

THE WEIGHTS OF KIDNEYS IN LATE INTRA-UTERINE LIFE AND CHILDHOOD

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Statistical tables including 50 and 95 percentile ranges are presented of the combined kidney weights compared with body weight, crown-rump length, and gestation age of foetuses and newborn children, and also a table of kidney weights related to post-natal age. The importance of relating kidney weight to more than one general body criterion in the perinatal period is illustrated.

It is difficult enough to estimate normality in living newborns and infants, but when we come to estimate the normal weights of organs from infants that have died in the perinatal period, largely from diseases not known to us, the difficulties are much greater. The early work in this field and the problems involved were well reviewed by Cruickshank and Miller (1924a and b) and Browne (1924).

The weights of different organs for the first few months of intra-uterine life were worked out by Clatworthy and Anderson in 1944. The present standard weights for older foetuses were established by Potter and Adair (1949) and Potter (1952). They grouped cases in such a way that crown-rump length and gestation age and body weight were brought together in the same groups. Their method, which follows that used by many of the earlier workers in this field (Giese, 1898; Ylppö, 1919; Feldman, 1920; Cruickshank and Miller, 1924b; and Browne, 1924), is excellent for elucidating the general principles of differential growth of organs, but does not supply the particular information sometimes required by the pathologist.

For later childhood, the best established normal weights are those of Coppoletta and Wolbach (1933). Since then the general weight and height of children has increased both in Europe and America (Provis and Ellis, 1955; Stein, 1955; Thomson, 1956; *Lancet*, 1956). Keddie (1956) suggests that during the past 40 years there has been an increase of approximately $7\frac{1}{2}$ lb. in weight and 3 in. in height in 9-year-old children.

The present paper is part of a general study being carried out in Sheffield to establish the

normal weights of different organs of infants and children at the present time in England.

Material and Methods

The kidneys used in this study came from the records of 2,500 necropsies carried out by the Department of Pathology at the Children's Hospital, Sheffield, from 1950 to 1960. Throughout this time the necropsies were carried out with the definite view of assessing the normal weights of organs. Kidneys were fixed uncut, while still attached to their blood vessels. After fixation the kidneys were separated from the ureters and blood vessels, and as much of the perirenal fat as possible was removed, but the capsule was not stripped. The kidneys were weighed together on a regularly tested Avery scale correct to the nearest half-gram.

All material was surveyed, and all cases showing abnormality of the renal tract, multiple congenital deformities, gross post-mortem changes, or histological abnormality of either kidney were eliminated. This left approximately 1,300 cases.

The combined weights of the kidneys were charted separately against crown-rump length, body weight (in grams), gestation age (estimated from the first day of the mother's last menstrual period) and post-natal age irrespective of gestation age at birth. These measurements were not complete in all cases, thus the number of cases used in the different correlations was not identical. Means, standard deviations, standard error of means based on the formula $SE = \frac{\sigma}{\sqrt{n}}$, and 50 and 95 percentile ranges were calculated.

Results and Discussion

A great variation in the range of weights of kidney was found for all criteria, but no greater than that found in the more recent studies on adult kidneys (Wald, 1937). The findings are given

TABLE I

KIDNEY WEIGHT RELATED TO CROWN-RUMP LENGTH

Crown-rump Length (cm.)	Mean (g.)	S.E.	50% Range	95% Range	Potter and Adair (1949)
22	7.0	0.65	4.5-8.0	2.0-11.0	9-7
23	8.5	0.65	5.5-9.5	3.0-12.0	
24	9.5	0.55	7.0-11.5	4.0-15.0	
25	11.0	0.55	8.0-13.0	5.0-16.0	
26	12.5	0.55	9.5-15.0	5.5-17.5	
27	14.0	0.3	11.0-17.0	6.5-19.5	13-6
28	15.5	0.3	12.5-19.0	7.0-21.5	
29	17.0	0.3	14.0-20.5	7.5-23.5	
30	18.5	1.4	16.0-22.5	8.0-26.0	
31	20.0	1.12	17.0-24.5	8.5-28.0	18-3
32	21.5	0.85	18.5-26.0	9.0-31.0	21-1
33	23.0	0.88	20.0-28.5	10.0-32.5	
34	25.0	0.92	21.5-30.5	10.0-35.0	23-6
35	26.5	0.94	23.0-32.0	11.0-38.0	
36	28.5	0.94	24.0-34.0	12.0-41.0	26-6
37	30.5	1.37	26.5-36.0	13.0-45.0	29-3
38	33.0	1.37	27.0-38.0	14.0-48.0	32-2
39	36.0	1.48	28.0-40.5	14.5-52.5	
40	39.0	1.48	30.0-43.0	15.5-56.5	
41	41.5	1.48	32.5-46.0	16.5-61.0	
42	45.5	1.48	36.0-50.0	18.0-66.0	
43	50.0	1.48	40.0-53.5	19.0-71.0	
44	53.5	3.75	43.0-58.0	21.0-75.5	
45	57.0	3.75	48.0-61.5	22.5-81.5	
46	61.5	3.75	51.0-65.5	24.0-88.0	
47	65.0	3.75	54.0-69.5	26.0-93.0	
48	69.0	3.75	57.0-73.5	28.0-99.0	
49	73.0	3.75	60.5-77.5	30.0-105.0	
50	77.0	3.75	64.0-82.0	32.5-113.0	

TABLE II

KIDNEY WEIGHT RELATED TO TOTAL BODY WEIGHT

Body Weight (g.)	Mean	S.E.	50% Range	95% Range	Potter and Adair (1949)	
1,400	15.5	1.03	14.0-20.5	9.5-25.5	18-3	
1,500	17.0	1.03	14.5-21.0	10.0-26.0		
1,600	18.0	1.03	15.5-21.5	10.5-27.0		
1,700	19.0	0.83	16.0-22.0	11.0-27.5		
1,800	19.8	0.83	16.5-23.0	11.5-28.0		
1,900	20.5	0.83	17.5-23.5	12.0-29.0		
2,000	21.0	0.83	18.5-24.5	13.0-30.0		
2,100	22.0	0.83	19.0-25.0	13.5-31.0		
2,200	23.0	1.24	19.5-25.5	14.0-32.0		
2,300	23.5	1.24	20.5-26.5	14.0-33.0		
2,400	24.0	1.24	21.0-27.0	14.5-34.5		
2,500	25.0	0.81	22.0-28.0	15.0-35.0		21-1
2,600	25.5	0.81	22.5-29.0	15.0-35.5		
2,700	26.0	0.81	22.5-30.0	15.0-37.0		
2,800	27.0	0.98	23.0-31.0	15.0-38.0		
2,900	27.5	0.98	23.0-32.0	15.5-39.0		
3,000	28.5	0.98	23.5-33.0	15.5-40.0	23-6	
3,100	29.0	0.98	23.5-34.0	15.5-41.5		
3,200	29.5	1.46	24.0-34.5	16.0-42.5		
3,300	30.0	1.46	24.5-35.5	16.5-43.5	26-6	
3,400	31.0	1.46	25.0-36.0	17.0-45.0		
3,500	31.5	1.27	26.0-36.5	17.5-46.0		
3,600	32.5	1.27	26.5-37.0	18.0-47.0		
3,700	33.0	1.27	27.5-38.0	18.0-48.5		
3,800	33.5	1.27	28.0-38.5	18.5-49.0		
3,900	34.5	1.27	29.0-39.0	19.0-50.5		29-3
4,000	35.0	2.00	30.0-40.5	20.0-52.0		

in Tables I to IV. Comparative figures, where available, are included. Kidney weights graphed against post-natal age are also presented in Fig. 1.

It is thought essential that the weights be presented separately, against body weight, gesta-

tion age, and length, and not combined, as Potter and Adair found convenient, due to the differences found in the variation from "normal" under different criteria. This is illustrated in Fig. 2, where the scatter diagrams of the kidney weights against crown-rump length and body weight are shown. In the chart using the total weight of the child, three cases, A, B, and C, are well outside the 95 percentile ranges. The same cases in the crown-rump length chart are not only well within the 95 percentiles, but close together. Thus, against body weight, these body weights are grossly abnormal, whereas against crown-rump length they are quite normal.

TABLE III

KIDNEY WEIGHT RELATED TO GESTATION AGE

Gestation Age (wk.)	Mean	S.E.	50% Range	95% Range	Potter (1952)
28	11.0	2.49	9.5-13.5	4.5-19.5	9-7
29	12.0	2.29	10.0-14.5	5.0-21.0	
30	13.0	2.20	11.0-16.0	5.5-22.5	13-6
31	14.5	2.16	12.0-17.0	6.0-24.0	
32	16.0	2.75	13.0-18.5	6.5-25.5	
33	17.0	3.33	14.0-19.5	7.0-26.5	
34	18.0	3.97	15.0-20.5	7.5-27.5	18-3
35	19.5	4.61	16.5-22.0	8.5-30.0	
36	20.5	3.50	17.0-23.0	9.0-31.5	
37	21.5	3.50	18.0-24.5	9.5-33.5	21-1
38	23.0	3.50	19.0-26.0	10.0-35.5	
39	24.0	2.38	20.0-27.5	11.0-37.5	23-6
40	25.5	2.87	21.0-29.5	11.5-39.5	26-6
41	27.0	3.36	21.5-31.0	12.5-41.0	32-2
42	28.0	4.41	22.5-32.5	13.0-43.0	
43	29.5	5.46	23.5-34.5	14.0-45.0	
44	30.5	6.12	24.5-36.0	15.0-47.0	
45	31.5	6.79	26.0-38.0	16.0-49.0	

TABLE IV

KIDNEY WEIGHT RELATED TO POST-NATAL AGE

Age	Mean	S.E.	50% Range	95% Range	Coppol-etta and Wolbach (1933)	Tkate-schenko (1900)
Birth	26	0.76	22-34	13-44	27	22-24
1 mth.	32	0.98	26-38	16-50	30	22.8-24.8
2 "	36	1.13	29-42	18-54	37	
3 "	39	1.43	33-46	21-60	39	32-36
4 "	44	1.73	36-50	24-65	43	
5 "	48	1.73	40-54	27-70	50	45.2-47.2
6 "	51	1.73	43-58	30-76	51	
7 "	56	2.04	46-63	32-82	60	58-60
8 "	60	2.04	50-68	35-88	61	
9 "	62	2.04	54-72	38-95	61	58-60
10 "	67	2.04	58-78	40-100	63	
11 "	69	2.04	63-85	43-109	67	
12 "	78	2.04	68-92	48-118	71	72-74
2 yrs.	88	2.74	74-103	54-130	93	
3 "	100	3.2	81-114	62-142	97	95-100
4 "	110	3.2	92-126	72-156	114	
5 "	121	3.2	100-136	81-169	129	110-112
6 "	134	6.4	110-150	90-182	135	
7 "	144	6.4	120-160	101-194	139	
8 "	156	6.4	131-173	111-207	149	
9 "	166	6.4	142-185	120-220	165	148-152
10 "	178	6.4	153-196	130-230	187	

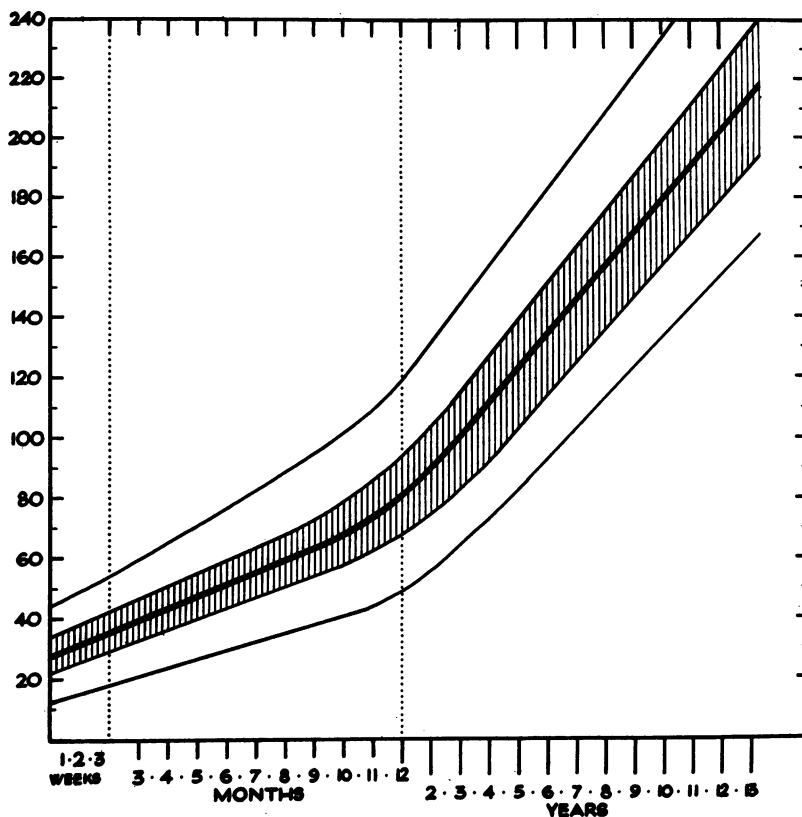


FIG. 1.—The mean combined kidney weights, the 50 percentile range (shaded), and the 95 percentiles (unshaded), the kidney weight being related to post-natal age, from 804 pairs of kidneys.

The method of estimation of the normal range used is that of percentiles rather than standard deviation. This problem was discussed well by Boyd (1935), who concludes that percentile ranges are the most useful as was originally stressed by Sir Francis Galton in 1885.

Our findings for post-natal kidney weight show slightly lower values than those of Coppoletta and Wolbach (1933). This is surprising because our method did not permit the kidneys to be squeezed and emptied of blood before weighing. Also, the general body weight and height of these children are probably higher than those of children used in the Boston series of 25 years ago.

The foetal kidney weights given by Cruickshank and Miller (1924b) and Browne (1924), from this country, compare very closely with our figures, suggesting that foetal kidney weights have not altered over the last 25 years. In general our weights show a higher range than those of Potter and Adair (1949) and Potter (1952), but their presentation is not strictly comparable to the

present study as they produced common body weight, age, and body length grouping. We have shown that quite different results can be obtained when the kidney weight is related to the total body weight than when related to crown-rump length, and the same applies to gestation age.

When attempts are made to elucidate intra-uterine disease, estimates should be made against the different general body measurements separately.

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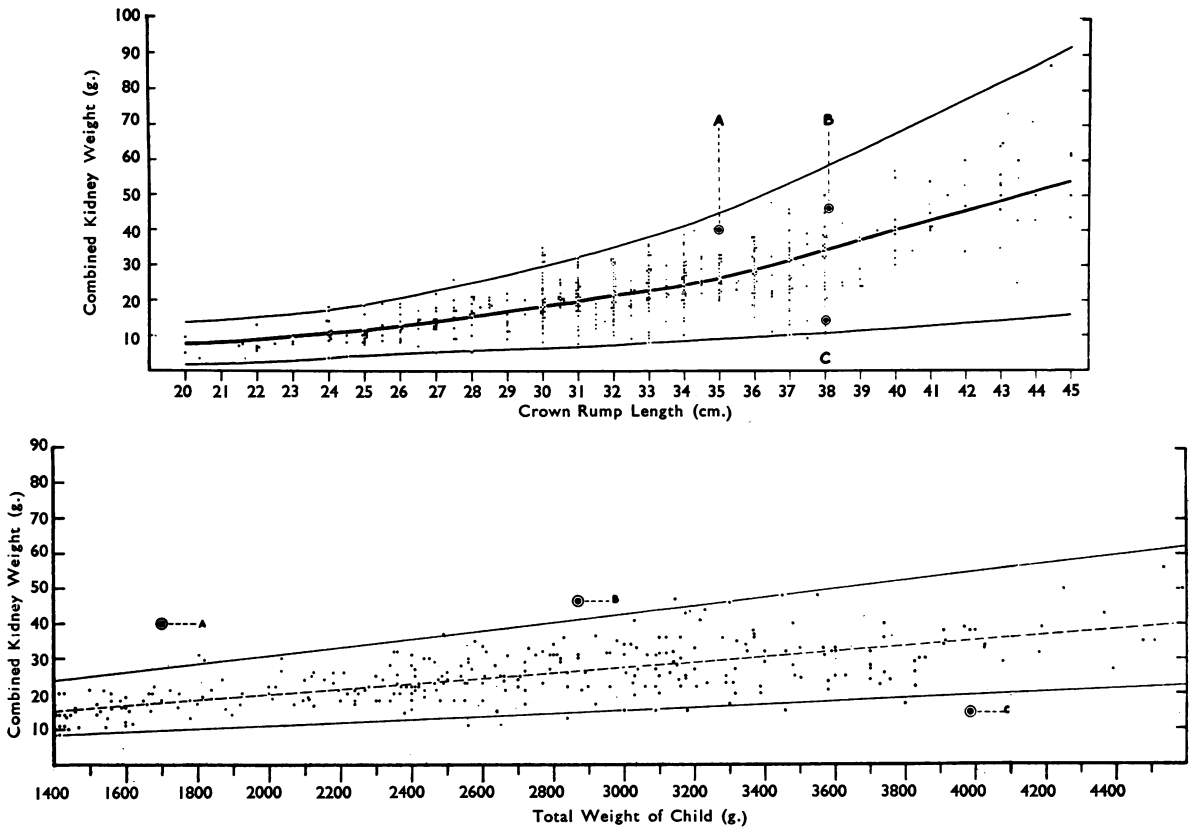


FIG. 2.—Scatter diagrams of the combined kidney weights with the means and 95 percentile lines against crown-rump length and total weight of the child in grams. The points marked A, B, and C represent the same kidneys as they fall in the different graphs.

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