Reference data on gains in weight and length during the first two years of life

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Serial data from studies of infants at the University of Iowa and from the Fels Longitudinal Study were used to develop sex-specific percentiles for increments in weight and recumbent length for selected intervals during the first 24 months of life. Weight increments are presented for 1-month intervals from birth to 6 months, 2-month intervals from birth to 12 months, and 3-month intervals from birth to 24 months. Length increments are presented for 2-month intervals from birth to 6 months, and for 3-month intervals from birth to 24 months of age. Weights and lengths at the target ages were obtained for the Iowa data by simple interpolation, and for the Fels data by fitting families of three-parameter mathematical functions to the serial data from ages 1 to 24 months. The tabular presentations are based on the Iowa data from birth to 3 months of age, on the combined Iowa and Fels data from 3 to 6 months of age, and on the Fels data from 6 to 24 months of age. We believe that these reference data will be useful in screening for deviations from normal growth and may aid in early detection of failure to thrive or excessive weight gain during early life. (J PEDIATR 1991;119:355-62)

Reference data for weight and recumbent length (referred to subsequently as length) at various ages during infancy permit assessment of size of a particular infant in relation to size of his or her peers. Such status data are essential for identifying infants with low or high weight or length for age, and low or high weight for length, but they provide little information about growth.

Growth data are needed for monitoring health status, identifying deviations from normality, and assessing the effects of intervention.[1] Although it is possible to detect changes in percentile level when serial data for weight and length of a child are plotted on age- and sex-specific status charts,[2] such data are of little use in comparing the magnitude of the gains in weight or length of person with those of a reference population. Reference data for *increments* in length and weight are necessary if one is to make a quantitative assessment of growth of a person in relation to that of a reference population.

See commentary, p. 415.

In developing reference data on gains in weight and length, it is important to identify the age intervals of greatest interest. We selected the following: increments in weight for 1-month intervals from birth to 6 months, for 2-month intervals from birth to 12 months, and for 3-month intervals

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Table I. One-month increments in weight (gm/day) from birth to 6 months*

Age (mo)	n	Weight (gm/day)†	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Boys									
Up to 1	580	30 ± 9.4	15	18	24	30	36	42	45
1-2	580	35 ± 8.5	22	25	29	35	40	46	50
2-3	580	27 ± 7.9	15	18	22	26	31	36	41
3-4	298	20 ± 3.6	15	16	18	20	22	24	26
4-5	298	17 ± 3.4	12	14	15	17	19	21	23
5-6	298	16 ± 3.5	11	12	14	15	17	19	21
Girls									
Up to 1	562	26 ± 8.4	11	16	20	26	32	36	39
1-2	562	29 ± 7.7	18	20	24	29	34	39	42
2-3	562	23 ± 7.2	12	14	19	23	28	32	35
3-4	298	19 ± 5.3	13	15	17	19	21	23	26
4-5	298	16 ± 5.0	11	13	14	16	18	20	22
5-6	298	15 ± 4.7	10	11	13	14	16	18	18

*From birth through 3 months, Iowa data; from 3 through 6 months, combined Iowa and Fels data.
†Values expressed as mean ± SD.

from birth to 24 months; increments in length for 2-month intervals from birth to 6 months and for 3-month intervals from birth to 24 months.

METHODS

The data summarized here are from the University of Iowa studies of infant growth and nutrition (Iowa study) and from the Fels Longitudinal Study (Fels study). The Iowa study sample consisted primarily of children of faculty or students of the University of Iowa; the Fels study sample included infants from families with a wide range of socioeconomic levels. Measurements were made in accordance with recommended procedures,[3] and measurement errors[4] were similar in the two data sets. Informed consent was obtained from one or both parents of the infants, and all procedures were approved by the institutional review boards.

Iowa data were numerous at young ages, and Fels data predominated in the combined set and at older ages. We therefore decided to limit the incremental data to only Iowa data from birth to 3 months, to use Iowa and Fels data from 3 to 6 months, and to use only Fels data after 6 months. As discussed later the extent of agreement of the two data sets is indicated by the similarity of the values for weight and length at age 3 months.

Iowa study. The Iowa study included 1142 normal, term, white infants (200 breast-fed boys, 214 breast-fed girls, 380 formula-fed boys, 348 formula-fed girls) with birth weights of 2500 gm or more. Birth dates were March 1965 through March 1987. Hospital records of birth weight were available. Measurements of weight and length were made by trained investigators within 2 days of ages 8, 14, 28, 42, and 56 days, and within 4 days of ages 84 and 112 days. Each measurement was made in duplicate and the mean of the two values was used in the analyses. With few exceptions the subjects are the same as those described by Nelson et al.[5] A subset of this cohort (65 formula-fed boys, 74 formula-fed girls) continued to be studied after 112 days of age and were fed formulas providing approximately 67 kcal/dl. They were measured within 4 days of ages 140, 168, and 196 days. Data concerning some of the infants studied from 112 to 196 days of age have been reported previously,[6-10] although in two of these reports[9, 10] growth data were not presented.

Because reliable data on length at birth were not obtained, the values for length at age 8 days were used. Gain in length between birth and 8 days is likely to be a rather small percentage of the gain from birth to 2 months or from birth to 3 months, and we do not believe that the absence of reliable length data at birth presents a serious problem.

Values for weight and length at the target ages (i.e., 1 month [30.5 days], 2 months [61 days], etc.) were interpolated from a second-degree polynomial on age with three consecutive measurement values (the value at the age closest to the target age, and the preceding and following values). As already mentioned, the value for length at birth was assumed to be the same as that obtained at age 8 days. The increment in weight (or length) of each infant for each age interval was calculated from the difference between the interpolated value at the end and that at the beginning of the interval.

Fels study. The Fels study[4] concerned 476 white infants (240 boys and 236 girls, mostly formula-fed) with birth dates from 1930 through 1987. Birth weights were 2500 gm

Table II. Two-month increments in weight from birth to 12 months*

Age (mo)	n	Weight (gm/day)†	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Boys									
Up to 2	580	33 ± 7.0	21	24	28	32	38	42	44
1-3	580	31 ± 6.9	20	22	27	31	35	39	43
2-4	65	23 ± 4.7	—	17	19	23	26	29	—
3-5	298	19 ± 3.2	14	15	17	18	20	22	24
4-6	298	16 ± 2.9	12	13	14	16	18	20	21
5-7	233	15 ± 2.4	11	12	13	15	16	18	18
6-8	233	13 ± 2.4	10	11	12	13	15	16	17
7-9	233	12 ± 2.4	9	10	11	12	14	15	16
8-10	233	12 ± 2.4	9	9	10	11	13	15	15
9-11	233	11 ± 2.3	8	8	9	11	12	14	14
10-12	233	10 ± 2.3	7	8	9	10	12	13	14
Girls									
to 2	562	28 ± 6.5	17	20	23	28	32	36	38
1-3	562	26 ± 6.3	16	19	22	26	30	34	37
2-4	74	22 ± 5.4	—	16	19	21	24	27	—
3-5	298	18 ± 4.7	13	14	16	17	19	21	22
4-6	298	15 ± 4.6	11	12	14	15	17	18	19
5-7	224	14 ± 4.7	11	11	13	14	15	17	17
6-8	224	13 ± 4.6	10	10	12	13	14	16	16
7-9	224	12 ± 4.5	9	10	11	12	13	15	15
8-10	224	12 ± 4.5	8	9	10	11	13	14	14
9-11	224	11 ± 4.4	8	8	9	10	12	13	14
10-12	224	10 ± 4.3	7	8	9	10	11	13	13

*From birth through 3 mo, Iowa data; from 3 through 6 mo, combined data; from 6 through 12 mo, Fels data.
†Values expressed as mean ± SD.

or more. Examinations were scheduled at 1, 3, 6, 9, 12, 18, and 24 months, and nearly all were examined within a few weeks of these target ages and also at intermediate ages. All measurements were made by trained observers from the Fels staff. The means of pairs of measurements were used in the analyses.

In the present study, as in several previous studies,[4, 11, 12] reference data were derived by fitting mathematical models to serial data for individual subjects. The data for each child were summarized in a few derived parameters that were then used to estimate status values at selected ages and increments during selected age intervals. This approach was necessary because many of the measurements were not made at the target (scheduled) ages. In such mathematical modeling, data need not be available for every age of interest, but the data points for each subject must be sufficient for satisfactory construction of the model.

A two-stage random-effects method[13] was applied to the serial data of each participant in the Fels study. This method assumes that the pattern of change over time for each subject in the group can be described by a family of mathematical models. With this approach the differences among subjects are characterized by the parameters in the fitted models. A subsample of individual observed curves was first plotted. A mathematical model was chosen on the basis of the shapes of the observed curves and then fitted to the serial data of each subject. This procedure was repeated until the result was satisfactory. The selected model was fitted to the serial data of each participant who had at least seven data points from birth through 24 months and who did not have two successive missing data points. The model for weight (in kilograms) or length (in centimeters) was as follows:

$$f(t) = a + b \log(t + 1) + c(t + 1)^{0.5} + e$$

where $f(t)$ is the weight (or length) at age t (months); a, b, and c are the parameters to be estimated for each participant; and e is an error term.

The parameters in the model were estimated with the Marquardt method.[14] The goodness of fit was evaluated by the residual mean square errors. The mathematical models fit the data well except in 7 boys and 12 girls. These participants were therefore excluded from the analyses. Data on weight, length, and weight for length at the target ages for each remaining subject were then obtained from the fitted model.

To explore the possibility of secular change, the data were

Table III. Three-month increments in weight from birth to 24 months*

Age (mo)	n	Weight (gm/day)†	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Boys									
Up to 3	580	31 ± 5.9	21	23	27	31	34	38	41
1-4	65	27 ± 5.1	—	21	23	27	30	34	—
2-5	65	21 ± 4.3	—	15	17	21	23	27	—
3-6	298	18 ± 2.9	13	14	16	18	19	21	23
4-7	233	16 ± 2.4	12	13	14	15	17	18	19
5-8	233	14 ± 2.4	11	11	13	14	15	17	18
6-9	233	13 ± 2.4	10	10	11	13	14	16	17
7-10	233	12 ± 2.4	9	9	10	12	13	15	16
8-11	233	11 ± 2.4	8	9	10	11	12	14	15
9-12	233	11 ± 2.3	8	8	9	10	12	14	14
10-13	233	10 ± 2.3	7	8	9	10	11	13	14
11-14	233	10 ± 2.3	7	7	8	9	11	12	13
12-15	233	9 ± 2.3	6	7	8	9	10	12	13
13-16	233	9 ± 2.3	6	6	7	9	10	12	13
14-17	233	8 ± 2.2	6	6	7	8	10	11	12
15-18	233	8 ± 2.2	5	6	7	8	9	11	12
16-19	233	8 ± 2.2	5	6	7	8	9	10	12
17-20	233	8 ± 2.2	5	5	6	7	9	10	12
18-21	233	7 ± 2.2	5	5	6	7	8	10	11
19-22	233	7 ± 2.1	4	5	6	7	8	10	11
20-23	233	7 ± 2.1	4	5	6	7	8	9	11
21-24	233	7 ± 2.1	4	5	6	7	8	9	11
Girls									
Up to 3	562	26 ± 5.5	17	20	23	26	30	33	36
1-3	74	24 ± 5.1	—	19	21	24	27	30	—
2-5	74	20 ± 3.9	—	16	17	19	21	25	—
3-6	298	17 ± 4.6	12	13	15	17	18	20	21
4-7	224	15 ± 4.8	11	12	13	15	16	17	18
5-8	224	14 ± 4.7	10	11	12	13	15	16	17
6-9	224	13 ± 4.6	10	10	11	12	14	15	16
7-10	224	12 ± 4.5	9	9	10	12	13	14	15
8-11	224	11 ± 4.4	8	9	10	11	12	14	14
9-12	224	11 ± 4.3	8	8	9	10	12	13	14
10-13	224	10 ± 4.2	7	8	9	10	11	12	13
11-14	224	10 ± 4.2	7	7	8	9	11	12	13
12-15	224	9 ± 4.1	7	7	8	9	10	12	12
13-16	224	9 ± 4.0	6	7	8	8	10	11	12
14-17	224	9 ± 3.9	6	6	7	8	9	11	12
15-18	224	8 ± 3.9	6	6	7	8	9	10	11
16-19	224	8 ± 3.8	6	6	7	8	9	10	11
17-20	224	8 ± 3.8	5	6	7	7	9	10	11
18-21	224	8 ± 3.7	5	5	6	7	8	10	11
19-22	224	7 ± 3.6	5	5	6	7	8	9	10
20-23	224	7 ± 3.6	5	5	6	7	8	9	10
21-24	224	7 ± 3.5	5	5	6	7	8	9	10

*From birth through 3 months, Iowa data; from 3 through 6 months, combined data; from 6 through 12 months, Fels data.
†Values expressed as mean ± SD.

categorized by decades, on the basis of date of birth of the infants: 1929 through 1939, 1940 through 1949, 1950 through 1959, 1960 through 1969, and 1970 through 1979. Analysis of variance revealed no evidence of secular change in gains in length or weight of boys or girls for the two selected 3-month intervals, 4 to 7 months and 21 to 24 months.

RESULTS

Similarity of weight and length values. The extent of agreement between the two data sets is best indicated by comparison of the data for weight and length at age 3 months.[15] The mean (±SD) and 5th percentile values of weight for boys at age 3 months were 6338 ± 643 gm and

Table IV. Two-month increments in length from birth to 6 months*

Age (mo)	n	Length (mm/day)†	Percentiles						
			5th	10th	25th	50th	75th	90th	95th
Boys									
Up to 2	580	1.10 ± 0.15	0.87	0.90	1.00	1.10	1.18	1.28	1.34
1-3	580	1.08 ± 0.14	0.85	0.90	0.98	1.08	1.17	1.26	1.31
2-4	65	0.93 ± 0.75	—	0.75	0.82	0.95	1.02	1.07	—
3-5	255	0.73 ± 0.09	0.60	0.63	0.68	0.73	0.79	0.86	0.90
4-6	255	0.64 ± 0.08	0.49	0.54	0.59	0.63	0.69	0.74	0.78
Girls									
Up to 2	562	1.03 ± 0.13	0.80	0.87	0.93	1.03	1.11	1.20	1.25
1-3	562	0.99 ± 0.13	0.79	0.84	0.92	0.98	1.07	1.15	1.18
2-4	74	0.89 ± 0.13	—	0.72	0.80	0.90	0.97	1.05	—
3-5	241	0.71 ± 0.10	0.57	0.60	0.66	0.71	0.77	0.82	0.87
4-6	241	0.62 ± 0.08	0.48	0.52	0.57	0.63	0.67	0.70	0.73

*From birth through 3 mo, Iowa data; from 3 through 6 mo, combined data; from 6 through 12 mo, Fels data.
†Values expressed as mean ± SD.

5331 gm in the Iowa study (580 boys), and 6297 ± 613 gm and 5305 gm in the Fels study (233 boys). The mean (±SD) and 5th percentile values of weight for girls at age 3 months were 5770 ± 600 gm and 4885 gm in the Iowa study (562 girls), and 5750 ± 600 gm and 4734 gm in the Fels study (224 girls). The mean (±SD) and 5th percentile values of length for boys at age 3 months were 61.0 ± 1.9 cm and 57.8 cm in the Iowa study (580 boys), and 61.4 ± 1.9 cm and 58.4 cm in the Fels study (190 boys). The mean (±SD) and 5th percentile values of length for girls at age 3 months were 59.4 ± 1.8 cm and 56.7 cm in the Iowa study (562 girls), and 59.5 ± 2.0 cm and 56.3 cm in the Fels study (167 girls).

Incremental data. Means, standard deviations, and the 10th, 25th, 50th, 75th, and 90th percentile values are presented on a sex-specific basis for increments in weight and length for selected age intervals. In most instances the number of subjects also justified inclusion of the 5th and 95th percentile values.

Weight. Table I presents 1-month increments in weight from birth to 6 months, and Table II presents 2-month increments in weight from birth to 12 months. During the early months of life, weight gains of boys were generally greater than those of girls. The sex-related differences in gains decreased toward the end of the first year (Table II). The variability in weight gain of boys tended to be larger than that of girls.

Table III presents 3-month increments in weight from birth to 24 months of age for boys and girls. During the second year of life, differences in weight gain between boys and girls were slight.

Length. Table IV presents 2-month increments in length from birth to 6 months, and Table V presents 3-month increments in length from birth to 24 months. The sex-associated differences were generally similar to those for weight.

DISCUSSION

Mathematical modeling similar to that used in processing the data for this report has been used previously to develop reference data for 1-month increments in weight and length during the first year of life.[4, 11, 12] Such data have contributed greatly to our understanding of growth during infancy, but we do not consider that data at 1-month increments for weight are clinically useful for infants more than 6 months of age or that data at 1-month increments for length are clinically useful at any age.

The incremental data presented in this report are those which we consider to be most useful clinically. After 6 months of age, day-to-day variation in weight is large in relation to the 1-month gains. The difference between the 5th and the 50th percentiles for 1-month weight gain of boys or of girls between 10 and 11 months of age is about 90 gm—a value less than the anticipated difference in weight of an infant before and after a feeding, and similar to the difference in weight before and after defecation. For this reason 1-month gains in weight have not been presented for ages beyond 6 months. Data on increments in length for intervals as short as 1 month are not useful clinically, because even with well-trained personnel the measurement error is a relatively large fraction of the increment. The difference between the 5th and the 50th percentile for 1-month length gain of boys between 4 and 5 months of age is about 0.4 cm, which is similar to the measurement error. Differences between the 5th and 50th percentile gains in length for 2-month intervals are also similar to the measurement er-

Table V. Three-month increments in length from birth to 24 months*

Age (mo)	n	Length (mm/day)†	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Boys									
Up to 3	580	1.07 ± 0.11	0.89	0.92	0.99	1.06	1.14	1.21	1.26
1-4	65	1.00 ± 0.08	—	0.90	0.94	1.01	1.06	1.09	—
2-5	65	0.84 ± 0.09	—	0.74	0.79	0.84	0.91	0.95	—
3-6	255	0.69 ± 0.08	0.56	0.60	0.64	0.68	0.73	0.79	0.82
4-7	190	0.62 ± 0.06	0.54	0.55	0.58	0.61	0.65	0.69	0.72
5-8	190	0.56 ± 0.05	0.49	0.50	0.53	0.56	0.59	0.63	0.65
6-9	190	0.52 ± 0.05	0.46	0.46	0.49	0.52	0.54	0.58	0.60
7-10	190	0.48 ± 0.05	0.42	0.43	0.45	0.48	0.51	0.54	0.57
8-11	190	0.45 ± 0.04	0.39	0.40	0.43	0.45	0.48	0.51	0.53
9-12	190	0.43 ± 0.04	0.36	0.38	0.40	0.43	0.45	0.48	0.51
10-13	190	0.41 ± 0.04	0.34	0.36	0.38	0.41	0.43	0.46	0.49
11-14	190	0.39 ± 0.04	0.33	0.34	0.36	0.39	0.41	0.44	0.47
12-15	190	0.37 ± 0.04	0.31	0.32	0.35	0.37	0.39	0.43	0.45
13-16	190	0.36 ± 0.04	0.30	0.31	0.33	0.36	0.38	0.41	0.44
14-17	190	0.35 ± 0.04	0.28	0.30	0.32	0.34	0.37	0.40	0.42
15-18	190	0.33 ± 0.04	0.27	0.28	0.31	0.33	0.35	0.39	0.41
16-19	190	0.32 ± 0.04	0.26	0.27	0.30	0.32	0.34	0.38	0.40
17-20	190	0.31 ± 0.04	0.25	0.26	0.29	0.31	0.33	0.37	0.39
18-21	190	0.03 ± 0.04	0.24	0.25	0.28	0.30	0.32	0.36	0.38
19-22	190	0.03 ± 0.04	0.23	0.25	0.27	0.29	0.31	0.35	0.37
20-23	190	0.29 ± 0.04	0.23	0.24	0.27	0.28	0.31	0.34	0.36
21-24	190	0.28 ± 0.04	0.22	0.23	0.26	0.28	0.30	0.33	0.35
Girls									
Up to 3	562	0.99 ± 0.10	0.82	0.86	0.93	0.99	1.06	1.11	1.15
1-4	74	0.95 ± 0.10	—	0.84	0.87	0.95	1.02	1.07	—
2-5	74	0.80 ± 0.10	—	0.67	0.73	0.81	0.87	0.92	—
3-6	241	0.67 ± 0.08	0.55	0.58	0.63	0.67	0.72	0.77	0.79
4-7	167	0.60 ± 0.06	0.53	0.54	0.57	0.61	0.64	0.67	0.69
5-8	167	0.56 ± 0.05	0.49	0.50	0.52	0.56	0.59	0.62	0.63
6-9	167	0.52 ± 0.05	0.45	0.46	0.48	0.52	0.55	0.57	0.58
7-10	167	0.48 ± 0.04	0.42	0.43	0.45	0.49	0.52	0.54	0.55
8-11	167	0.46 ± 0.04	0.39	0.41	0.43	0.46	0.49	0.51	0.52
9-12	167	0.44 ± 0.04	0.37	0.38	0.41	0.44	0.46	0.48	0.49
10-13	167	0.42 ± 0.04	0.35	0.37	0.39	0.42	0.45	0.46	0.48
11-14	167	0.40 ± 0.04	0.34	0.35	0.37	0.40	0.43	0.44	0.46
12-15	167	0.38 ± 0.04	0.32	0.34	0.36	0.38	0.41	0.43	0.44
13-16	167	0.37 ± 0.04	0.31	0.32	0.34	0.37	0.40	0.42	0.43
14-17	167	0.36 ± 0.04	0.29	0.31	0.33	0.36	0.38	0.40	0.41
15-18	167	0.34 ± 0.04	0.28	0.30	0.32	0.35	0.37	0.39	0.40
16-19	167	0.33 ± 0.04	0.27	0.29	0.31	0.34	0.36	0.38	0.39
17-20	167	0.32 ± 0.04	0.26	0.28	0.30	0.33	0.35	0.37	0.38
18-21	167	0.32 ± 0.04	0.26	0.27	0.29	0.32	0.34	0.36	0.37
19-22	167	0.31 ± 0.04	0.25	0.26	0.28	0.31	0.33	0.35	0.36
20-23	167	0.30 ± 0.04	0.24	0.26	0.28	0.30	0.33	0.35	0.36
21-24	167	0.29 ± 0.04	0.23	0.25	0.27	0.30	0.32	0.34	0.35

*From birth through 3 months, Iowa data; from 3 through 6 months, combined data; from 6 through 24 months, Fels data.
†Data expressed as mean ± SD.

ror after 6 months of age. We therefore restricted our presentation of 2-month increments in length to the first 6 months of life.

Previously published reference data[3, 11, 16-23] on gains in length and weight during the first 2 years (or a portion of the first 2 years) of life have limited clinical usefulness. The data presented here represent an improvement because the more extensive data base for the first 6 months of life permits greater confidence in the percentiles for gain during the early period of most rapid

growth. In addition, we believe that the age intervals for which increments are presented are of greater clinical usefulness.

Evaluation of growth progress of an individual subject with the aid of reference tables that present increments in weight and length is far superior to the conventional practice of plotting weight and length values for the subject on weight-for-age, length-for-age, and weight-for-length charts. However, plotting values on weight-for-age and length-for-age charts is simple and familiar, whereas use of tables of incremental data is unfamiliar to most clinicians and is admittedly cumbersome. Recognizing the difficulty in use of reference tables of incremental data, we do not urge that such tables replace charts of weight for age and length for age for evaluation of growth progress. Use of the more sensitive but less convenient method is recommended for evaluating growth progress of infants suspected of being at high risk of growth failure. For meaningful evaluation of the data concerning an individual infant by use of these reference data, the measurement of weight and length of the infant in question must be made by sound anthropometric procedures, and the age interval must be of similar duration to that of the reference data (e.g., for use of the data presented here, 1, 2, or 3 months).

The reference data presented in this report are based on measurements of both breast-fed and formula-fed white infants. Differences in gains in weight and length between white and black infants are small[24, 25] and should not interfere with use of the tables for evaluation of growth progress of black infants. As is true in the use of all reference data on infant growth, it may at times be necessary to take into account differences in rates of gain by breast-fed and formula-fed infants[5, 26-30] and by infants with greater or lesser size at birth.[30-34]

REFERENCES

1. Chumlea WC. Clinical methods of assessing obesity in children. Perspect Lipid Disord 1986;3:14-9.
2. Hamill PVV, Drizd TA, Johnson CL, Reed RB, Roche AF. NCHS growth curves for children birth–18 years. United States Vital and Health Statistics. Washington, DC: Government Printing Office, 1977:74. Department of Health, Education and Welfare Publication PHS 78-1650, series 11.
3. Lohman TG, Roche AF, Martorell R, eds. Anthropometric standardization reference manual. Champaign, Ill: Human Kinetics Publishers, 1988.
4. Roche AF, Guo S, Moore WM. Weight and recumbent length from 1 to 12 mo of age: reference data for 1-mo increments. Am J Clin Nutr 1989;49:599-607.
5. Nelson BA, Rogers RR, Ziegler EE, Fomon SJ. Gain in weight and length during early infancy. Early Hum Dev 1989;19:223-39.
6. Fomon SJ, Thomas LN, Filer LJ Jr, Ziegler EE, Leonard MT. Food consumption and growth of normal infants fed milk-based formulas. Acta Paediat Scand 1971;223(suppl): 1-36.
7. Fomon SJ, Filer LJ Jr, Ziegler EE, Bergmann KE, Bergmann RL. Skim milk in infant feeding. Acta Paediatr Scand 1977;66:17-30.
8. Fomon SJ, Ziegler EE, Nelson SE, Edwards BB. Cow milk feeding in infancy: gastrointestinal blood loss and iron nutritional status. J PEDIATR 1981;98:540-5.
9. Nelson SE, Ziegler EE, Copeland AM, Edwards BB, Fomon SJ. Lack of adverse reactions to iron-fortified formula. Pediatrics 1988;81:360-4.
10. Ziegler EE, Fomon SJ, Nelson SE, et al. Cow milk feeding in infancy: further observations on blood loss from the gastrointestinal tract. J PEDIATR 1989;116:11-8.
11. Roche AF, Guo S, Yeung DL. Monthly growth increments from a longitudinal study of Canadian infants. Am J Hum Biol 1989;1:271-9.
12. Guo S, Roche AF, Yeung DL. Monthly growth status from a longitudinal study of Canadian infants. Can J Public Health 1990;81:215-21.
13. Laird NM, Ware JH. Random-effects models for longitudinal data. Biometrics 1982;38:963-74.
14. Marquardt DW. An algorithm for least-squares estimation of nonlinear parameters. J Soc Indust Appl Math 1963;11:431-41.
15. Siegel S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.
16. Roche AF, Himes JH. Incremental growth charts. Am J Clin Nutr 1980;33:2041-52.
17. Baumgartner RN, Roche AF, Himes JH. Incremental growth tables: supplementary to previously published charts. Am J Clin Nutr 1986;43:711-22.
18. Bialik O, Peritz E, Arnon A. Weight growth in infancy: a regression analysis. Hum Biol 1973;45:81-93.
19. Bayley N, Davis FC. Growth changes in bodily size and proportions during the first three years: a developmental study of sixty-one children by repeated measurements. Biometrics 1935;27:26-87.
20. Pomerance HH, Krall JM. Linear regression to approximate longitudinal growth curves: revised standards for velocity of weight and length in infants. Pediatr Res 1981;15:1390-5.
21. Brandt I. Growth dynamics of low-birth-weight infants with emphasis on the perinatal period. In: Falkner F, Tanner JM, eds. Human growth; vol 2. New York: Plenum Press, 1978:557-617.
22. Falkner F. Some physical measurements in the first three years of life. Arch Dis Child 1958;33:1-9.
23. Karlberg P, Engström I, Lichtenstine H, Svennberg I. The development of children in a Swedish urban community: a prospective longitudinal study. III. Physical growth during the first three years of life. Acta Paediatr Scand 1968;187: (suppl)48.
24. Wingerd J, Schoen EJ, Solomon IL. Growth standards in the first two years of life based on measurements of white and black children in a prepaid health care program. Pediatrics 1971; 47:818-25.
25. Dewey KG, Heinig MJ, Normmsen LA, Lonnerdal B. Low energy intake and growth velocity of breast-fed infants at 6-12 mo: are there functional consequences [Abstract]? FASEB J 1989;3(4):A1055.
26. Jung E, Czajka-Narins DM. Birth weight doubling and

tripling times: an updated look at the effects of birth weight, sex, race and type of feeding. Am J Clin Nutr 1985;42:182-9.
27. de Swiet M, Fayers P, Cooper L. Effects of feeding habits on weight in infancy. Lancet 1977;1:892-4.
28. Yeung DL. Infant nutrition. Canadian Public Health Association. Ontario, Canada: MOM Printers, 1983.
29. Neumann CG, Alpaugh M. Birth weight doubling time: a fresh look. Pediatrics 1976;57:469-73.
30. Chandra RK. Physical growth of exclusively breast fed infants. Nutr Res 1982;2:275-6.
31. Ministry of Health. Standards of normal weight in infancy. Reports on Public Health and Medical Subjects. London: Her Majesty's Stationery Office, 1959:No. 99.
32. Fergusson DM, Horwood LJ, Shannon FT. Length and weight gain in the first three months of life. Hum Biol 1980;52:169-80.
33. Banik NDD, Krishna R, Mane SIS, Raj L. A longitudinal study on physical growth of children of different birth weight groups from birth to 5 years. Indian J Pediatr 1970;37:95-101.
34. Holmes GE, Miller HC, Hassenein K, Lansky SB, Goggin JE. Postnatal somatic growth in infants with atypical fetal growth patterns. Am J Dis Child 1977;131:1078-83.