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THE APPLICABILITY OF THE DU BOIS HEIGHT-WEIGHT FORMULA FOR MEASUREMENT OF BODY SURFACE OF INDIAN SUBJECTS

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ABSTRACT

The body surface area of 18 healthy adult Indian subjects was measured by taking part by part linear measurements for the whole body with the help of Anthropometer Beam Calipers and applying Du Bois linear formula method. The surface area values computed from Du Bois Height-weight formula were compared with the measured values. The average error in the eighteen cases is 1.5 percent. The standard deviation of the errors is 1.8 per cent. about the mean error of —0.5 per cent. The errors are not statistically significant. As the original Du Bois formula itself is stated to have an average error of 1.5 per cent, the present work confirms that the accuracy with which Du Bois formula predicts body surface, is not sensibly different for Indians as against Europeans.

Introduction

Many important physiological activities *e.g.,* thermal regulation of the body, metabolism and heart rate are influenced by the body surface. Hence an accurate knowledge of the body surface is very essential for such physiological studies. Body surface is a function of both height and weight of the individual. Meeh (1879) who proposed the formula $A=W^{\frac{2}{3}}\times C$, where $A =$ surface area, $W =$ body weight and $C =$ a constant, did not take the height factor into account. But inclusion of the height factor, as observed by Du Bois et al (1916) 'makes it more nearly applicable to subjects of the same general shape, but differing somewhat in relative dimensions'. Du Bois and Du Bois (1915) on the basis of actual measurements of the body surface of five persons of widely varying body size proposed a linear formula to measure body surface. Later on, the same authors (1916) developed a height-weight formula based on the surface area values obtained for ten subjects by actual measurement and thirty three subjects by regional measurements using the linear formula method which is described elsewhere in this paper. This height-weight formula, $A = W^{0\cdot425} \times H^{0\cdot725} \times 71\cdot84$, where $A =$ surface area in sq. cm, $W=$body weight in kilograms and $H=$height in cm, gave an average error of 1.5 per cent. in the measured cases. It is interesting to note that Takahira from Japan (quoted by Otto Glasser, 1947) has slightly modified this formula as $A=W^{0\cdot427} \times H^{0\cdot718} \times 74.49$.

where A, W and H represent the same variables as in Du Bois Formula. Nomograms constructed on the basis of Dubois formula are widely used in physiological studies.

Object

The present work is intended to assess how closely the surface area of Indian subjects as measured by a suitable standard method, agrees with the surface area value computed from the height and weight of the subjects by applying Du Bois height-weight formula. It is to be expected that the accuracy with which the Du Bois formula predicts the surface area of individuals will not be sensibly different for Indians as against Europeans. The measurements here described confirm this expectation.

Method

In previous works various methods have been adopted to measure body surface *e. g.*, tin foil, paper strip, mould and linear formula methods. For the purpose of the present work the linear formula method has been adopted for the following reasons. It is extremely laborious and time consuming to carry out the actual measurement of body surface by the other methods. On the other hand the accuracy of the simpler linear formula method has been found by Sawyer et al (1916) to be practically the same as that of the mould method. Further, the accuracy of this method is not likely to be affected by racial factors as appears from the work of Kaare Rodahl (1952) who also adopted this method as the standard method for measuring the surface area of 53 Eskimo subjects who are racially quite different from Europeans.

In the present investigation measurements were made on eighteen healthy Indian male subjects. The following types of body build were available.

(i) Tall and flabby — 3
(ii) Tall, well built and muscular — 2
(iii) Tall and lean — 2
(iv) Short and flabby — 2
(v) Short and lean — 2
(vi) Average body build — 7

The height of the subjects varied from 5′ to 5′ 11½″ and the weight from 90 pounds to 158 pounds.

In the Du Bois linear formula method the following measurements were made with the help of Anthropometer Beam Calipers and a measuring tape. The values for each region were multiplied by suitable factors as given hereunder :

Head :

$AB \times 0.308$

A = Around vertex and point of chin

B = Coronal circumference around occiput and forehead just above eyebrows.

Arms :

$F(G + H + I) \times 0.611$

F = Tip of acromial process to lower border of radius measured with forearm extended.

G = Circumference at level of upper border of axilla.

H = Largest circumference of forearm (Just below elbow).

I = Smallest circumference of forearm (just above head of ulna).

Hands :

JK × 2.22

J = Lower posterior border of radius to tip of second finger.

K = Circumference of open hand at the meta-carpo-phalangeal joints.

Trunk :

(Including neck and external genitals in the male, breasts in female)

L(M + N) × 0.703

L = Suprasternal notch to upper border of pubes.

M = Circumference of abdomen at level of umbilicus.

N = Circumference of thorax at level of nipples in the male and just above breasts in female.

Thighs :

O(P + Q) 0.508 —— (1st method)

O = Superior border of great trochanter to the lower border of the patella.

P = Circumference of thigh just below the level of perineum.

Q = Circumference of hips and buttocks at the level of great trochanter.

or

W(P + Q) × 0.552 ——(2nd method)

W = Upper border of pubes to lower border of patella (measured with legs straight and feet pointed anteroposteriorly)

P = as in the 1st method.

Q = as in the 1st method.

Legs :

RS × 1.40

R = From sole of foot to lower border of patella.

S = Circumference at level of lower border of patella.

Feet :

T(U + V) × 1.04

T = Length of foot including great toe.

U = Circumference of foot at base of little toe.

V = Smallest circumference of ankle (just above malleoli.)

Experimental data and Discussion

The values for the body surface obtained from the different sets of regional measurements according to the linear formula, are compared with those computed from the height-weight formulae of Du Bois and Takahira and in each case the error or the deviation from the measured value, is worked out. The complete data are given in Appendix Table—I.

In Table I an arbitrary allowance of one pound in body weight *i.e.*, observed body weight minus one pound, has been made in order to get the basal weight of the subjects, and substituting this value for W and the vertical height of the subject for H in the Du Bois and Takahira formulae the surface area is computed in each case. The percentage error of the computed values over the measured, is worked out for each subject, and the values are tabulated. With Du Bois Formula, the average error is 1.5 per cent, the mean error is—0.5 per cent and the standard deviation of the errors is 1.8 per cent. With Takahira's formula, the average error is 1.5 per cent., the mean error is + 0.4 per cent. and the standard deviation of the errors is 1.8 per cent. With both the formulae, the errors on statistical analysis are found to be not significantly different from zero even at 30 per cent. level, which suggests that the errors are only due to random causes.

However an attempt was made to change the value of the constant in the Du Bois formula while retaining the powers of W and H as such so as to have a better fit of the formula in the eighteen cases. The value of the constant works out to be 72.17 instead of 71.84 in the original formula. According to Takahira (quoted by Patwardhan, 1952) the value of the constant was to be changed to 72.46 to have a better fit of the formula with the data obtained for his subjects. He has stated that the value of the constant increases with decreasing height of the subjects. Our value seems to confirm this, as it falls between the values for the Japanese and the Europeans (72.46 and 71.84), and the height of the Indians is intermediate between those of the Japanese and the Europeans. But it is not necessary to introduce these corrections as the errors involved in the two cases are only 0.85 per cent. (Japanese) and 0.45 percent (Indians) both being far below the average error (1.5 per cent.) attributed to the formula by Du Bois himself.

In applying the correction for the body weight, arbitrarily one pound has been deducted. The maximum error that is possible in such a treatment is ± 0.5 pound. The body weights of the subjects vary from 90 pounds to 158 pounds. In the two extreme cases, the above error in weight correction will introduce in the final value of surface area only errors of 0.2 per cent. and 0.1 per cent. respectively which are not of practical significance.

Conclusion

For 18 Indian subjects of different body build, Du Bois height-weight formula gives values for body surface with an average error of only 1.5 per cent. when compared with the values obtained by actual measurement on the basis of the linear formula method, which was earlier proved to be quite accurate for European subjects and later on accepted as applicable to even the Eskimos who differ in body build from the Europeans. This error of 1.5 per cent. is not significant, as the average error mentioned for the Du Bois formula itself is 1.5 per cent. Hence for all practical purposes Du Bois height-weight formula can be made use of to compute the body surface of Indian subjects also.

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TABLE I.

Dubois' Formula : $A = W^{0.425} \times H^{0.725} \times 71.84$

Takahira's Formula : $A = W^{0.427} \times H^{0.718} \times 74.49$

Serial number of subjects	Height cms.	Corrected weight (W—1 lbs). in kgms	Surface area measured by linear formula method (sq. m)	Surface area calculated by Du Bois formula (sq. m)	Error of calculated value over the measured (sq. m)	Percentage error	Surface area calculated by Takahira's formula (sq. m)	Error of Calculated value over the measured (sq. m)	Percentage error
1	163·9	42·186	1·4367	1·419	—0·0177	—1·23	1·432	—0·0047	—0·30
2	172·7	66·686	1·7650	1·793	+0·0280	+1·59	1·806	+0·0410	+2·32
3	174·6	69·856	1·8848	1·841	—0·0438	—2·32	1·859	—0·0258	—1·37
4	172·0	69·396	1·9104	1·819	—0·0914	—4·78	1·833	—0·0774	—4·05
5	177·1	71·226	1·9255	1·874	—0·0515	—2·67	1·893	—0·0325	—1·69
6	163·9	48·536	1·4788	1·506	+0·0272	+1·84	1·521	+0·0422	+2·35
7	166·3	57·156	1·6267	1·632	+0·0053	+0·33	1·649	+0·0223	+1·37
8	166·2	50·356	1·5642	1·547	—0·0172	—1·10	1·559	—0·0052	—0·33
9	168·0	61·436	1·6927	1·700	+0·0073	+0·43	1·713	+0·0203	+1·20
10	172·5	51·256	1·5663	1·603	+0·0367	+2·34	1·615	+0·0487	+3·11
11	165·7	52·626	1·5502	1·569	+0·0188	+1·21	1·584	+0·0338	+2·18
12	171·2	70·766	1·8175	1·827	+0·0095	+0·52	1·841	+0·0235	+1·29
13	152·9	43·276	1·3768	1·363	—0·0138	—1·00	1·376	—0·0008	—0·06
14	178·4	59·836	1·7229	1·740	+0·0171	+0·99	1·766	+0·0431	+2·50
15	160·7	40·490	1·3820	1·375	—0·0070	—0·51	1·388	+0·0060	+0·43
16	181·9	62·016	1·8340	1·808	—0·0260	—1·42	1·822	—0·0120	—0·65
17	160·0	50·946	1·5450	1·512	—0·0330	—2·14	1·523	—0·0220	—1·42
18	165·2	51·596	1·5620	1·557	—0·0050	—0·32	1·568	+0·0060	+0·38
				Sum of Positive errors :		9·25%	Sum of Positive errors :		17·63%
				Sum of Negative errors :		17·49%	Sum of Negative errors :		9·87%
				Average error ..		1·486%	Average error ..		1·528%
				Mean error ..		—0·458%	Mean error		+0·431%
				S. D. of errors .		1·774%	S. D. of errors ..		1·825%