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Gain in weight and length during early infancy

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Summary

Although rate of growth is generally recognized as a valuable indicator of health status, few reference data are available for gain in weight or length during the period of most rapid growth in infancy. We have therefore summarized our data concerning gains in length and weight of 203 breast-fed males, 216 breast-fed females, 380 formula-fed males, and 340 formula-fed females. Seven sets of measurements (at ages 8, 14, 28, 42, 56, 84 and 112 days) were made with each infant. The 5th, 10th, 25th, 50th, 75th, 90th and 95th centile values together with the means and standard deviations are presented for selected age intervals on a feeding-specific (i.e. breast-fed or formula-fed) and sex-specific basis. We believe that these data will be useful as a reference for interpreting results of infant studies.

gain in weight; gain in length; early infancy.

Introduction

Charts, such as those developed by the National Center for Health Statistics (NCHS) [12], are unquestionably useful as a reference for evaluating the size of infants and children. Plotting of sequential data for size—weight, length (or height), and weight for length (or weight for height) — permits a visual inspection of growth progress, and the intuitive appraisal of such progress by experienced individuals appears to be satisfactory in most instances. Nevertheless, such charts generally prove to be inadequate as reference data for evaluating growth progress in infant

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nutrition research. We therefore believe that a summary of our incremental data concerning the period of the neonatal growth spurt may be useful.

We have previously published incremental data from 8 to 112 days of age on weight and length of breast-fed infants [5,6,9] and infants fed milk-based and isolated soy protein (ISP)-formulas [6—8,11]. In the present report, we have combined data from these studies with previously unpublished data and present a summary of gains in weight and length of breast-fed and formula-fed infants. The centile gains presented here represent a major extension of the data base from the 233 breast-fed infants considered in 1978 [9] and the 142 formula-fed infants considered in 1971 [7].

Methods

Subjects

Normal, term, Caucasian infants with birth weights of 2500 g or more were observed from no later than 9 days of age until 112 days of age. Data concerning formula-fed infants enrolled in certain studies were excluded because we questioned the normality of growth with a particular experimental formula [3,10] or because the energy concentration of the formula was less than 64 or more than 70 kcal/dl [4]. With these exceptions, the observations presented in this report concern all infants who were enrolled in our growth studies from March 1965 to March 1987 and who completed the planned 112 days of observation. Most of the infants were children of students or faculty of the University of Iowa. Each study protocol was reviewed and approved by the University of Iowa Committee on Research Involving Human Subjects. Enrollment opportunities were continuously available for breast-fed and formula-fed infants.

Feeding

Breast-fed infants. Breast-fed infants were permitted to receive supplementary feedings of a commercially available milk-based formula. Most infants received one such feeding (not more than 240 ml/day) at least several times each week beginning at 4—6 weeks of age. A daily supplement provided vitamin D 400 IU, iron 15 mg (from ferrous sulfate) and fluoride 0.25 mg (from stannous fluoride).

Formula-fed infants. The infants were fed commercially available formulas or experimental formulas that were, in most instances, modifications of commercially available formulas. The source of protein was cow milk, cow milk plus cow milk whey, or isolated soy protein. The formulas were provided in ready-to-feed form (67 kcal/dl). Nearly all of the formulas were iron-fortified (12 mg of iron from ferrous sulfate per liter).

Beikost (foods other than milk or formula). From 1966 to 1978, all infants were permitted to receive selected foods other than milk or formula beginning at age 28 days. These foods have been identified previously [5]. After December, 1978, beikost was not fed during the first 112 days of life.

Measurements of weight and length

The infants were weighed and measured between 6 and 9 days of age, within 2 days of ages 14, 28, 42 and 56 days, and within 4 days of ages 84 and 112 days. Nude weight was determined to the nearest 5 g with infant scales (Continental Sales Company, Chicago, IL). The measurement was not repeated. Length was measured as described by Fomon [2]. Two examiners measured each infant, one holding the head against the headboard while the other stretched the lower extremities, pressed the footboard firmly against the soles of the feet and noted body length. The examiners then exchanged positions, repeated the procedure, and the average of the two measurements was recorded. When the results of the two examiners differed by more than 0.4 cm, the measurements were repeated and the two values agreeing more closely were used.

The recorded measurements were "corrected" to the nominal age by parabolic interpolation or extrapolation, using two adjacent values to correct a value obtained at a specified age to the corresponding value at the desired age (e.g. using the values at 14 and 40 days with a value obtained at 26 days to obtain the value appropriate for 28 days of age).

Statistical analysis

The data were analyzed by descriptive statistical methods, by analysis of variance for comparison of gains, and by analysis of variance of repeated measures for comparisons of size data. The general linear models procedure of the SAS statistics program (SAS Institute, Inc., Cary, SC) was used.

The standard error of various centile values may be calculated [15] as follows:

$$\text{S.E.} = a\sigma/\sqrt{n}$$

where σ is the standard deviation, n is the number of observations and a is a factor characteristic of the specified centile — 1.253 for the 50th, 1.362 for the 75th (or 25th), 1.710 for the 90th (or 10th) and 2.114 for the 95th (or 5th).

Results

Data were available for 203 breast-fed males, 216 breast-fed females, 380 formula-fed males, and 340 formula-fed females. Seven sets of measurements (at ages 8, 14, 28, 42, 56, 84 and 112 days) were made with each infant.

Size

The mean and standard deviation for body weight and length at each age are presented in Table I for breast-fed males and females and for formula-fed males and females. On a feeding-specific basis (i.e. breast-fed or formula-fed), weights of male infants were greater than weights of female infants (analysis of variance, $P < 0.001$). Similarly, on a feeding-specific basis, lengths of male infants were greater than those of female infants ($P < 0.001$).

TABLE I

Weights and lengths of breast-fed and formula-fed infants at selected ages.

Age (days)	Feeding							
	Breast-fed				Formula-fed			
	203 males		216 females		380 males		340 females	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Weight (g)								
8	3457	425	3355	406	3585	437	3396	387
14	3660	434	3545	413	3790	438	3575	390
28	4245	493	4058	453	4393	460	4081	396
42	4780	524	4504	496	4940	487	4529	430
56	5237	562	4879	534	5426	526	4935	461
84	5956	622	5512	593	6248	597	5642	536
112	6559	677	6085	661	6920	685	6262	607
Length (mm)								
8	512	18	506	17	514	18	504	17
14	521	18	515	17	523	18	513	17
28	539	18	533	18	542	18	530	17
42	556	18	549	17	559	19	546	17
56	570	18	562	17	576	19	562	17
84	598	19	588	18	605	19	589	18
112	623	20	611	18	631	20	612	18

Weights of formula-fed males were greater than those of breast-fed males ($P < 0.001$), but weights of formula-fed females were not significantly greater than those of breast-fed females ($P = 0.07$). On a sex-specific basis, lengths of formula-fed males were significantly greater than those of breast-fed males ($P < 0.01$), but lengths of formula-fed and breast-fed females were not different ($P = 0.40$).

As we have noted previously [6], the sex-related difference in body weight is greater than the difference related to mode of feeding. For example, at age 112 days, the sex-related difference in weight was 474 g for breast-fed infants and 662 g for formula-fed infants, whereas the difference related to mode of feeding was 361 g for males and 177 g for females.

Gain

Relation to sex and type of feeding. Gains in weight and length of breast-fed and formula-fed infants during the age intervals 8—42 days, 42—112 days and 8—112 days are presented in Table II.

On a sex-specific basis, gains in weight and length from 8 to 42 days were not significantly different for breast-fed and formula-fed infants. This may be explained for weight gain, at least in part, by the fact that most formula-fed but not most breast-fed infants have exceeded their birth weights by age 8 days [7]. Gains in

TABLE II

Gains in weight and length during selected age intervals in relation to sex and type of feeding.

Gain	Feeding							
	Breast-fed				Formula-fed			
	203 males		216 females		380 males		340 females	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Weight (g/d)								
8—42	38.9	9.7	33.8	9.3	39.8	7.7	33.3	7.4
42—112	25.4	6.2	22.6	6.3	28.5	6.4	24.7	5.2
8—112	29.8	5.8	26.2	5.6	32.2	5.6	27.5	4.9
Length (mm/d)								
8—42	1.29	0.22	1.24	0.22	1.33	0.22	1.25	0.19
42—112	0.96	0.17	0.89	0.13	1.03	0.12	0.94	0.11
8—112	1.07	0.12	1.01	0.11	1.13	0.11	1.04	0.09

weight and length by formula-fed infants were greater than those by breast-fed infants in the age intervals 42—112 and 8—112 days ($P < 0.001$).

On a feeding-specific basis, gains in weight and length were greater by males than by females in the age intervals 8—42, 42—112 and 8—112 days ($P < 0.01$).

Because of the secular trend in feeding custom in the community, we analyzed the data for the effect of permitted age of introduction of beikost. As already mentioned, infants enrolled in our studies were permitted until the end of 1978 to receive beikost beginning at 42 days of age. From the beginning of 1979, feeding of beikost was not permitted during the age period considered in this report. We therefore compared gains in weight and length on a sex-specific and feeding-specific (breast-fed or formula-fed) basis for the age interval 42—112 days. There were no significant differences in gains in weight or length of breast-fed infants or of formula-fed female infants. Formula-fed male infants enrolled before 1979 gained more rapidly in weight ($P < 0.03$) and length ($P < 0.01$), than did those enrolled in 1979 and subsequently. We cannot, of course, feel confident that the difference in gain was related to time of introduction of beikost, especially because the finding applied to only one of the four groups of infants.

Centile values for gains in weight and length. The 5th, 10th, 25th, 50th, 75th, 90th and 95th centiles for gain in weight during various age intervals are presented for breast-fed males in Table III and for breast-fed females in Table IV. Means and standard deviations for gain in weight are also presented. Corresponding data on gains in weight of formula-fed infants are presented in Tables V and VI. Data on gain in length for the age interval 8—42 days and for other age intervals of 42 days or longer are presented in Table VII (breast-fed males), Table VIII (breast-fed females), Table IX (formula fed males) and Table X (formula-fed females).

TABLE III

Weight gain (g/day) of 203 male breast-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5	3.3	20.1	21.8	22.9	21.3	20.1
	10	11.1	24.6	25.9	25.3	23.4	22.0
	25	22.7	31.3	31.9	31.1	27.9	25.1
	50	35.7	39.3	38.7	36.6	32.8	30.2
	75	46.5	48.1	46.3	44.4	37.5	33.5
	90	53.4	55.3	51.7	48.5	42.1	37.2
	95	60.4	58.5	54.3	51.3	44.1	40.5
Mean		33.9	39.4	38.9	37.1	32.9	29.8
S.D.		16.8	11.9	9.7	8.7	6.9	5.8
14	5		19.8	22.5	23.0	21.5	20.4
	10		24.8	26.6	26.0	23.5	21.6
	25		34.4	33.2	32.2	28.0	25.5
	50		41.9	39.8	36.6	32.7	29.8
	75		50.0	46.9	44.1	37.8	33.3
	90		57.2	52.3	49.0	41.7	37.2
	95		62.5	56.1	52.2	44.6	40.2
Mean			41.7	40.0	37.5	32.8	29.6
S.D.			12.5	9.7	8.7	6.9	5.9
28	5			20.6	21.3	20.0	17.7
	10			25.1	23.5	21.3	20.2
	25			30.3	28.7	25.3	22.8
	50			38.6	35.1	30.1	27.7
	75			45.8	41.7	36.1	31.2
	90			52.0	48.0	39.6	35.6
	95			54.9	50.7	43.3	38.2
Mean				38.2	35.4	30.6	27.6
S.D.				10.4	9.0	7.1	6.0
42	5				15.0	17.2	15.3
	10				17.3	18.5	17.9
	25				25.1	22.8	21.4
	50				33.1	28.1	25.0
	75				40.0	33.1	29.1
	90				47.0	37.6	34.2
	95				50.8	40.4	36.8
Mean					32.7	28.0	25.4
S.D.					11.1	7.4	6.2
56	5					14.8	14.9
	10					16.7	16.8
	25					20.3	19.4
	50					25.0	23.1
	75					29.6	27.1
	90					35.9	32.2
	95					39.5	35.5

TABLE III (*Continued*)

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
Mean						25.7	23.6
S.D.						7.7	6.2
84	5						10.5
	10						12.7
	25						16.9
	50						20.5
	75						25.5
	90						31.3
	95						36.8
Mean							21.5
S.D.							7.5

TABLE IV

Weight gain (g/day) of 216 female breast-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5	2.2	15.2	17.2	18.6	18.3	17.3
	10	10.0	20.1	22.8	22.6	20.9	19.8
	25	21.1	27.5	27.2	26.3	23.9	22.3
	50	33.5	35.6	34.0	31.6	27.9	25.8
	75	42.5	42.2	39.4	37.4	32.9	29.6
	90	49.2	50.2	46.2	41.8	36.1	32.9
	95	57.9	54.8	49.2	45.6	39.6	36.6
Mean		31.5	35.1	33.8	31.7	28.4	26.2
S.D.		16.8	11.1	9.3	7.9	6.5	5.6
14	5		16.4	18.9	18.0	18.2	17.5
	10		20.6	23.2	22.7	20.2	19.3
	25		28.3	27.9	26.2	23.5	22.2
	50		37.0	34.0	31.9	27.8	25.2
	75		43.1	40.0	36.8	32.3	29.3
	90		51.7	46.6	41.2	36.1	32.6
	95		55.6	51.1	47.6	39.6	35.9
Mean			36.7	34.3	31.8	28.1	25.9
S.D.			11.3	9.3	7.9	6.6	5.6
28	5			14.9	16.6	15.4	15.2
	10			18.3	19.6	17.4	17.2
	25			24.9	23.6	21.4	20.3
	50			31.4	29.0	25.5	23.8
	75			38.3	34.5	30.2	27.6

TABLE IV (*Continued*)

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
	90			46.7	40.3	35.3	31.4
	95			50.5	44.4	36.8	35.3
Mean				31.9	29.3	26.0	24.1
S.D.				10.6	8.4	6.9	5.9
42	5				12.1	12.7	12.8
	10				14.2	14.7	15.4
	25				20.0	19.1	18.9
	50				25.9	23.4	21.9
	75				32.9	28.8	26.0
	90				40.4	32.4	30.1
	95				45.8	37.2	35.2
Mean					26.8	24.0	22.6
S.D.					10.1	7.5	6.3
56	5					9.3	11.9
	10					12.0	14.1
	25					17.3	17.2
	50					22.9	21.1
	75					27.6	25.0
	90					32.0	29.6
	95					36.5	35.5
Mean						22.6	21.5
S.D.						8.3	6.6
84	5						8.5
	10						10.9
	25						15.9
	50						19.9
	75						24.5
	90						30.1
	95						34.0
Mean							20.5
S.D.							7.8

With few exceptions, the difference between the 5th and 10th centile values for gains in weight or length in each of the selected age intervals is more than twice the standard error of the 5th centile value.

Comment

Few data are available for use as reference values for gains in weight and length during early infancy. Hansman [13] presented monthly increments of gains in weight

TABLE V

Weight gain (g/day) of 380 male formula-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5	9.7	24.3	27.2	26.7	25.2	24.4
	10	15.7	28.3	29.8	29.5	27.4	25.4
	25	25.5	34.5	34.5	33.5	30.8	28.5
	50	34.4	40.1	39.9	38.1	34.6	32.0
	75	43.0	46.3	45.3	42.7	38.6	35.4
	90	53.8	52.5	48.9	47.5	43.2	39.7
	95	58.6	56.2	53.0	50.0	45.9	42.4
Mean		34.2	40.4	39.8	38.3	35.0	32.2
S.D.		14.9	9.7	7.7	7.0	6.1	5.6
14	5		27.5	27.4	27.3	24.5	23.5
	10		30.2	30.4	29.4	27.2	24.9
	25		36.2	35.9	34.1	30.8	28.3
	50		43.3	41.2	38.7	35.0	31.7
	75		49.6	46.3	43.7	38.9	35.1
	90		57.4	50.6	48.6	43.2	39.8
	95		61.5	53.9	50.8	46.4	43.4
Mean			43.1	41.1	38.9	35.1	32.1
S.D.			10.5	7.9	7.3	6.4	5.8
28	5			23.8	23.9	22.1	20.9
	10			27.6	27.6	24.6	22.5
	25			33.1	31.6	28.2	26.0
	50			38.6	35.8	32.9	29.9
	75			45.1	41.6	37.3	33.5
	90			51.4	47.9	41.4	38.1
	95			55.1	51.2	45.9	42.5
Mean				39.0	36.8	33.1	30.2
S.D.				10.1	8.3	6.9	6.2
42	5				17.9	19.1	18.5
	10				21.6	21.3	20.5
	25				27.1	25.4	23.9
	50				34.0	31.0	27.9
	75				40.6	36.0	32.6
	90				49.7	40.4	36.3
	95				53.3	44.0	40.9
Mean					34.6	31.1	28.5
S.D.					10.8	7.6	6.4
56	5					15.7	17.1
	10					19.8	18.7
	25					24.2	22.6
	50					29.1	26.3

TABLE V (*Continued*)

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
	75					33.6	30.7
	90					39.9	35.3
	95					43.6	38.8
Mean						29.3	26.9
S.D.						8.2	6.6
84	5						12.7
	10						15.1
	25						19.5
	50						24.2
	75						29.4
	90						34.3
	95						36.8
Mean							24.6
S.D.							7.6

TABLE VI

Weight gain (g/day) of 340 female formula-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5	7.5	22.1	21.7	21.7	20.5	19.4
	10	13.4	24.0	24.0	24.0	23.2	21.5
	25	22.5	28.1	28.0	27.2	25.7	24.0
	50	29.4	33.5	33.4	32.2	29.5	27.4
	75	37.4	39.6	38.1	36.4	32.9	30.7
	90	46.0	45.0	43.2	40.9	36.8	33.8
	95	49.5	48.5	46.2	43.4	39.6	35.6
Mean		29.9	34.3	33.3	32.1	29.6	27.5
S.D.		12.5	8.2	7.4	6.5	5.7	4.9
14	5		22.5	21.6	21.5	20.5	19.0
	10		24.8	24.4	24.2	22.6	21.4
	25		29.4	28.5	27.4	25.6	23.8
	50		35.6	33.7	32.3	29.3	27.2
	75		42.3	39.6	36.9	33.1	30.6
	90		48.6	45.0	41.9	37.0	34.2
	95		51.4	48.2	44.2	39.9	35.6
Mean			36.1	34.1	32.4	29.5	27.4
S.D.			9.0	7.9	6.8	5.8	5.0
28	5			15.8	18.4	18.4	17.4

TABLE VI (*Continued*)

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
	10			20.0	21.1	20.3	19.9
	25			25.4	24.8	23.7	22.5
	50			31.9	30.2	27.7	25.8
	75			38.2	35.5	31.5	29.0
	90			45.0	40.9	36.4	32.9
	95			48.6	43.0	38.1	35.2
Mean				32.0	30.5	27.9	25.9
S.D.				9.7	7.4	6.0	5.1
42	5				14.4	16.0	16.3
	10				17.8	18.8	18.2
	25				23.5	22.4	21.2
	50				28.5	26.2	24.3
	75				34.5	30.5	27.8
	90				39.9	35.0	31.1
	95				44.0	36.5	34.2
Mean					29.0	26.5	24.7
S.D.					9.1	6.2	5.2
56	5					14.3	15.7
	10					17.3	17.3
	25					20.7	19.7
	50					24.8	23.3
	75					29.7	26.9
	90					33.6	30.4
	95					35.6	33.1
Mean						25.2	23.6
S.D.						6.7	5.4
84	5						10.3
	10						14.0
	25						18.1
	50						22.0
	75						26.1
	90						30.5
	95						34.0
Mean							22.0
S.D.							7.0

and length from birth to 6 months of age and 3-monthly increments from 6 to 12 months of age. Mean, standard deviation, median, maximum and minimum values for each interval were presented for approximately 55 male and 55 female infants. Karlberg et al. [14] presented incremental growth data on 112—119 male infants and on 81—86 female infants for the age intervals 1—3, 3—6, 6—9 and 9—12 months.

TABLE VII

Length gain (mm/day) of 203 male breast-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5			0.88	0.92	0.96	0.91
	10			1.03	1.00	0.98	0.94
	25			1.15	1.11	1.06	1.00
	50			1.30	1.23	1.14	1.07
	75			1.45	1.34	1.22	1.13
	90			1.56	1.41	1.31	1.19
	95			1.62	1.47	1.33	1.26
Mean				1.29	1.22	1.14	1.07
S.D.				0.22	0.16	0.12	0.12
14	5				0.89	0.91	0.87
	10				0.97	0.96	0.92
	25				1.06	1.01	0.96
	50				1.17	1.10	1.04
	75				1.28	1.19	1.10
	90				1.36	1.27	1.19
	95				1.40	1.31	1.23
Mean					1.17	1.11	1.04
S.D.					0.16	0.12	0.12
28	5					0.84	0.80
	10					0.89	0.85
	25					0.95	0.92
	50					1.07	0.99
	75					1.15	1.07
	90					1.25	1.17
	95					1.33	1.21
Mean						1.06	0.99
S.D.						0.15	0.15
42	5					0.74	0.77
	10					0.78	0.80
	25					0.89	0.87
	50					1.02	0.95
	75					1.13	1.05
	90					1.21	1.13
	95					1.28	1.19
Mean						1.02	0.96
S.D.						0.18	0.17
56	5						0.70
	10						0.76
	25						0.84
	50						0.94
	75						1.04
	90						1.12
	95						1.21
Mean							0.94
S.D.							0.19

TABLE VIII

Length gain (mm/day) of 216 female breast-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5			0.87	0.88	0.87	0.82
	10			0.97	0.94	0.90	0.86
	25			1.11	1.04	0.99	0.93
	50			1.23	1.17	1.09	1.01
	75			1.38	1.26	1.16	1.07
	90			1.50	1.36	1.20	1.15
	95			1.59	1.43	1.26	1.21
Mean				1.24	1.15	1.07	1.01
S.D.				0.21	0.17	0.12	0.11
14	5				0.81	0.85	0.81
	10				0.87	0.87	0.83
	25				1.00	0.94	0.90
	50				1.11	1.03	0.97
	75				1.21	1.12	1.04
	90				1.32	1.18	1.14
	95				1.38	1.22	1.18
Mean					1.10	1.03	0.98
S.D.					0.17	0.12	0.11
28	5					0.73	0.73
	10					0.80	0.78
	25					0.88	0.84
	50					0.98	0.92
	75					1.06	1.00
	90					1.16	1.09
	95					1.18	1.13
Mean						0.97	0.93
S.D.						0.15	0.12
42	5					0.67	0.68
	10					0.73	0.73
	25					0.83	0.80
	50					0.94	0.90
	75					1.05	0.97
	90					1.12	1.05
	95					1.17	1.11
Mean						0.93	0.89
S.D.						0.16	0.13
56	5						0.64
	10						0.68
	25						0.76
	50						0.87
	75						0.98
	90						1.07
	95						1.13
Mean							0.88
S.D.							0.16

TABLE IX

Length gain (mm/day) of 380 male formula-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5			1.00	1.02	1.00	0.95
	10			1.06	1.06	1.04	0.99
	25			1.20	1.17	1.10	1.05
	50			1.32	1.28	1.20	1.12
	75			1.47	1.38	1.27	1.21
	90			1.60	1.50	1.37	1.26
	95			1.67	1.58	1.41	1.31
Mean				1.33	1.28	1.20	1.13
S.D.				0.22	0.17	0.13	0.11
14	5				0.97	0.97	0.93
	10				1.02	1.01	0.97
	25				1.13	1.09	1.03
	50				1.24	1.17	1.10
	75				1.36	1.25	1.18
	90				1.48	1.32	1.24
	95				1.55	1.37	1.27
Mean					1.25	1.17	1.10
S.D.					0.18	0.13	0.11
28	5					0.88	0.86
	10					0.94	0.92
	25					1.02	0.99
	50					1.13	1.07
	75					1.22	1.14
	90					1.31	1.20
	95					1.37	1.24
Mean						1.13	1.06
S.D.						0.15	0.12
42	5					0.81	0.82
	10					0.88	0.88
	25					0.98	0.95
	50					1.09	1.03
	75					1.20	1.11
	90					1.29	1.18
	95					1.36	1.23
Mean						1.09	1.03
S.D.						0.17	0.12
56	5						0.76
	10						0.80
	25						0.90
	50						1.00
	75						1.09
	90						1.18
	95						1.22
Mean							0.99
S.D.							0.15

TABLE X

Length gain (mm/day) of 340 female formula-fed infants.

Age at beginning of interval (days)	Centile	Age at end of interval (days)					
		14	28	42	56	84	112
8	5			0.94	0.97	0.95	0.88
	10			1.01	1.02	0.98	0.93
	25			1.12	1.10	1.04	0.98
	50			1.25	1.20	1.12	1.04
	75			1.37	1.29	1.18	1.10
	90			1.49	1.41	1.24	1.15
	95			1.57	1.46	1.27	1.21
Mean				1.25	1.20	1.11	1.04
S.D.				0.19	0.14	0.10	0.09
14	5				0.90	0.90	0.87
	10				0.97	0.93	0.90
	25				1.06	1.01	0.96
	50				1.16	1.09	1.02
	75				1.27	1.16	1.08
	90				1.36	1.22	1.13
	95				1.41	1.25	1.17
Mean					1.16	1.08	1.02
S.D.					0.15	0.11	0.09
28	5					0.84	0.82
	10					0.89	0.85
	25					0.96	0.91
	50					1.03	0.97
	75					1.12	1.04
	90					1.19	1.10
	95					1.24	1.15
Mean						1.04	0.98
S.D.						0.12	0.10
42	5					0.75	0.78
	10					0.81	0.81
	25					0.91	0.87
	50					1.00	0.94
	75					1.10	1.01
	90					1.20	1.09
	95					1.26	1.13
Mean						1.00	0.94
S.D.						0.15	0.11
56	5						0.71
	10						0.76
	25						0.82
	50						0.90
	75						0.99
	90						1.07
	95						1.12
Mean							0.91
S.D.							0.13

For each interval the mean, standard deviation, and the 10th, 50th and 90th centile values were presented. Baumgartner et al. [1] presented incremental growth data on 277 to 298 male infants and on 259 to 284 female infants for the age intervals 0—6, 3—9 and 6—12 months. For each interval the 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 97th centile values were presented.

Sample size of the Hansman [13] data is small and therefore of limited use as a reference for evaluating gains at the outlying centiles (e.g. the 5th, 10th, 90th and 95th). The data of Karlberg et al. [14] and Baumgartner et al. [1] are valuable as references for gains during later infancy and early childhood but, because of the relatively long intervals, are of less use during the early months of life. We believe that our data, concerning short intervals during the early months of life, when growth is most rapid, provide a useful addition to the other published reference data. Because of the relatively large sample size, the 5th and 95th centile values are statistically distinguishable from the corresponding 10th and 90th centile values.

This report is the first publication of separate centile values for concurrently studied breast-fed and formula-fed infants. The data confirm previous reports indicating that male infants gain more rapidly than do female infants [5—7,9,13,14], and, on a sex-specific basis, formula-fed infants gain more rapidly than do breast-fed infants [5—7,9].

In use of the reference data for clinical assessment of growth progress, the age interval to which the reference value applies should conform as closely as possible with respect to age of the infant(s) and the length of time between the two measurements used to calculate gain. The effect of age is readily apparent by comparing in Table III the 10th centile value for gain in weight by breast-fed male infants during the 28-day intervals from 14 to 42 days of age (26.6 g/day) and from 84 to 112 days of age (12.7 g/day). The effect of length of the interval of observation may also be seen from Table III. Thus, during the age intervals, 14—28, 28—42 and 42—56 days, 10th centile values for weight gain are 24.8, 25.1 and 17.3 g/day, respectively, whereas for the entire interval, 14—56 days, the 10th centile gain is 26.0 g/day. As discussed elsewhere [5], infants who gain slowly (or rapidly) during one short age interval often compensate during the next short age interval. For this reason, an infant's gain over a longer interval (e.g. 42 days) will often be closer to the median gain by his peers than will his gains over shorter intervals (e.g. 14 days).

Even under the best of circumstances (measurement by two well-trained examiners), error in measurement of length will be relatively large in relation to increments in length over short intervals. For this reason, we have not presented reference data on gain in length for intervals less than 42 days (with the exception of the 34-day interval of rapid gain from 8 to 42 days of age). If measurement errors exceed 0.6 cm, as will commonly be the case when measurements are not made by two well-trained individuals (e.g. the mother is asked to hold the infant's head against the headboard), incremental data on length will be of little value. The extent of the problem may be illustrated by an example.

If a breast-fed male's true length is 57.0 cm at age 56 days and 62.2 cm at age 112 days, gain in length during the interval 56—112 days will be 0.93 mm/day — a value at about the 50th centile (Table VII). However, if the length measurement is high by

0.6 cm at age 56 days (i.e. 57.6 cm) and low by 0.6 cm at age 112 days (i.e. 61.6 cm), the apparent gain will be 4.0 cm, or 0.71 mm/day, a value at about the 5th centile (Table VII). Because increments in length based on inaccurate measurements are likely to be misleading, use of data on gain in length should be restricted to circumstances in which measurements are made by well-trained individuals.

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