

FIG. 3.

A histogram illustrating the variability of the method used on test subjects to determine the precision of the casting and coating method.

error of the difference shows that the area of the plaster ball by the spherometer is significantly less than its area by the cathetometer.

These comparisons indicate that the total error of the casting and coating method is of the order of 2%.

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The Relation of Surface Area to Body Weight in Postnatal Life.

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The 9 determinations of surface area on 3 children from 2 to 5 years reported in the first paper of this series, are not sufficient to warrant the computation of a formula for surface area at this age

level but their relation to the trend of previous determinations by other methods on both living and dead may be determined.

A preliminary survey of the literature furnished 135 actual determinations of the surface areas of normal individuals who ranged from birth to late maturity in age and whose heights and weights were given. The minimal body weight in this series was 2.5 kg. The sources and methods are as follows: Fubini and Ronchi,¹ 1 living adult, geometric method; Meeh,² 16 living males, 6 days to 66 years, coating and geometric method; Ssytscheff,³ 23 males and females, 15 days to 43 years, coating method; Lissauer,⁴ 8 male and female cadavera, 28 days to 15 months, coating method; Lassablière,⁵ 15 determinations each based on averages of 2 or 3 living children, one day to 24 months, geometric method; Pfaundler⁶ (including Kastner), 14 infant cadavera from one-fourth month to 18½ months, coating method; Du Bois *et al.*,⁷ 8 living males and females, 12 to 32 years, 1 female cadaver, 21 months, coating method; Wörner,⁸ 16 living males and females from 5 to 50 years, coating method; and Frontali,¹⁰ 33 living boys and girls from 24 days to 12 years, integrator method.

The trend of increment of surface area of these cases with body weight is shown in Fig. 1. This trend has been fitted by 2 variations of the method of least squares. The first expression is:

$$S = 1008W^{0.692} \quad (1)$$

where S is surface area in square centimeters and W is weight in kilograms. The constants were fitted by the least squares of the logarithms of surface and weight. Measures of goodness of fit of this expression are shown in the upper panel of Fig. 1.

The second formula is:

$$S = 1070W^{0.675} \quad (2)$$

In this instance the constants of the equation were obtained by assuming a series of exponents, 0.62 to 0.72, that covered the range of powers found in various attempts to fit certain of these data by

¹ Fubini and Ronchi, *Moleschotts Untersuchungen*, Heft 1, xii.

² Meeh, K., *Z. f. Biol.*, 1879, xv, 425.

³ Ssytscheff, A. I., *Diss.*, St. Petersburg, 1902.

⁴ Lissauer, W., *Jahrb. f. Kinderheilk.*, 1903, lviii, 392.

⁵ Lassablière, P., *Compt. Rend. Soc. Biol.*, 1910, lxviii, 339.

⁶ Pfaundler, M., *Z. f. Kinderheilk.*, 1916, xiv, 48.

⁷ Du Bois, D., and Du Bois, E. F., *Arch. Int. Med.*, 1915, xv, 868.

⁸ Sawyer, M., Stone, R. H., and Du Bois, E. F., *Arch. Int. Med.*, 1916, xvii, 855.

⁹ Wörner, H., *Z. f. gesamte Exp. Med.*, 1923, xxxiii, 510.

¹⁰ Frontali, G., *Riv. d. Clin. Pediat.*, 1927, xxv, 241.

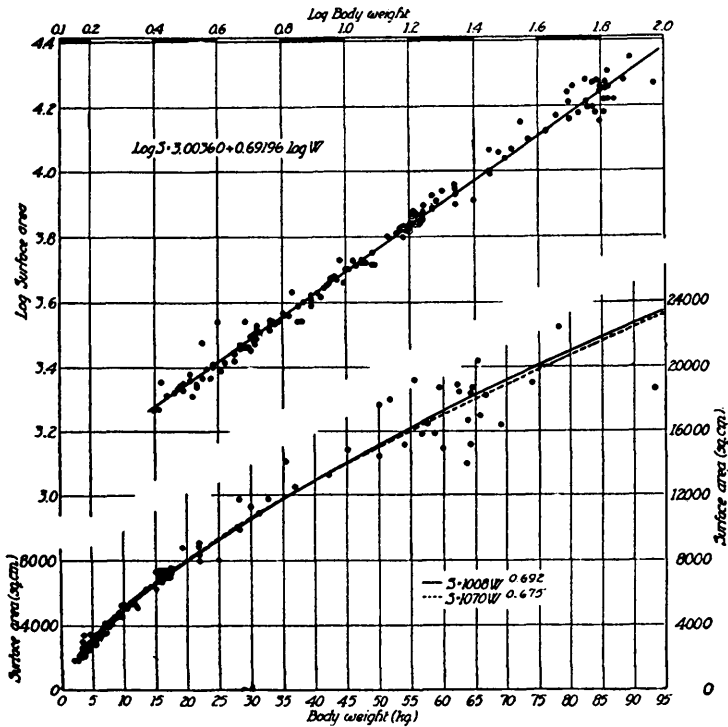


FIG. 1.

Body weight and surface area in postnatal life. Upper graph shows relation of logarithms of surface area to logarithms of body weight. Lower graph shows relation of body surface to body weight. Individual observations represented by solid dots. The 9 observations in the present series represented by circled dots. Analytic expressions indicated by solid lines.

other methods, and selecting the one giving the lowest sum of the squares of the deviations. The details of this method will be given in a subsequent publication.

Since formulae involving both height and weight are commonly considered more reliable for prediction of surface area than those based upon weight alone, the constant according to the Du Bois and Du Bois height-weight formula¹¹ was solved for these data, giving the expression :

$$S = 76.40W^{0.425}H^{0.725} \quad (3)$$

The mean relative deviation of the first constant is 6.3%. Also the mean relative deviation of the calculated values for this formula from the observed values of surface area is less (6.3%) than that (7.3%) for the original Du Bois formula :

$$S = 71.84W^{0.425}H^{0.725} \quad (4)$$

¹¹ Du Bois, D., and Du Bois, E. F., *Arch. Int. Med.*, 1916, xvii, 863.

Using Du Bois' principle of a bidimensional formula :

$$S = W^{1/a} \times H^{1/b} \times c$$

$$1/a + 1/b = 2$$

when

we varied 1/a from 0 to 0.667 and obtained

$$S = 394.56W^{0.575}H^{0.275} \quad (5)$$

as the expression with the lowest mean relative deviation for the first or "c" constant, 5.1%. According to Du Bois' criterion (5) is a better fit to these data than (3) and (4).

The percentage deviations of the calculated values from the observed were computed to compare the departure of these determinations from the values obtained by the formulae. The frequency distributions of these percentage deviations and their interquartile ranges for each formula are given in Fig. 2.

The average percentage deviation and the root mean square deviations for each 25 cases in order of magnitude of body weight for

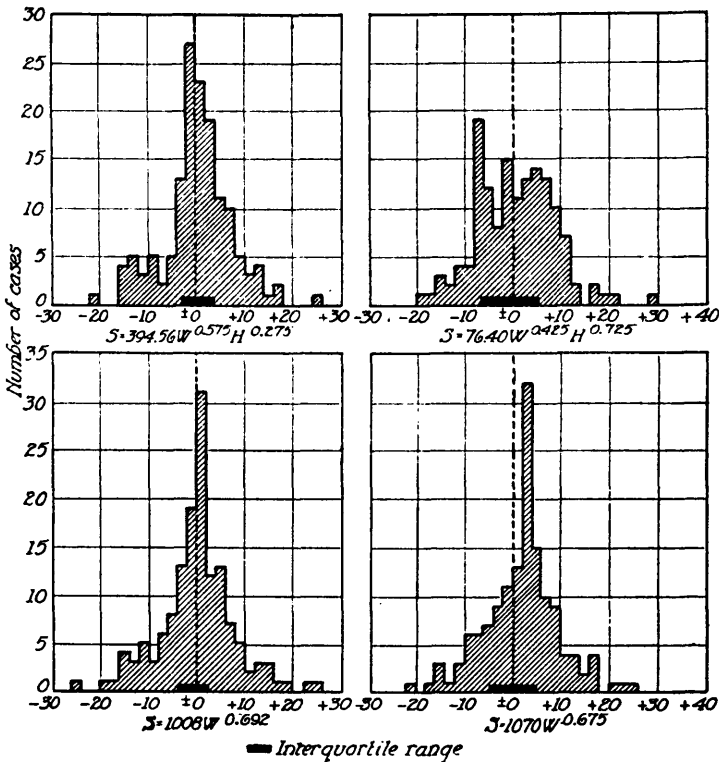


FIG. 2.

Histograms illustrating the distribution of the relative deviations of calculated surface areas of 2 weight and 2 height-weight formulae from the corresponding observed values.

formulae (1), (2), (4) and (5) are given in the table. The weight formulae are scarcely as good fits for the lower weight levels, although all the expressions give prediction values of the same general order of precision except for the last weight group (57.62 to 93.01 kg.). Here the cases are few and certain of the individuals used were "atypical" in body form.

TABLE I.
Deviations of Calculated from Observed Surface Areas for 144 Observations.

Weight intervals (kg.) and number of observations in each interval	Mean relative deviations (%) of formula:				Root mean square deviations (sq. cm.) of formula:			
	(1)	(2)	(4)	(5)	(1)	(2)	(4)	(5)
2.50 to 4.14 (25)	6.7	8.2	7.7	7.1	257	264	273	232
4.45 to 6.28 (25)	3.2	5.3	9.0	3.1	143	188	324	135
6.50 to 11.21 (25)	3.9	5.3	10.0	3.7	226	266	508	227
11.30 to 18.72 (25)	3.1	3.5	3.9	2.9	272	282	371	255
18.75 to 56.91 (25)	7.2	6.6	6.6	6.3	1228	1093	1174	1160
57.62 to 93.01 (19)	9.3	9.0	6.3	7.9	2031	1956	1577	1715
Total range 2.50 to 93.01 (144)	5.4	6.2	7.3	5.0	902	854	806	796

These comparisons seem to justify the following conclusions in so far as the present data* are concerned. Surface area *in the growing period* can be calculated with about equal precision from expressions with constants determined by least squares for weight alone, and from expressions derived by the geometric method of Du Bois and based on both weight and length. In this period the relation of surface to weight closely approximates the expression

$$S = cW^{2/3}$$

regardless of differences in method of determining surface area or whether these methods are applied to living individuals or cadavera.

* Since the calculations were made, 50 additional observations have been found in the literature and these will be included in an analysis of all available data in a final report.