MEASUREMENT OF TISSUE COMPONENTS RADIOLOGICALLY

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In carrying out a detailed growth study of children we require to know the rates of growth of different tissues. These are mainly bone, muscle, and subcutaneous fat. Anthropometric methods of measurement have limitations of accuracy, especially in the infant and younger child and in the measurement of subcutaneous fat. We therefore have experimented radiologically on this problem.

Up to the present the radiological method of determining the proportion of tissue components has been basically the same (Stuart *et al.*, 1940; Stuart and Dwinell, 1942; Files, 1943; Stuart, 1944; Reynolds,

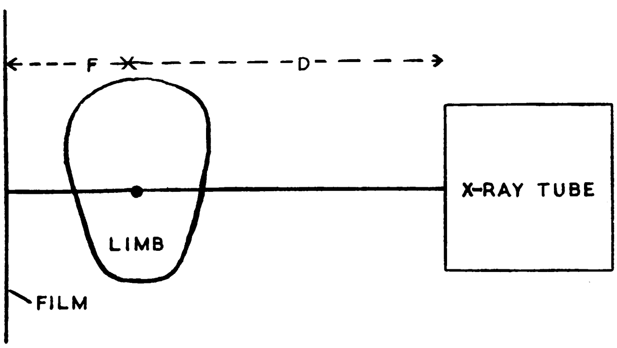

FIG. 1.—The usual method.

1944, 1946; Stuart and Sobel, 1946; Reynolds and Schoen, 1947; Tanner, personal communication, 1952). This consists in taking an *x*-ray photograph of a limb, for example, with the tube at a long distance from the limb—between 6 and 8 feet (1.8 and 2.4 metres) (Fig. 1).

The limb–film distance is kept at a " known " constant —usually 4–6 in. (10–15 cm.) (F in Fig. 1). Because the distance of *x*-ray tube to limb (D in Fig. 1) is great, the subsequent distortion or magnification on the film of the actual limb is small and can be calculated. It is of the order of 2–4%. By allowing for this distortion the measurements of the various tissues can be found direct on the *x*-ray film.

This method has several disadvantages: (1) The *x*-ray tube must be capable of producing 200 mA and ideally 400 mA, because of the great distance from the limb. It is thus a very expensive piece of apparatus. The scatter is large. (2) The exposure time still needs to be of the order of $\frac{1}{2}$ second; this is a source of trouble in the younger child, who does not wish to keep still. (3) The limb should be placed accurately at a known distance from the film. It is not possible to do this, however. The " centre " of the limb (which is where the arbitrary measurements are required to be taken) can only be guessed. There is therefore a source of error here.

Method

The following method is particularly suitable for the infant or younger child.

Two exposures are made on the same *x*-ray plate in a plane parallel to the plate, at a known and constant distance apart. The distance from the tube plane to the plate plane is kept constant. Under these conditions the picture shift is a function of the distance of the object from the plate. By selecting arbitrary values of this distance a graph, or table, may be obtained giving the distance of an object from the *x*-ray plate for any measured picture shift.

When the distance of the object is known its actual size may be accurately calculated by measuring the size of the picture of the object on the plate, and applying the simple formula $x = \frac{x' (K-d)}{K}$, where x = the true size of the object, x′ = its picture size on the plate, K = constant distance of the *x*-ray tube plane from the plate plane, and d = distance of the object from the plate as calculated above (Fig. 2). In our experiments K = 60 cm., and the *x*-ray tube shift = 8 cm.

In practice, the shifting of the tube, however quickly done, adds considerably to the time required for the limb to be kept still. Therefore we propose to use two tubes fixed a known distance apart, and energize them simultaneously.

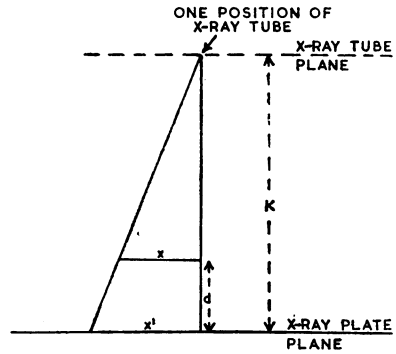

FIG. 2.—The new method.

The advantages of this method are: (1) The tube (or tubes) need only be capable of producing 15 mA—the distance from limb to *x*-ray tube being short. The apparatus is therefore comparatively cheap. The scatter is small. (2) The exposure time is very short—of the order of $\frac{1}{8}$ second. (3) It is not necessary to try to place the limb a known distance from the plate. A source of error is thus removed.

When the film is examined the picture shift is determined by measuring the distance between the two images of, say, skin at the point required for assessment. When this has been done the tissues are measured on the film from " one set " of images. This can be confusing, and good definition is required. By applying the formula the exact tissue measurements can be determined.

We carried out two experiments to test our method. First, rigid metal objects of known size were *x*-rayed. The mean error was 0.02 cm. Secondly, a completely sectioned lower limb in the mid-calf region from a human cadaver was *x*-rayed. The soft tissue and bones were measured at the same time by callipers directly on the specimen. The mean error of eight measurements was 0.11 cm. Measurements on the actual objects and the *x*-ray plates were carried out independently by the two experimenters, one doing all the measurements on the cadaver and metal objects, the other the measurements and calculations from the *x*-ray plates.

Errors have been calculated from the differences between the two sets of results obtained independently. The sources of error are in the actual measuring on the *x*-ray film and in positioning the limb. In the case of the calf, being generally circular in shape, this is comparatively easy to overcome, but in other parts it is important to be sure that a central perpendicular or horizontal axis is maintained parallel to the *x*-ray plate.

We intend to incorporate this method into the practical side of a growth study, as it will not only greatly increase our accuracy but provide us with permanent records of the tissue growth.

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THE THERAPEUTIC RESPONSE OF SECONDARY ANAEMIAS TO ORGANIC AND INORGANIC IRON SALTS

BY

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In 1926 Starkenstein discovered that only ferrous iron is utilizable by the haemopoietic system. Since then inorganic ferrous salts have provided the standard form of ferrotherapy. In particular, ferrous sulphate has been widely used in various official and proprietary presentations. The *National Formulary 1952* informs us that there is need for only two oral preparations of iron in the treatment of ferro-sensitive anaemias. These are those containing either ferrous sulphate or iron and ammonium citrate.

Benstead and Theobald (1952), in their work on the incidence of anaemia in pregnancy, showed in their series of cases that in one group of patients 33%, and in another group 40.2%, found it difficult or impossible to tolerate ferrous sulphate tablets. They concluded that 30–40% of antenatal patients do not, in fact, consume these tablets when prescribed as routine in antenatal departments. It therefore seems that, although ferrous sulphate tablets are widely ordered, their therapeutic value, owing to gastric intolerance, leaves much to be desired.

Following their publication I wrote (Haler, 1952) that I was investigating the therapeutic effects of the organic ferrous gluconate in ferro-sensitive anaemias. The results are herewith appended.

Ferrous gluconate is the normal ferrous salt of D-gluconic acid; it is a dihydrate crystal and contains 11.5% of ferrous iron.

Staub (1949), Jasinki (1949), and others have shown that this salt is the most easily absorbed of all ferrous salts. It does not appear to produce gastric upsets. The following figures result from the decision to compare the therapeutic response of ferro-sensitive anaemias when treated with the standard inorganic iron preparations with those obtained from the use of ferrous gluconate.

The Investigation

The cases investigated are classified as follows:

Anaemia following	post-partum haemorrhage	..	25 cases
,, ,,	normal delivery	..	13 ,,
,, ,,	illness	..	6 ,,

TABLE I

Code	No. of Cases	Key	Daily Dosage of Available Iron
		Group A. Inorganic Iron Preparations	
A	5	Proprietary ferrous sulphate and folic acid in capsules	184 mg.
B	1	Proprietary ferrous sulphate capsules	184 ,,
C	11	,, ,, ,, ,,	180 ,,
D	1	Tab. ferrous sulphate Co. *N.F.* ..	180 ,,
F	1	Ferri dia'ysata	216 ,,
H	1	Proprietary saccharated iron for intravenous use	100 ,,
J	1	Proprietary iron and folic acid tablets	184 ,,
		Group B. Organic Iron Preparations	
I	23	Ferrous gluconate	105 ,,

The cases were selected at random, the average Hb value (King and Gilchrist, 1947; King *et al.*, 1947, 1948a, 1948b, 1948c, 1951; Macfarlane *et al.*, 1948; Donaldson *et al.*, 1951) over the series being 65%; organic and inorganic iron preparations were given to alternate cases. The organic preparation of iron was available as a liquid proprietary preparation which in addition contained aneurin hydrochloride, nicotinamide, and riboflavin in blackcurrant juice syrup, which also provided 5 mg. of natural vitamin C per drachm.

In Group A cases (Table I) supplementary vitamins were given to those patients in whom avitaminosis was suspected.

TABLE II

Case No.	Group	Hb Initial	Hb Final	Hb Increase	Hb Mean Daily Increase %	Total Fe++ Administered	% Fe++ Utilized	Coefficient
			Group A. Inorganic Iron Preparations					
1	A	62 (9·25)	90 (13·5)	28 (4·25)	1·16	4,416	19·02	16·4
2	A	70 (10·45)	92 (13·80)	22 (3·35)	0·54	7,554	8·7	16·1
3	A	80 (12·0)	86 (12·9)	6 (0·90)	1·2	920	19·6	16·3
4	A	68 (10·15)	80 (12·0)	12 (1·85)	1·5	1,288	28·0	16·45
5	A	32 (4·75)	41 (6·1)	9 (1·35)	1·0	900	30·0	30·0
6	C	52 (7·7)	74 (11·05)	22 (3·35)	2·2	1,800	36·0	16·4
7	C	60 (9·0)	76 (11·4)	16 (2·4)	0·67	2,880	18·8	28·0
8	C	54 (8·05)	68 (10·15)	14 (2·1)	0·67	3.780	11·1	16·6
9	C	70 (10 5)	90 (13·5)	20 (3·0)	0·57	6.300	9·5	16·7
10	C	68 (10·15)	90 (13·5)	22 (3·35)	0·43	8,820	7·5	17·4
11	C	48 (7·2)	72 (10·7)	24 (3·5)	0·84	5.580	13·9	16·6
12	C	68 (10·15)	82 (12·3)	14 (2·15)	0·5	5,040	8·3	16·6
13	C	34 (5·00)	76 (11·4)	42 (6·4)	0·875	8,640	14·5	16·7
14	C	58 (8·65)	84 (12·6)	26 (3·95)	0·74	6,300	12·4	16·75
15	C	60 (9·0)	78 (11·7)	18 (2·7)	0·47	13,680	4·0	8·5
16	C	50 (7·5)	58 (8·65)	8 (1·15)	0·53	5,400	4·5	8·5
17	B	76 (11·4)	80 (12·0)	4 (0·60)	1·0	736	16·3	16·3
18	D	48 (7·2)	70 (10·5)	22 (3·30)	1·0	7,560	8·8	8·8
19	F	45 (6·7)	75 (11·2)	30 (4·5)	1·4	4,536	13·9	10·0
20	H	41 (6·1)	58 (8·65)	17 (2·55)	3·4	525	97·0	28·6
21	J	55 (8·2)	82 (12·3)	27 (4·10)	0·77	6,440	7·9	10·2
			Group B. Organic Iron Preparation					
23	I	62 (9·2)	92 (13·8)	30 (4·6)	1·67	1,890	47·6	29·5
24	I	58 (8·65)	92 (13·8)	34 (5·15)	1·88	1,890	52·9	28·0
25	I	76 (11·4)	90 (13·5)	14 (2·1)	1·2	1,890	22·2	18·5
26	I	72 (10·7)	94 (14·1)	22 (3·4)	1·8	1,890	50·8	28·2
27	I	70 (10·5)	98 (14·85)	28 (4·35)	1·6	1,890	44·4	27·8
28	I	80 (12·0)	98 (14·85)	18 (2·85)	1·0	1,890	28·6	28·6
29	I	47 (7·0)	84 (12·6)	37 (5·6)	1·8	2,205	50·2	27·9
30	I	80 (12·0)	98 (14·85)	18 (2·85)	1·5	1,260	42·9	28·6
31	I	54 (8·0)	92 (13·8)	38 (5·8)	2·1	1,890	60·3	28·8
32	I	72 (10·7)	90 (13·5)	18 (2·8)	2·6	735	75·2	28·9
33	I	72 (10·7)	88 (13·2)	16 (2·5)	1·33	1,260	38·1	28·7
34	I	77 (11·5)	95 (14·2)	18 (2·7)	1·5	1,260	42·9	28·6
35	I	76 (11·4)	96 (14·4)	20 (3·0)	1·67	1,890	47·6	28·5
36	I	78 (11·7)	96 (14·4)	18 (2·7)	2·33	1,260	66·6	28·6
37	I	68 (10·15)	90 (13·50)	22 (3·35)	1·2	1,890	34·9	29·0
38	I	78 (11·7)	93 (14·0)	15 (2·3)	1·5	1,050	42·8	28·8
39	I	90 (13·5)	96 (14·4)	6 (0·9)	0·85	735	25·0	29·4
40	I	60 (9·0)	82 (12·3)	22 (3·3)	1·8	1,260	52·4	29·0
41	I	74 (11·05)	96 (14·4)	22 (3·35)	1·0	2,205	30·0	30·0
42	I	70 (10·5)	94 (14·1)	24 (3·6)	0·85	2,940	24·5	28·8
43	I	72 (10·7)	98 (14·85)	26 (4·15)	0·62	4,410	17·7	28·6
44	I	65 (9·7)	100 (15·0)	35 (5·3)	1·2	2,940	35·7	29·8
45	I	68 (10·15)	78 (11·7)	10 (1·55)	1·4	735	40·8	29·2

	Available Fe++/day
A = "Plastules" with folic acid	184 mg.
B = "Plastu'es" plain	184 ,,
C = "Ferso'ate"	180 ,,
D = Tab ferri sulph. co.	180 ,,
F = Ferri dia'ysat.	216 ,,
G = Ferri ammon. cit.	189 ,,
H = "Ferrivenin"	100 ,,
I = "Cerevon"	105 ,,
J = "Folvite" with iron ("Folvron") ..	184 ,,