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11. BODY WEIGHT STUDIES

11.1   INTRODUCTION

The average daily dose is a dose that is typically normalized to the average body weight of the exposed population. The purpose of this section is to describe key published studies on body weight for children in the general U.S. population, as described in the *Exposure Factors Handbook* (U.S. EPA, 1997). Recommended values are based on the results of these studies.

11.2   BODY WEIGHT STUDIES

11.2.1 Hamill et al., 1979

A National Center for Health Statistics (NCHS) Task Force that included academic investigators and representatives from the Centers for Disease Control (CDC) Nutrition Surveillance Program selected, collated, integrated, and defined appropriate data sets to generate growth curves for the age interval from birth to 36 months (Hamill et al., 1979). The percentile curves were developed to assess the physical growth of children in the U.S. and are based on accurate measurements made on large, nationally representative samples of children. Smoothed percentile curves were derived for body weight by age for all children and independently for boys and for girls. The data used to construct the curves were provided by the Fels Research Institute, Yellow Springs, Ohio. These data came from an ongoing longitudinal study in which anthropometric data from direct measurements are collected regularly from approximately 1,000 participants in various areas of the U.S. The NCHS used advanced statistical and computer technology to generate the growth curves. Table 11-1 presents the percentiles of weight by sex and age. Figures 11-1 and 11-2 present percentile values of body weight grouped by age for boys and for girls, respectively. Limitations of this study are that mean body weight values were not reported and the data are more than 25 years old. However, this study does provide body weight data for infants less than 6 months old, which are lacking in many other studies.

11.2.2. National Center for Health Statistics, 1987

Statistics on anthropometric measurements, including body weight, for the U.S. population were collected by NCHS through the second National Health and Nutrition

1 Examination Survey (NHANES II). NHANES II was conducted on a nationwide probability

2 sample of 27,801 persons aged 6 months to 74 years from the civilian, noninstitutionalized

3 population of the United States. A total of 20,322 individuals in the sample were interviewed

4 and examined—a response rate of 73.1 percent. The survey began in February 1976 and was

5 completed in February 1980. The sample was selected so that certain subgroups thought to be at

6 high risk of malnutrition (persons with low incomes, preschool children, and the elderly) were

7 oversampled. The estimates were weighted to reflect national population estimates. The

8 weighting was accomplished by inflating examination results for each subject by the reciprocal

9 of selection probabilities adjusted to account for those who were not examined, and-post

10 stratifying by race, age, and sex.

11 The NHANES II collected standard body measurements of sample subjects, including

12 height and weight, that were made at various times of the day and in different seasons of the

13 year. This technique was used because an individual's weight may vary between winter and

14 summer and may fluctuate with patterns of food and water intake and other daily activities

15 (NCHS, 1987). Percentile data for children, by age, are presented in Table 11-2 for males, and

16 in Table 11-3 for females.

17

18 **11.2.3. Burmaster and Crouch, 1997**

19 Burmaster and Crouch (1997) performed data analysis to fit normal and lognormal

20 distributions to the body weights of females and males aged 9 months to 70 years. *Exposure*

21 *Factors Handbook* (U.S. EPA, 1997) used a pre-published version of this paper. The numbers

22 reported in Table 11-4 are based on the final paper and vary slightly from those reported in the

23 *Exposure Factors Handbook*.

24 Data used in this analysis were from the second survey of the National Center for Health

25 Statistics, NHANES II, which included 27,801 persons 6 months to 74 years of age in the U.S.

26 (Burmaster et al., 1997). The NHANES II data had been statistically adjusted for non-response

27 and probability of selection, and stratified by age, sex, and race to reflect the entire U.S.

28 population prior to reporting. Burmaster and Crouch conducted exploratory and quantitative data

29 analyses and fit normal and lognormal distributions to percentiles of body weights of children,

30 teens, and adults as a function of age. Cumulative distribution functions were plotted for female

31 and male body weights on both linear and logarithmic scales.

1 The maximum likelihood estimation was used to fit lognormal distributions to the data.

2 Linear and quadratic regression lines were fitted to the data. A number of goodness-of-fit

3 measures were conducted on data generated. The investigators found that lognormal

4 distributions give strong fits to the data for each gender across all age groups. Statistics for the

5 lognormal probability plots for children aged 9 months to 20 years are presented in Table 11-4.

6 These data can be used for further analyses of body weight distribution (i.e., application of

7 Monte Carlo analysis). The reader is referred to the original study for a more detailed

8 description.

9

10 **11.2.4 U.S. EPA, 2000**

11 EPA's Office of Water has estimated body weights for children by age and gender using

12 data from NHANES III, which was conducted from 1988 to 1994. NHANES III collected body

13 weight data for approximately 15,000 children between the ages of 2 months and 17 years.

14 Table 11-5 presents the body weight estimates in kilograms by age and gender. Table 11-6

15 shows the body weight estimates for infants under the age of 3 months; Figures 11-3 and 11-4

16 compare the body weights (mean and median) of males and females of various age groups,

17 respectively.

18 The limitations of these data are that the data were not available for infants under 2

19 months old, and that the data are roughly over 12 years old. With the upward trends in body

20 weight from NHANES II (1976-1980) to NHANES III, the data in Tables 11-5 and 11-6 may

21 underestimate current body weights. Adjustment factors may be needed to update the estimates

22 from 1988-1994 data to the present. However, the data are national in scope and represent the

23 general children's population.

24

25 **11.2.5 Ogden et al., 2004**

26 Ogden et al. (2004) analyzed trends in body weight measured by the National Health

27 Examination Surveys II and III (NHES II and III), the National Health and Nutrition

28 Examination Surveys I, II, and III (NHANES I, II, and III), and NHANES 1999-2002. The

29 surveys covered the period from 1960 to 2002. Table 11-7 presents the measured body weights

30 for various age groups as measured in NHES and NHANES. Population means were calculated

31 using sample weights to account for variation in sampling for certain subsets of the U.S.

1   population. The data indicate that mean body weight has increased over the period analyzed.

2   There is some uncertainty inherent in such an analysis, however, because of changes in sampling

3   methods during the 42 year time span covered by the studies. Because this study is based on an

4   analysis of NHANES data, its limitations are the same as those for that study. However, it does

5   serve to illustrate the importance of the use of timely data when analyzing body weight.

6

7   **11.2.6 EPA Analysis of NHANES III Data**

8   The NHANES III, 1988-94 was conducted on a nationwide probability sample of

9   approximately 33,994 persons aged 2 months and older, of which approximately 15,000 were

10   children. The survey was designed to obtain nationally representative information on the health

11   and nutritional status of the population of the United States through interviews and direct

12   physical examinations. A number of anthropometrical measurements were taken for each

13   participant in the study, including body weight. Unit nonresponse to the household interview

14   was 14 percent, and an additional 8 percent did not participate in the physical examinations

15   (including body weight measurements).

16   Certain subpopulations were oversampled to ensure a prespecified minimum sample size

17   for each analytic domain. These oversampled subpopulations include children, older persons,

18   Mexican-Americans, African-Americans, and people living in certain geographic areas. Sample

19   data were assigned weights to account both for the disparity in sample sizes for these groups and

20   for other inadequacies in sampling, such as the presence of non-respondents. The weight for

21   each participant was calculated as the reciprocal of the participant's probability of selection, with

22   adjustments for other variabilities in sampling rates such as changes made to the sampling rates

23   at the time of data collection.

24   Using the data and the weighting factors from NHANES III, EPA calculated body weight

25   statistics for the standard age categories. Mean and percentile values were calculated using the

26   sampling weights provided for each individual in the data set. The mean value for a given group

27   was calculated using the following formula:

28

29

30

31

$$\bar{x} = \frac{\sum_i w_i x_i}{\sum_i w_i}$$

1   where:

2         $\bar{x}$ = sample mean;

3   x_i = the ith observation;

4   w_i = sample weight assigned to observation x_i.

5

6   Percentile values were calculated by first calculating the sum of the weights for all observations

7   in a given group and multiplying this sum by the percentile of interest (e.g., multiplying by 0.25

8   to determine the 25th percentile). The observations were then ordered from least to greatest, and

9   each observation was assigned a cumulative weight, equal to its own weight plus all weights

10   listed before the observation. The first observation listed with a cumulative weight greater than

11   the value calculated for the percentile of interest was selected.

12   Table 11-8 presents the percentiles of body weight for all children by age category.

13   Tables 11-9 and 11-10 present body weight by age category for male and female children,

14   respectively.

15   Limitations of these data are that the data were not available for infants younger than 2

16   months old, and that the data are over 12 years old. As with EPA's earlier analysis of NHANES

17   II data with different age categories (U.S. EPA, 2000), the data in Tables 11-8 to 11-10 may

18   underestimate current body weights due to an observed upward trend in body weights (Ogden et

19   al., 2004). Adjustment factors may be needed to update the estimates from 1988-1994 data to

20   the present. However, the NHANES data remain the principal source of body weight data

21   collected nationwide from a large number of subjects.

22

23   **11.3   RECOMMENDATIONS**

24   The recommended values for body weight are summarized in Table 11-11. Table 11-12

25   presents the confidence ratings for body weight recommendations.

26   For infants (birth to 2 months), appropriate values for body weight may be selected from

27   Table 11-1. These data (percentiles only) are presented for male and female infants. For older

28   infants and children, means and percentiles may be selected from Tables 11-8 (all), 11-9 (males)

29   and 11-10 (females).

30

11.4   REFERENCES FOR CHAPTER 11

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Table 11-1. Smoothed Percentiles of Weight (In Kg) by Sex And Age: Statistics From NCHS And Data From Fels Research Institute, Birth to 36 Months

Sex and Age	Smoothed[a] Percentile						
	5th	10th	25th	50th	75th	90th	95th
	Weight in Kilograms						
Male							
Birth	2.54	2.78	3.00	3.27	3.64	3.82	4.15
1 Month	3.16	3.43	3.82	4.29	4.75	5.14	5.38
3 Months	4.43	4.78	5.32	5.98	6.56	7.14	7.37
6 Months	6.20	6.61	7.20	7.85	8.49	9.10	9.46
9 Months	7.52	7.95	8.56	9.18	9.88	10.49	10.93
12 Months	8.43	8.84	9.49	10.15	10.91	11.54	11.99
18 Months	9.59	9.92	10.67	11.47	12.31	13.05	13.44
24 Months	10.54	10.85	11.65	12.59	13.44	14.29	14.70
30 Months	11.44	11.80	12.63	13.67	14.51	15.47	15.97
36 Months	12.26	12.69	13.58	14.69	15.59	16.66	17.28
Female							
Birth	2.36	2.58	2.93	3.23	3.52	3.64	3.81
1 Month	2.97	3.22	3.59	3.98	4.36	4.65	4.92
3 Months	4.18	4.47	4.88	5.40	5.90	6.39	6.74
6 Months	5.79	6.12	6.60	7.21	7.83	8.38	8.73
9 Months	7.00	7.34	7.89	8.56	9.24	9.83	10.17
12 Months	7.84	8.19	8.81	9.53	10.23	10.87	11.24
18 Months	8.92	9.30	10.04	10.82	11.55	12.30	12.76
24 Months	9.87	10.26	11.10	11.90	12.74	13.57	14.08
30 Months	10.78	11.21	12.11	12.93	13.93	14.81	15.35
36 Months	11.60	12.07	12.99	13.93	15.03	15.97	16.54

[a]Smoothed by cubic-spline approximation.

Source: Hamill et al. (1979).

Table 11-2. Weight in Kilograms For Males 2 Months-19 Years of Age– Number Examined, Mean, and Selected Percentiles, by Age Category: United States, 1976-1980[a]

Age	Number of Persons Examined	Mean (kg)	Percentile								
			5th	10th	15th	25th	50th	75th	85th	90th	95th
birth to <1 month[b]	-	-	-	-	-	-	-	-	-	-	-
1 to <2 months[b]	-	-	-	-	-	-	-	-	-	-	-
2 to <3 months	103	6.6	5.3	5.5	5.7	5.9	6.8	7.2	7.6	7.8	8.4
3 to <6 months	287	7.7	6.3	6.6	6.7	7.0	7.7	8.4	8.9	9.2	9.6
6 to <12 months	589	9.4	7.5	7.9	8.1	8.6	9.4	10.2	10.6	10.9	11.4
1 to <2 years	613	11.7	9.4	9.8	10.1	10.8	11.7	12.6	13.1	13.7	14.5
2 to <3 years	627	13.7	11.4	11.8	12.2	12.6	13.6	14.6	15.2	15.8	16.5
3 to <6 years	1556	18.0	13.7	14.6	14.9	15.7	17.5	19.7	21.0	22.0	24.0
6 to <11 years	1373	30.7	19.5	21.1	22.1	24.0	28.5	35.2	40.5	43.5	48.7
11 to <16 years	1037	55.2	34.0	36.5	38.7	42.8	53.0	63.0	69.4	74.8	84.3
16 to <21 years	890	71.8	54.1	56.6	58.3	61.8	68.7	77.9	84.3	89.7	101.0

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.
[b] No data available for infants less than two months old.
Source: National Center for Health Statistics (1987).

Table 11-3. Weight in Kilograms For Females 6 Months-19 Years of Age– Number Examined, Mean, and Selected Percentiles, by Age Category: United States, 1976-1980[a]

Age	Number of Persons Examined	Mean (kg)	Percentile								
			5th	10th	15th	25th	50th	75th	85th	90th	95th
birth to <1 month[b]	-	-	-	-	-	-	-	-	-	-	-
1 to <2 months[b]	-	-	-	-	-	-	-	-	-	-	-
2 to <3 months	131	6.0	4.7	5.1	5.2	5.6	6.0	6.5	7.1	7.3	7.8
3 to <6 months	269	7.1	5.8	5.9	6.1	6.4	7.1	7.7	7.9	8.4	8.7
6 to <12 months	574	8.8	7.2	7.5	7.7	8.0	8.7	9.4	10.1	10.4	10.8
1 to <2 years	617	11.0	9.1	9.4	9.6	9.9	10.9	11.9	12.6	12.9	13.4
2 to <3 years	597	13.4	10.8	11.2	11.6	12.1	13.2	14.6	15.4	15.6	16.3
3 to <6 years	1658	18.0	13.3	14.0	14.5	15.4	17.2	19.7	21.1	22.6	25.1
6 to <11 years	1321	30.6	19.0	20.5	21.3	23.4	28.9	35.0	39.6	44.3	50.2
11 to <16 years	1144	53.2	34.1	37.2	40.4	45.2	51.6	60.0	67.2	70.6	78.2
16 to <21 years	1001	62.2	46.7	48.2	49.7	52.2	58.9	68.3	74.7	80.8	92.6

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.
[b] No data available for infants less than two months old.
Source: National Center for Health Statistics (1987).

Table 11-4. Statistics for Probability Plot Regression Analyses: Natural Log of Body Weights 6 Months to 20 Years of Age

Age Midpoint (yrs)	Best-Fit Parameters for Lognormal Distribution (kg)			
	Males		Females	
	$\mu_2{}^a$	$\sigma_2{}^b$	$\mu_2{}^a$	$\sigma_2{}^b$
0.75	2.23	0.132	2.16	0.145
1.5	2.46	0.119	2.38	0.129
2.5	2.60	0.120	2.56	0.112
3.5	2.75	0.114	2.69	0.136
4.5	2.87	0.133	2.83	0.134
5.5	2.98	0.138	2.98	0.164
6.5	3.13	0.145	3.10	0.174
7.5	3.21	0.151	3.19	0.174
8.5	3.33	0.181	3.31	0.156
9.5	3.43	0.165	3.46	0.214
10.5	3.59	0.195	3.57	0.199
11.5	3.69	0.252	3.71	0.226
12.5	3.78	0.224	3.82	0.213
13.5	3.88	0.215	3.92	0.215
14.5	4.02	0.181	3.99	0.187
15.5	4.09	0.159	4.00	0.156
16.5	4.20	0.168	4.05	0.167
17.5	4.19	0.167	4.08	0.165
18.5	4.25	0.159	4.07	0.147
19.5	4.26	0.154	4.10	0.149

[a] μ_2, - Natural log mean of body weight (kg).
[b] σ_2 - Natural log standard deviation of body weight (kg).

Source: Burmaster et al. (1997).

Table 11-5. Body Weight Estimates (in kilograms) by Age and Gender, U.S. Population 1988-94

Age	Sample Size	Population	Male and Female		Male		Female	
			Median	Mean	Median	Mean	Median	Mean
2-6 months	1,020	1,732,702	7.4	7.4	7.6	7.7	7.0	7.0
7-12 months	1,072	1,925,573	9.4	9.4	9.7	9.7	9.1	9.1
1 year	1,258	3,935,114	11.3	11.4	11.7	11.7	10.9	11.0
2 years	1,513	4,459,167	13.2	12.9	13.5	13.1	13.0	12.5
3 years	1,309	4,317,234	15.3	15.1	15.5	15.2	15.1	14.9
4 years	1,284	4,008,079	17.2	17.1	17.2	17.0	17.3	17.2
5 years	1,234	4,298,097	19.6	19.4	19.7	19.3	19.6	19.4
6 years	750	3,942,457	21.3	21.7	21.5	22.1	20.9	21.3
7 years	736	4,064,397	25.0	25.5	25.4	25.5	24.1	25.6
8 years	711	3,863,515	27.4	28.1	27.2	28.4	27.9	27.9
9 years	770	4,385,199	31.8	32.7	32.0	32.3	31.1	33.0
10 years	751	3,991,345	35.2	35.6	35.9	36.0	34.3	35.2
11 years	754	4,270,211	40.6	41.5	38.8	40.0	43.4	42.8
12 years	431	3,497,661	47.2	46.9	48.1	49.1	45.7	48.6
13 years	428	3,567,181	53.0	55.1	52.6	54.5	53.7	55.9
14 years	415	4,054,117	56.9	61.1	61.3	64.5	53.7	57.9
15 years	378	3,269,777	59.6	62.8	62.6	66.9	57.1	59.2
16 years	427	3,652,041	63.2	65.8	66.6	69.4	56.3	61.6
17 years	410	3,719,690	65.1	67.5	70.0	72.4	60.7	62.2
1 and older	31,311	251,097,002	66.5	64.5	73.9	89.0	80.8	80.3
1-3 years	4,080	12,711,515	13.2	13.1	13.4	13.4	13.0	12.9
1-14 years	12,344	56,653,796	24.9	29.9	25.1	30.0	24.7	29.7
15-44 years	10,393	118,430,653	70.8	73.5	77.5	80.2	63.2	67.3

Source: U.S. EPA, 2000.

Table 11-6. Body Weight Estimates (in kilograms) by Age, U.S. Population 1988-94

Age	Sample Size	Population	Male and Female		
			Median	Mean	95% CI
Newborn	NA	NA	NA	NA	NA
1 Month	NA	NA	NA	NA	NA
2 Months	243	408,837	6.3	6.3	6.1-6.4
3 Months	190	332,823	7.0	6.9	6.7-7.1
3 Months and Younger	433	741,660	6.6	6.6	6.4-6.7

NA = Not available.
CI = Confidence Intervals.

Source: U.S. EPA (2000).

Table 11-7. Mean Body Weight (kilograms) by Age and Gender Across Multiple Surveys

Gender and Age (years)	NHES II, 1963-65			NHES III, 1966-70			NHANES I, 1971-74			NHANES II, 1976-80			NHANES III, 1988-94			NHANES 1999-2002		
	N	mean	std. err.	N	mean	std. err.	N	mean	std. err.	N	mean	std. err.	N	mean	std. err.	N	mean	std. err.
Male																		
2	-	-	-	-	-	-	298	13.6	0.2	370	13.4	0.1	644	13.6	0.1	262	13.7	0.1
3	-	-	-	-	-	-	308	15.6	0.1	421	15.5	0.1	516	15.8	0.2	216	15.9	0.2
4	-	-	-	-	-	-	304	17.7	0.1	405	17.6	0.1	549	17.6	0.2	179	18.5	0.2
5	-	-	-	-	-	-	273	20.2	0.2	393	19.7	0.1	497	20.1	0.2	147	21.3	0.5
6	575	22.0	0.1	-	-	-	179	22.0	0.3	146	22.8	0.4	283	23.2	0.6	182	23.5	0.4
7	632	24.7	0.2	-	-	-	164	24.9	0.4	150	24.9	0.4	269	26.3	0.4	185	27.2	0.4
8	618	27.8	0.2	-	-	-	152	26.4	0.3	145	28.0	0.6	266	30.2	0.8	214	32.7	1.0
9	603	31.2	0.4	-	-	-	169	31.6	0.8	141	30.7	0.6	281	34.4	1.0	174	36.0	0.7
10	576	33.7	0.3	-	-	-	184	34.2	0.6	165	36.2	0.7	297	37.3	0.9	187	38.6	0.8
11	595	38.2	0.3	-	-	-	178	38.8	0.8	153	39.7	0.9	281	42.5	0.9	182	43.7	1.1
12	-	-	-	643	42.9	0.4	200	44.0	0.8	147	44.1	1.0	203	49.1	1.1	299	50.4	1.3
13	-	-	-	626	50	0.5	174	49.9	1.0	165	49.5	1.2	187	54.0	1.0	298	53.9	1.9
14	-	-	-	618	56.7	0.6	174	56.3	0.9	188	56.4	0.9	188	64.1	3.6	266	63.9	1.6
15	-	-	-	613	61.6	0.4	171	60.3	1.2	180	61.2	1.0	187	66.9	1.9	283	68.3	1.1
16	-	-	-	556	64.8	0.6	169	66.9	1.3	180	66.5	1.2	194	68.7	1.6	306	74.4	1.4
17	-	-	-	458	68.1	0.4	176	68.6	1.1	183	66.7	0.8	196	72.9	1.3	313	75.6	1.4
18	-	-	-	-	-	-	124	74.3	1.3	156	71.1	1.2	176	71.3	1.7	284	75.6	1.1
19	-	-	-	-	-	-	136	72.6	1.3	150	71.8	0.8	168	73.0	2.2	270	78.2	1.3
Female																		
2	-	-	-	-	-	-	272	13.0	0.1	330	12.8	0.1	624	13.2	0.1	248	13.3	0.1
3	-	-	-	-	-	-	292	15.0	0.2	367	14.8	0.1	587	15.4	0.1	178	15.2	0.2
4	-	-	-	-	-	-	281	16.8	0.2	388	16.8	0.2	537	17.9	0.3	191	17.9	0.3
5	-	-	-	-	-	-	314	19.7	0.3	369	19.4	0.3	554	20.2	0.2	186	20.6	0.6
6	536	21.5	0.2	-	-	-	176	21.6	0.3	150	21.9	0.4	272	22.6	0.6	171	22.4	0.5
7	609	24.2	0.2	-	-	-	169	24.3	0.4	154	24.6	0.5	274	26.4	0.8	196	25.9	0.5
8	613	27.5	0.2	-	-	-	152	27.5	0.5	125	27.5	0.4	248	29.9	0.6	184	31.9	1.2
9	581	31.4	0.4	-	-	-	171	32.0	0.6	154	31.7	0.7	280	34.4	1.2	183	35.4	0.7
10	584	35.2	0.4	-	-	-	197	33.8	0.6	128	35.7	0.6	258	37.9	1.2	164	40.0	1.0
11	525	39.8	0.4	-	-	-	166	41.2	0.8	143	41.4	0.9	275	44.1	1.1	194	47.9	1.3
12	-	-	-	547	46.6	0.4	177	46.7	1.0	146	46.1	0.9	236	49.0	1.2	316	52.0	1.1
13	-	-	-	582	50.5	0.5	198	51.8	1.0	155	50.9	1.2	220	55.8	1.6	321	57.7	1.4
14	-	-	-	586	54.2	0.4	184	54.6	1.0	181	54.3	1.0	218	58.5	1.4	324	59.9	1.0
15	-	-	-	503	56.5	0.5	167	56.6	0.9	144	55.0	0.8	191	58.1	1.1	266	61.1	1.7
16	-	-	-	536	58.1	0.7	171	56.8	1.1	167	57.7	0.9	208	61.3	1.4	273	63.0	1.2
17	-	-	-	442	57.6	0.6	150	59.5	1.6	134	59.6	1.0	201	62.4	1.2	256	61.7	1.2
18	-	-	-	-	-	-	141	58.2	1.1	156	59.0	1.0	175	61.2	1.9	243	65.2	1.5
19	-	-	-	-	-	-	130	59.5	1.4	158	59.8	1.0	177	63.2	1.9	225	67.9	1.2

NHES = National Health Examination Survey; NHANES = National Health and Nutrition Examination Survey.
Source: Ogden et al., 2004

Table 11-8. Mean and Percentile Body Weights (kg) Derived from NHANES III (All Children)

Age Group	N	mean	percentiles								
			5th	10th	15th	25th	50th	75th	85th	90th	95th
2 to <3 months	234	6.3	4.8	5.2	5.4	5.7	6.3	6.9	7.3	7.4	7.8
3 to <5 months	556	7.4	5.9	6.2	6.4	6.7	7.4	7.9	8.6	8.9	9.4
6 to <11 months	1163	9.1	7.3	7.7	7.8	8.3	9.1	9.9	10.4	10.7	11.2
1 to <2 years	1230	11.4	9.1	9.5	9.8	10.2	11.3	12.2	12.8	13.3	14.0
2 to <3 years	1224	13.5	10.9	11.4	11.9	12.4	13.4	14.6	15.3	15.8	16.3
3 to <5 years	3214	18.0	13.5	14.3	14.8	15.6	17.4	19.7	21.1	22.2	24.5
6 to <11 years	2694	30.6	19.2	20.8	21.6	23.6	28.8	35.0	40.0	43.8	49.2
11 to <16 years	2181	54.2	34.0	36.7	39.5	44.0	52.0	61.9	68.1	72.7	81.4
16 to <21 years	1891	67.0	48.0	50.7	52.5	56.0	64.1	74.2	80.5	85.8	98.3

Note: No data are available for persons less than 2 months old.
Source: EPA Analysis of NHANES III data

Table 11-9 Mean and Percentile Body Weights (kg) Derived from NHANES III (Male Children)

Age Group	N	mean	percentiles								
			5th	10th	15th	25th	50th	75th	85th	90th	95th
2 to <3 months	103	6.6	5.3	5.5	5.7	5.9	6.8	7.2	7.6	7.8	8.4
3 to <5 months	287	7.7	6.3	6.6	6.7	7.0	7.7	8.4	8.9	9.2	9.6
6 to <11 months	589	9.4	7.5	7.9	8.1	8.6	9.4	10.2	10.6	10.9	11.4
1 to <2 years	613	11.7	9.4	9.8	10.1	10.8	11.7	12.6	13.1	13.7	14.5
2 to <3 years	627	13.7	11.4	11.8	12.2	12.6	13.6	14.6	15.2	15.8	16.5
3 to <5 years	1556	18.0	13.7	14.6	14.9	15.7	17.5	19.7	21.0	22.0	24.0
6 to <11 years	1373	30.7	19.5	21.1	22.1	24.0	28.5	35.2	40.5	43.5	48.7
11 to <16 years	1037	55.2	34.0	36.5	38.7	42.8	53.0	63.0	69.4	74.8	84.3
16 to <21 years	890	71.8	54.1	56.6	58.3	61.8	68.7	77.9	84.3	89.7	101.0

Note: No data are available for persons less than 2 months old.
Source: EPA Analysis of NHANES III data

Table 11-10. Mean and Percentile Body Weights (kg) Derived from NHANES III (Female Children)

Age Group	N	mean	percentiles								
			5th	10th	15th	25th	50th	75th	85th	90th	95th
2 to <3 months	131	6.0	4.7	5.1	5.2	5.6	6.0	6.5	7.1	7.3	7.8
3 to <5 months	269	7.1	5.8	5.9	6.1	6.4	7.1	7.7	7.9	8.4	8.7
6 to <11 months	574	8.8	7.2	7.5	7.7	8.0	8.7	9.4	10.1	10.4	10.8
1 to <2 years	617	11.0	9.1	9.4	9.6	9.9	10.9	11.9	12.6	12.9	13.4
2 to <3 years	597	13.4	10.8	11.2	11.6	12.1	13.2	14.6	15.4	15.6	16.3
3 to <5 years	1658	18.0	13.3	14.0	14.5	15.4	17.2	19.7	21.1	22.6	25.1
6 to <11 years	1321	30.6	19.0	20.5	21.3	23.4	28.9	35.0	39.6	44.3	50.2
11 to <16 years	1144	53.2	34.1	37.2	40.4	45.2	51.6	60.0	67.2	70.6	78.2
16 to <21 years	1001	62.2	46.7	48.2	49.7	52.2	58.9	68.3	74.7	80.8	92.6

Note: No data are available for persons less than 2 months old.
Source: EPA Analysis of NHANES III data

Table 11-11. Summary of Recommended Values for Body Weight

Population	Table Reference	Source
birth to <1 month	See Table 11-1	Hamill et al. (1979)
1 to <2 months		
2 to <3 months	See Tables 11-9 (all), 11-10 (males), and 11-11 (females)	EPA analysis of NHANES III data
3 to <5 months		
6 to <11 months		
1 to <2 years		
2 to <3 years		
3 to <5 years		
6 to <11 years		
11 to <16 years		
16 to <21 years		

Table 11-12. Confidence in Body Weight Recommendations

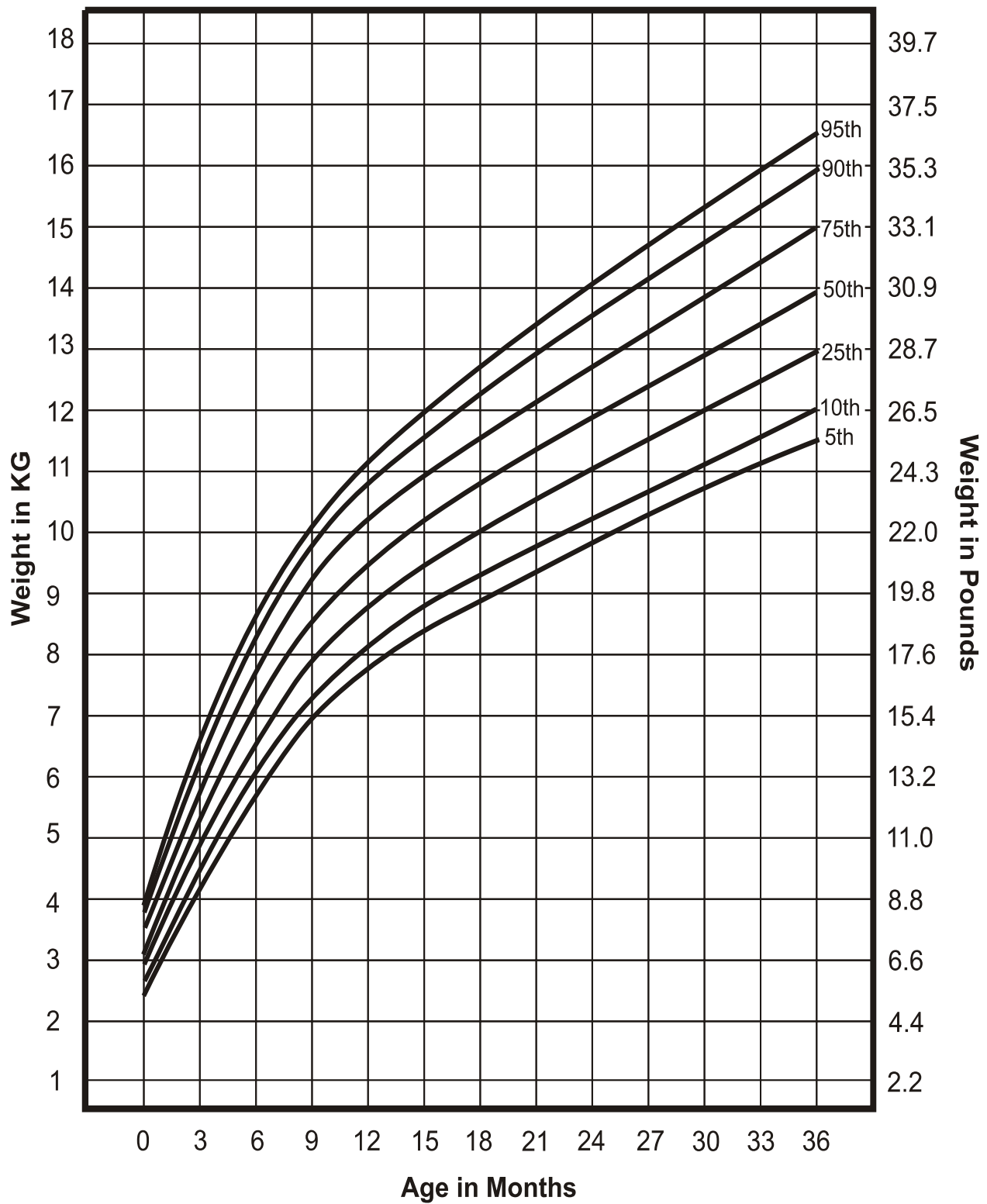| Considerations	Rationale	Rating
Study Elements		
• Level of peer review	NHANES III was the major source for central tendency and percentile values. This analysis has not yet been published. Body weights of young infants (0-2 months) are derived from Hamill et al. (1979), a published study which received a high level of peer review	Low for NHANES analysis; High for young infants
• Accessibility	NHANES III and Hamill et al. (1979) are available to the public. U.S. EPA (2000) is available upon request.	High
• Reproducibility	Results can be reproduced by analyzing NHANES II data, NHANES III data, and the Fels Research Institute data.	High
• Focus on factor of interest	The studies focused on body weight, the exposure factor of interest.	High
• Data pertinent to US	The data represent the U.S. population.	High
• Primary data	The primary data were generated from NHANES II and III data and Fels studies, thus these data are secondary.	Medium
• Currency	The data were collected between 1976-1980 for Hamill et al. and NHANES II. U.S. EPA (2000) and EPA's analysis of NHANES III using the new age groupings covered the years 1988-94. Ogden et al. (2004) covered the years 1960-2002.	High for central tendency; medium for percentiles
• Adequacy of data collection period	The NHANES II study included data collected over a period of 4 years. Body weight measurements were taken at various times of the day and at different seasons of the year. NHANES III study included data collected over a 7-year period.	High
• Validity of approach	Direct body weights were measured for both studies. For NHANES II, subgroups at risk for malnutrition were over-sampled. Weighting was accomplished by inflating examination results for those not examined and were stratified by race, age, and sex. The Fels data are from an ongoing longitudinal study where the data are collected regularly.	High
• Study size	The sample size consisted of 28,000 persons for NHANES II. Author noted in Hamill et al. (1979) that the data set was large. NHANES III study included 14,387 individuals under the age of 21 years.	High
• Representativeness of the population	Data collected focused on the U.S. population for both studies.	High
• Characterization of variability	All studies characterized variability regarding age and sex. Additionally NHANES II characterized race (for Blacks, Whites and total populations) and sampled persons with low income.	High
• Lack of bias in study design (high rating is desirable)	There are no apparent biases in the study designs for NHANES II. The study design for collecting the Fels data was not provided.	Medium-High
• Measurement error	For NHANES II and III, measurement error is expected to be low because body weights were performed in a mobile examination center using standardized procedures and equipment. Also, measurements were taken at various times of the day to account for weight fluctuations as a result of recent food or water intake. The authors of Hamill et al. (1979) report that study data are based on accurate direct measurements from an ongoing longitudinal study.	High
Other Elements		
• Number of studies	There are two studies.	Medium
• Agreement between researchers	There is consistency among the studies.	High
Overall Rating		**High**

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Figure 11-1. Weight by Age percentiles for Girls Aged Birth-36 Months

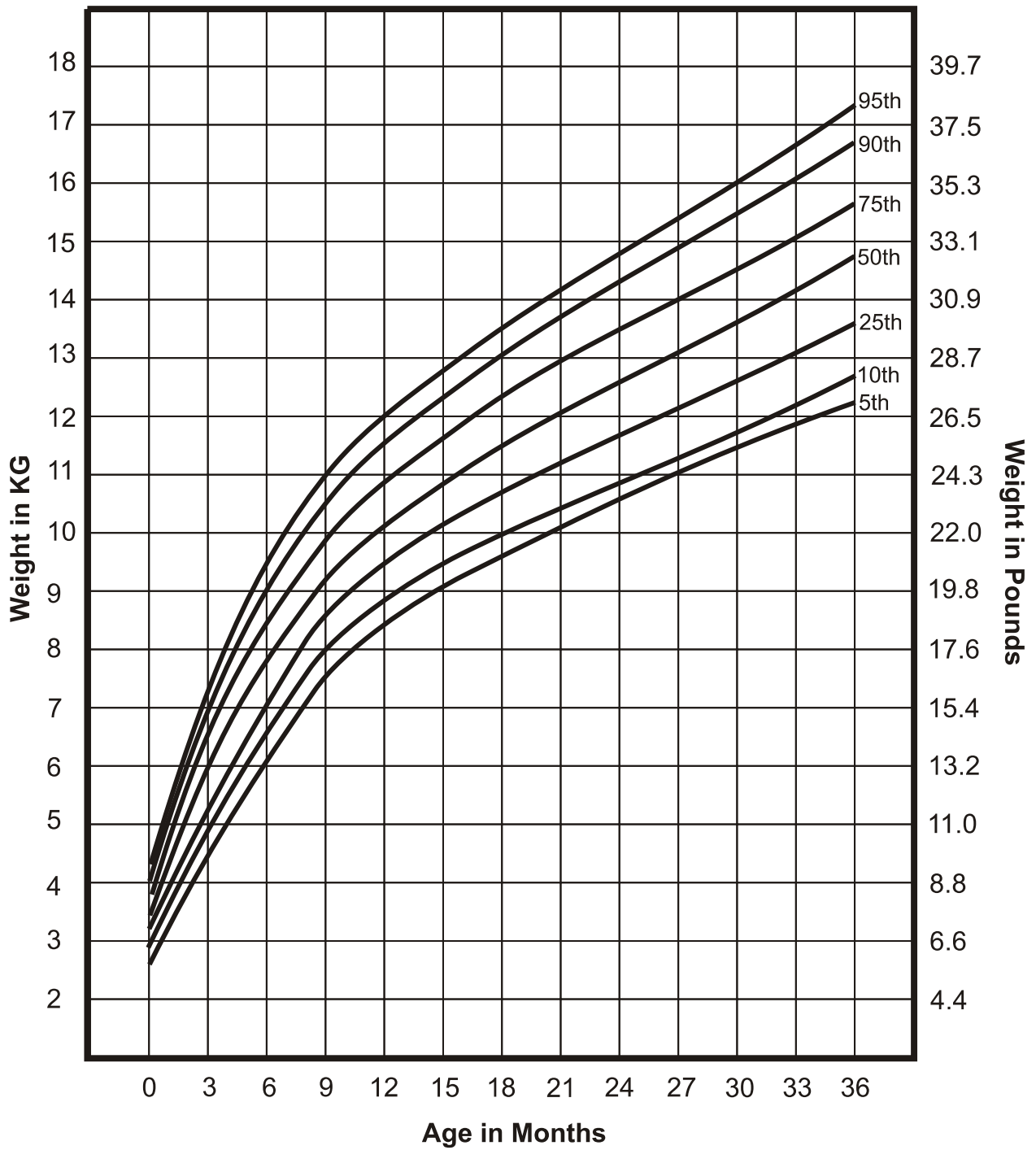Source: Hamill et al. (1979).

11-17

Figure 11-2. Weight by Age Percentiles for Boys Aged Birth-36 Months
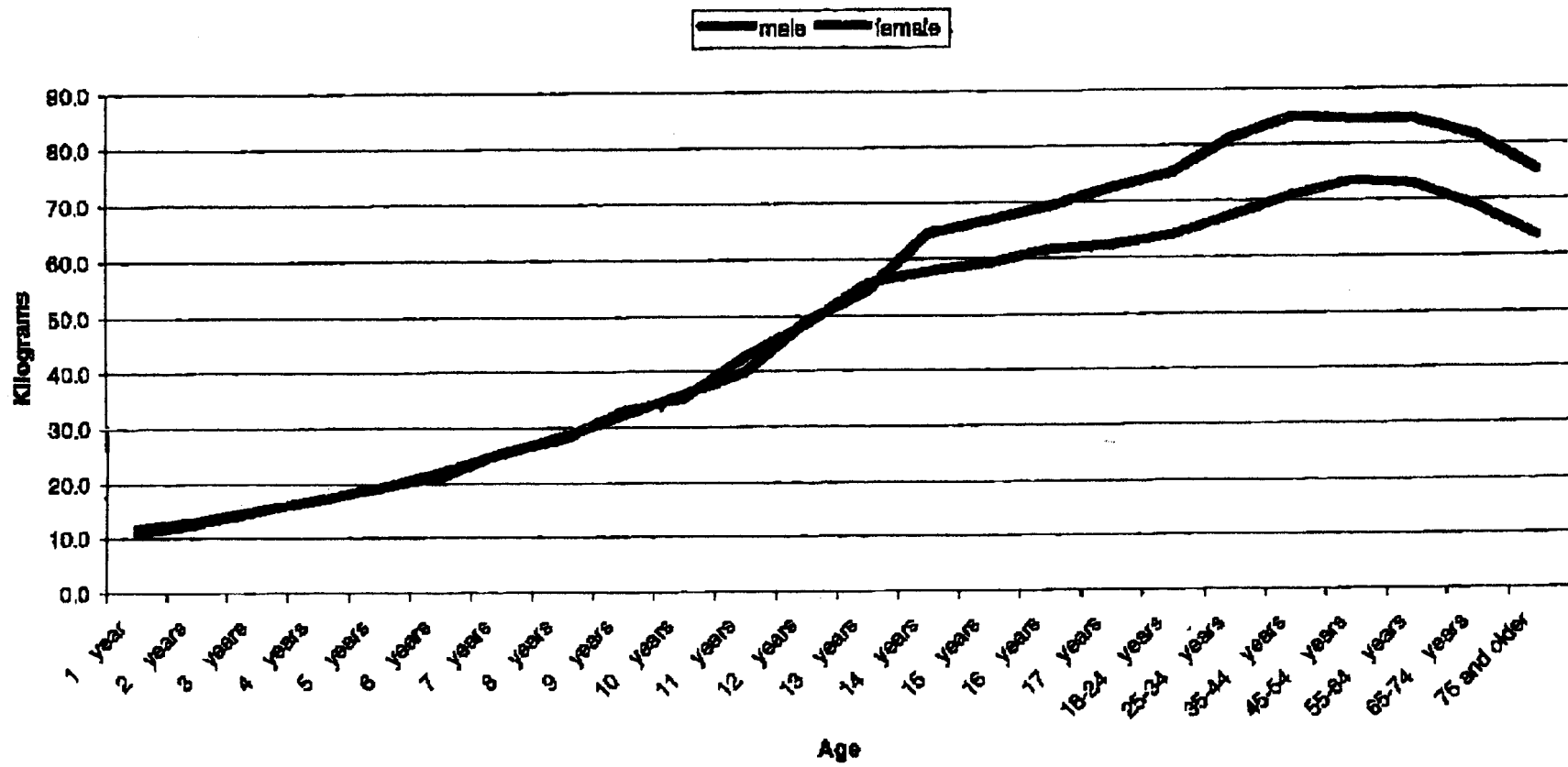
Source: Hamill et al. (1979).

Figure 11-3.   Mean Body Weight Estimates, U.S. Population, 1988-94

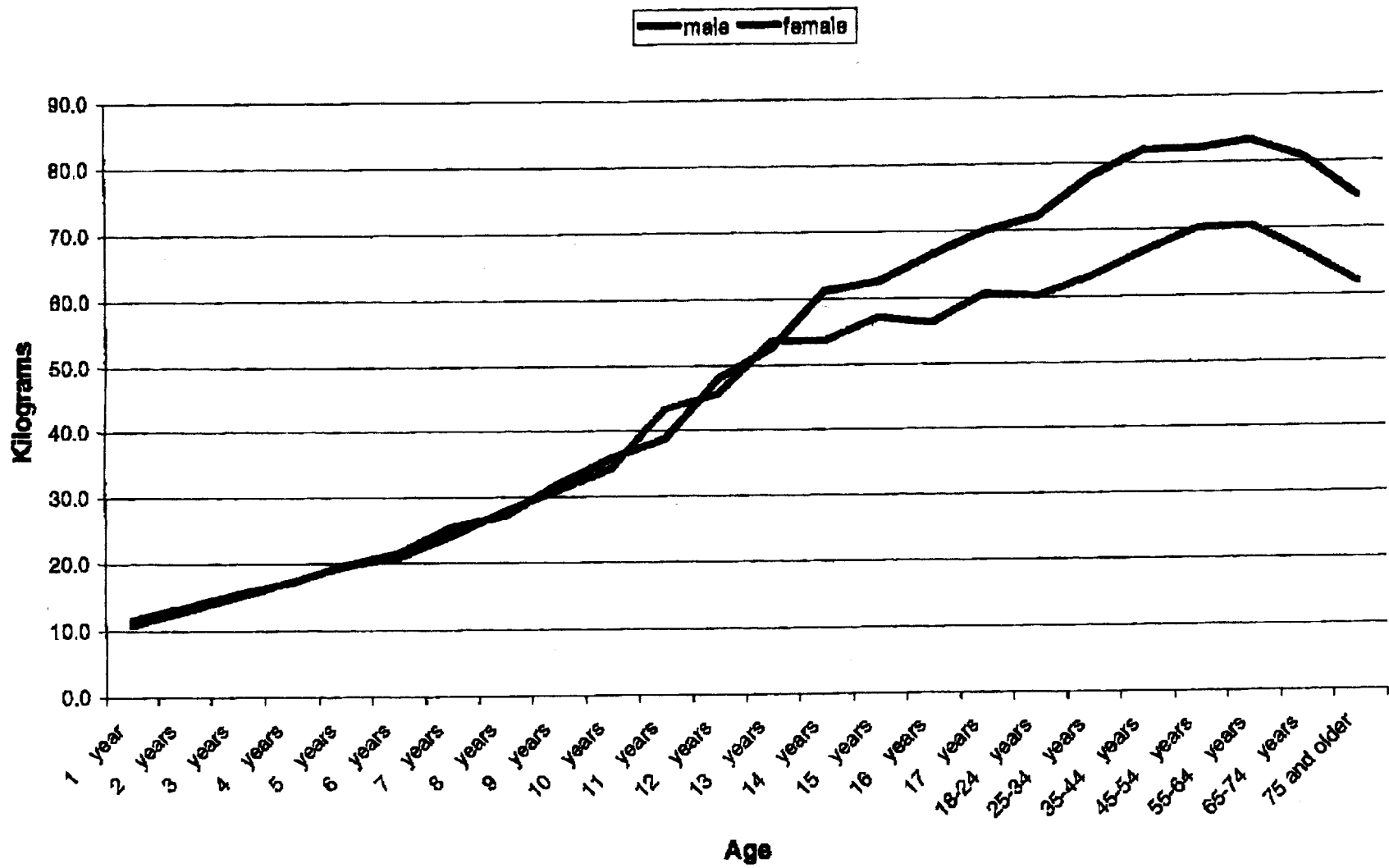Source: U.S. EPA (2000).

Figure 11-4.   Median Body Weights Estimates, U.S. Population, 1988-94

Source: U.S. EPA (2000).