.3	68.3	69.3
181	60.2	61.2	62.2	63.2	64.2	65.2	66.2	67.2	68.2	69.2
182	60.2	61.2	62.2	63.2	64.1	65.1	66.1	67.1	68.1	69.1
183	60.1	61.1	62.1	63.1	64.1	65.1	66.1	67.1	68.1	69.1
184	60.1	61.1	62.1	63.0	64.0	65.0	66.0	67.0	68.0	69.0
185	60.0	61.0	62.0	63.0	64.0	65.0	66.0	67.0	68.0	69.0

weight in kg

height in cm	75	76	77	78	79	80	81	82	83	84
155	71.9	73.0	74.0	75.0	76.1	77.1	78.1	79.2	80.2	81.2
156	71.9	72.9	73.9	75.0	76.0	77.0	78.0	79.1	80.1	81.1
157	71.8	72.8	73.9	74.9	75.9	76.9	78.0	79.0	80.0	81.1
158	71.7	72.8	73.8	74.8	75.8	76.9	77.9	78.9	80.0	81.0
159	71.7	72.7	73.7	74.7	75.8	76.8	77.8	78.8	79.9	80.9
160	71.6	72.6	73.6	74.7	75.7	76.7	77.7	78.8	79.8	80.8
161	71.5	72.5	73.6	74.6	75.6	76.6	77.7	78.7	79.7	80.7
162	71.4	72.5	73.5	74.5	75.5	76.6	77.6	78.6	79.6	80.7
163	71.4	72.4	73.4	74.4	75.5	76.5	77.5	78.5	79.6	80.6
164	71.3	72.3	73.3	74.4	75.4	76.4	77.4	78.5	79.5	80.5
165	71.2	72.3	73.3	74.3	75.3	76.3	77.4	78.4	79.4	80.4
166	71.2	72.2	73.2	74.2	75.2	76.3	77.3	78.3	79.3	80.4
167	71.1	72.1	73.1	74.2	75.2	76.2	77.2	78.2	79.3	80.3
168	71.0	72.0	73.1	74.1	75.1	76.1	77.1	78.2	79.2	80.2
169	71.0	72.0	73.0	74.0	75.0	76.0	77.1	78.1	79.1	80.1
170	70.9	71.9	72.9	73.9	75.0	76.0	77.0	78.0	79.0	80.0
171	70.8	71.8	72.9	73.9	74.9	75.9	76.9	77.9	79.0	80.0
172	70.8	71.8	72.8	73.8	74.8	75.8	76.8	77.9	78.9	79.9
173	70.7	71.7	72.7	73.7	74.8	75.8	76.8	77.8	78.8	79.8
174	70.6	71.6	72.7	73.7	74.7	75.7	76.7	77.7	78.7	79.8
175	70.6	71.6	72.6	73.6	74.6	75.6	76.6	77.7	78.7	79.7
176	70.5	71.5	72.5	73.5	74.5	75.6	76.6	77.6	78.6	79.6
177	70.4	71.5	72.5	73.5	74.5	75.5	76.5	77.5	78.5	79.5
178	70.4	71.4	72.4	73.4	74.4	75.4	76.4	77.4	78.5	79.5
179	70.3	71.3	72.3	73.3	74.3	75.4	76.4	77.4	78.4	79.4
180	70.3	71.3	72.3	73.3	74.3	75.3	76.3	77.3	78.3	79.3
181	70.2	71.2	72.2	73.2	74.2	75.2	76.2	77.2	78.2	79.3
182	70.1	71.1	72.1	73.1	74.2	75.2	76.2	77.2	78.2	79.2
183	70.1	71.1	72.1	73.1	74.1	75.1	76.1	77.1	78.1	79.1
184	70.0	71.0	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0
185	70.0	71.0	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0

volume. Total body volume calculated by the obtained equation were approximate to the measured values. Correlation coefficient was 0.9983, and standard error of estimate, S.E.E., was 0.479 liters. The validity of the obtained equation was tested with use of samples of other studies. For white men in South Africa (Sloan 1967), Japanese men (Sato 1975) and Scotsmen (Womersley et al. 1976), S.E.E. of total body volume were 0.660 liters, 0.437 liters and 0.542 liters, respectively. Any of S.E.E. did not exceed 1 percent when expressed as a percent to the mean of measured value. These results indicate that little difference also occurred for other samples between calculated and measured total body volume. In order to make application of this obtained equation easy, calculated values are shown in Table 1. Density is obtained from dividing weight by volume. We can also get body fat percent by substituting density into the equations devised by various investigators.

In summary, a simple equation was given for calculation of total body volume in man from only weight and height. Small differences were presented between calculated and measured total body volume in original samples and also in other samples of literatures. It should be noted that this equation is useful when no further accurate procedure for estimation can be employed.

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