A Longitudinal Study of the Animal Protein Intake of Children from One to Eighteen Years of Age

BERTHA S. BURKE, M.A.,* ROBERT B. REED, PH.D.,† ANNA S. VAN DEN BERG, M.S.‡ AND HAROLD C. STUART, M.D.§

MANY studies have contributed to the description of dietary intakes of children. Virtually nothing, however, is known about sequential changes in the food intakes of children as individuals during the years of growth and development. This report is one of a series dealing with the dietary intake data of a group of children followed individually throughout the major portion of their growth period while living at home under varying conditions of everyday life; it deals with the usual food intakes of these children and the various ways in which they changed their nutrient intake patterns during their years of growing up. The 125 children, sixty-four boys and sixty-one girls, whose animal protein intakes are reported here, belong to the Maturity Series of the Longitudinal Studies of Child Health and Development conducted by the Department of Maternal and Child Health, Harvard School of Public Health, under the direction of one of us (H.C.S.). The background of this research project, the methodologies and technics employed in the collection and analysis of the data have already been described.[1] The Burke Research Dietary History Method[2] was used for the collection of the dietary data at each routine visit of the child to the clinic, i.e., semi-annually during the early years and annually thereafter. Detailed nutrition histories were obtained in which the average daily dietary intakes of the preceding time interval were ascertained.

The total caloric and total protein intakes of these children have already been reported.[2] In line with the objectives of future reports from this research project, i.e., to determine relationships between intakes of nutrients and manifestations of health and development, it was considered important to ascertain qualitative as well as quantitative differences in the protein intakes of these children. It is generally accepted that most proteins from animal origin are of higher biologic value than those derived from plants, and in diets in which growth is a factor it has long been considered desirable to provide a relatively high proportion of total protein from animal sources. On the other hand, it is well known that despite the relatively low biologic value of plant pro-

From the Department of Maternal and Child Health, Harvard School of Public Health, Boston, Massachusetts.

* Associate Professor of Maternal and Child Nutrition, Emerita, Department of Maternal and Child Health; † Associate Professor of Biostatistics, Department of Biostatistics; ‡ Research Associate in Child Nutrition, Department of Maternal and Child Health; Present address: Department of Home Economics, University of Pretoria, Pretoria, South Africa; §Director of the Study, and Professor of Maternal and Child Health, Emeritus.

This paper is No. 8 of the monodisciplinary reports in Series II of the Longitudinal Studies of Child Health and Development, Department of Maternal and Child Health, Harvard School of Public Health, Boston, Massachusetts.

Financial support from the many organizations listed in the introductory paper of this Series[1] made possible the collection of the dietary intake histories on which this study is based. In recent years these studies have been supported by the Research Grants Division of the U. S. Public Health Service and the Nutrition Foundation, Inc.

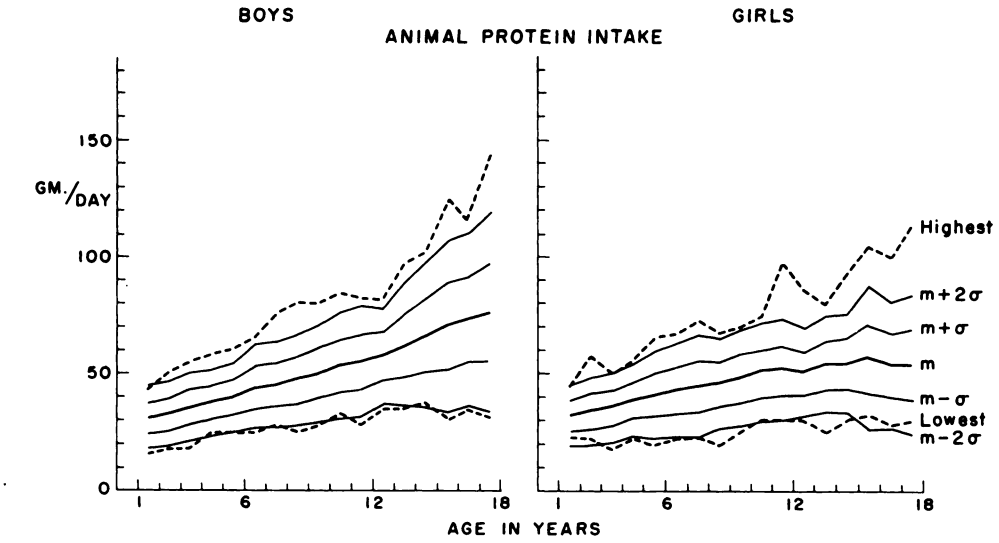


FIG. 1. Animal protein intake of children in the Harvard Longitudinal Studies according to age and sex.

teins mutually supplementary relationships exist when plant foods are combined in the diet whereby deficiencies of essential amino acids in one plant food can be corrected, to some extent at least, by additional amounts of these amino acids from other carefully chosen plant foods. Furthermore, it has been shown that small amounts of animal protein of high biologic value can considerably augment the biologic value of an otherwise vegetarian diet. Research already is concerned with and in the future will show increased interest in the amino acid evaluation of diets in relation to amino acid requirements. However, with the information at present available on the amino acid composition of foods, and the nature of our data, it does not appear practical to attempt detailed evaluation of the diets of these children in terms of their essential amino acid content. With this in mind the amount of animal protein intake was determined. Since both the total and animal protein intakes (grams per day) are known, the amount of protein (grams per day) from plant origin can be obtained by difference.

METHODS

The dietary data covering the entire childhood of these 125 children are based on 2,707 nutrition histories, each history providing a quantitative appraisal of the average daily dietary intake of a child for the preceding six- or twelve-month interval. The total person years of experience represented by the 125 children are 2,125, i.e., a seventeen-year period for each child. The 2,707 histories provide information for approximately 91 per cent of these person years. Estimates of intakes were made by interpolation for the years when histories were not obtained and for the occasional history considered too incomplete to justify inclusion in this analysis. In this way every child was represented in the analysis at every age period. For the description of the procedure used in the estimation of intakes and the use of these estimates the reader is referred to the report on the caloric and protein intakes of these 125 children.[2]

RESULTS

The cross-sectional distribution of the animal protein intakes of the sixty-four boys and sixty-one girls of the Maturity Series of this longitudinal research project is represented by sex and age in Figure 1 and Table 1.

Variations in intake with age and sex are clearly illustrated by the animal protein curves. The average intakes are very similar for the two sexes in the preschool years. During the school years, especially the late school years, the boys display a high rate of increase in intake compared to the girls, resulting in increasingly higher values for the boys in the

TABLE 1
Animal Protein Intake (grams per day) According to Age and Sex

Age (yr.)	Boys				Girls			
	Mean	S.D.	Lowest	Highest	Mean	S.D.	Lowest	Highest
1–2	30.6	6.5	15.0	42.5	32.1	6.4	22.5	45.0
2–3	32.5	7.0	17.5	50.0	33.9	7.4	22.5	57.5
3–4	35.7	7.3	17.5	55.0	35.4	7.4	17.0	50.0
4–5	37.7	7.0	25.0	57.5	38.9	7.7	22.0	55.0
5–6	39.8	7.4	25.0	60.0	41.0	9.3	19.0	65.0
6–7	44.0	9.1	25.0	65.0	43.0	9.9	22.5	67.5
7–8	44.9	9.1	27.5	75.0	44.6	10.8	23.0	72.5
8–9	46.8	9.9	25.0	80.0	46.0	9.6	20.0	67.5
9–10	49.9	10.4	27.5	80.0	48.2	10.4	25.0	70.0
10–11	53.4	11.5	32.5	85.0	50.9	11.0	30.0	75.0
11–12	54.9	11.9	27.5	82.5	51.5	11.0	30.0	97.5
12–13	57.3	10.2	35.0	82.5	50.5	9.4	30.0	85.0
13–14	62.2	13.3	35.0	97.5	54.0	10.5	25.0	80.0
14–15	66.3	15.5	37.5	102.5	54.4	10.7	30.0	92.5
15–16	70.3	18.6	30.0	125.0	56.9	15.2	32.5	105.0
16–17	73.4	18.4	35.0	115.0	54.2	13.7	27.5	100.0
17–18	76.0	21.0	30.0	142.5	53.8	14.7	30.0	112.5

S.D. = Standard deviation.

later years. The boys' animal protein intakes were highest at eighteen years of age when the average value was 76 gm. per day, the girls reached their maximum, 57 gm. per day, during the fifteen- to sixteen-year period.

Widdowson,[3] in her cross-sectional study of individual children's diets, investigated the average animal protein intakes of children between the ages of one and eighteen years. Insofar as we know, no other equally comprehensive study of animal protein in children's diets exists in the literature. A comparison of her values with those of our Maturity Series shows that our values for animal protein, both for boys and for girls, are always appreciably higher than those of the British children. Except for a few age periods the Boston children also displayed higher total protein intakes than the British children.[2]

The wide range encountered in the total caloric and total protein intakes of these individual children is shown also by the animal protein values. In Widdowson's group similar individual variation is in evidence. In the Boston group at every age period, among the boys as well as the girls, the child with the highest intake consumed at least twice as much animal protein as the child with the lowest intake. At every age, one to eighteen years, and for both sexes there was at least one child whose animal protein intake was actually lower than the maximum intake at one year of age.

It was not always the same children who occupied these extreme positions. Although some children maintained the highest or lowest positions for only two or three consecutive years, the intake of one boy ranked highest for eleven different age periods. Figure 1 gives a cross-sectional picture of the animal protein intakes and progressive changes in intakes of the boys and girls in this series during their years of growing up. It does not, however, show how individual children deviate from their average pattern of change in intake.

In order to make it possible to view the data longitudinally in terms of individual patterns of consumption of animal protein, the children were classified according to their levels during three broad age periods (one to six, six to twelve, and twelve to eighteen years). Within each age interval the cumulative intake of animal protein was calculated for each boy and girl, and these values were grouped into quartiles for each sex. Children ranking in

TABLE II
Cumulative Values of Animal Protein Intake Which Define the Extreme Quartiles by Sex and Age Intervals

Age (yr.)	Gram per Day							
	Boys				Girls			
	Lowest Value	25th Percentile	75th Percentile	Highest Value	Lowest Value	25th Percentile	75th Percentile	Highest Value
1–6	115.0	156.2	191.9	262.5	111.0	160.0	207.5	272.2
6–12	172.5	259.4	326.2	467.5	166.8	241.9	322.5	385.0
12–18	210.0	348.0	443.8	640.0	210.0	283.5	357.5	530.0
1–18	615.0	772.5	957.5	1,370.0	487.8	696.2	876.4	1,082.5

TABLE III
Frequency of Occurrence of Individual Longitudinal Patterns of Animal Protein Intake

Patterns	No. of Boys	No. of Girls
HHH	5	5
MMM	12	12
LLL	6	4
MLL, HLL, HMM	(2 + 0 + 5) = 7	(1 + 1 + 2) = 4
LMM, LHH, MHH	(2 + 0 + 3) = 5	(2 + 0 + 3) = 5
MML, HHL, HHM	(2 + 1 + 3) = 6	(7 + 0 + 4) = 11
LLM, LLH, MMH	(3 + 0 + 4) = 7	(5 + 1 + 2) = 8
LML, LHL, LHM, MHL, MHM	(4 + 0 + 0 + 1 + 3) = 8	(2 + 0 + 0 + 0 + 3) = 5
MLM, MLH, HLM, HLH, HMH	(4 + 1 + 0 + 0 + 2) = 7	(3 + 0 + 0 + 0 + 3) = 6
LMH	1	1
HML	0	0

H—High; M—Medium; L—Low.

the lowest quartile of the distribution were classified as having a "low" (L) value, those in the highest quartile as having a "high" (H) value, and those that fell between the 25th and 75th percentiles were classified as "medium" (M) value in intakes. The values defining the extreme quartiles are given in Table II.

For the one- to eighteen-year period each child was assigned a pattern according to the combination of his ratings in the three age intervals. For example, Boy 139 (Fig. 2) was among the sixteen boys who for the one- to six-year interval had the lowest cumulative values of the group, but this boy increased his intake rapidly so that for the six- to twelve-year interval his intake rated "medium" and for the twelve- to eighteen-year interval his cumulative value ranked in the highest quartile of the distribution. Therefore, his pattern of intake was classified as "consistently rising" (LMH).

According to this method of classification there were twenty-seven possible patterns. On the basis of direction of change in intake from one interval to the other these twenty-seven patterns were combined into eleven pattern groups. The distribution of the sixty-four boys and sixty-one girls in the different patterns and pattern groups is shown in Table III.

Figures 2 and 3 illustrate differences as well as similarities between patterns and pattern groups and between children in the same pattern or pattern group. For example, boys in the "consistently low," "consistently medium" and "consistently high" groups conform more or less to the average pattern of the series in the rate at which they change their

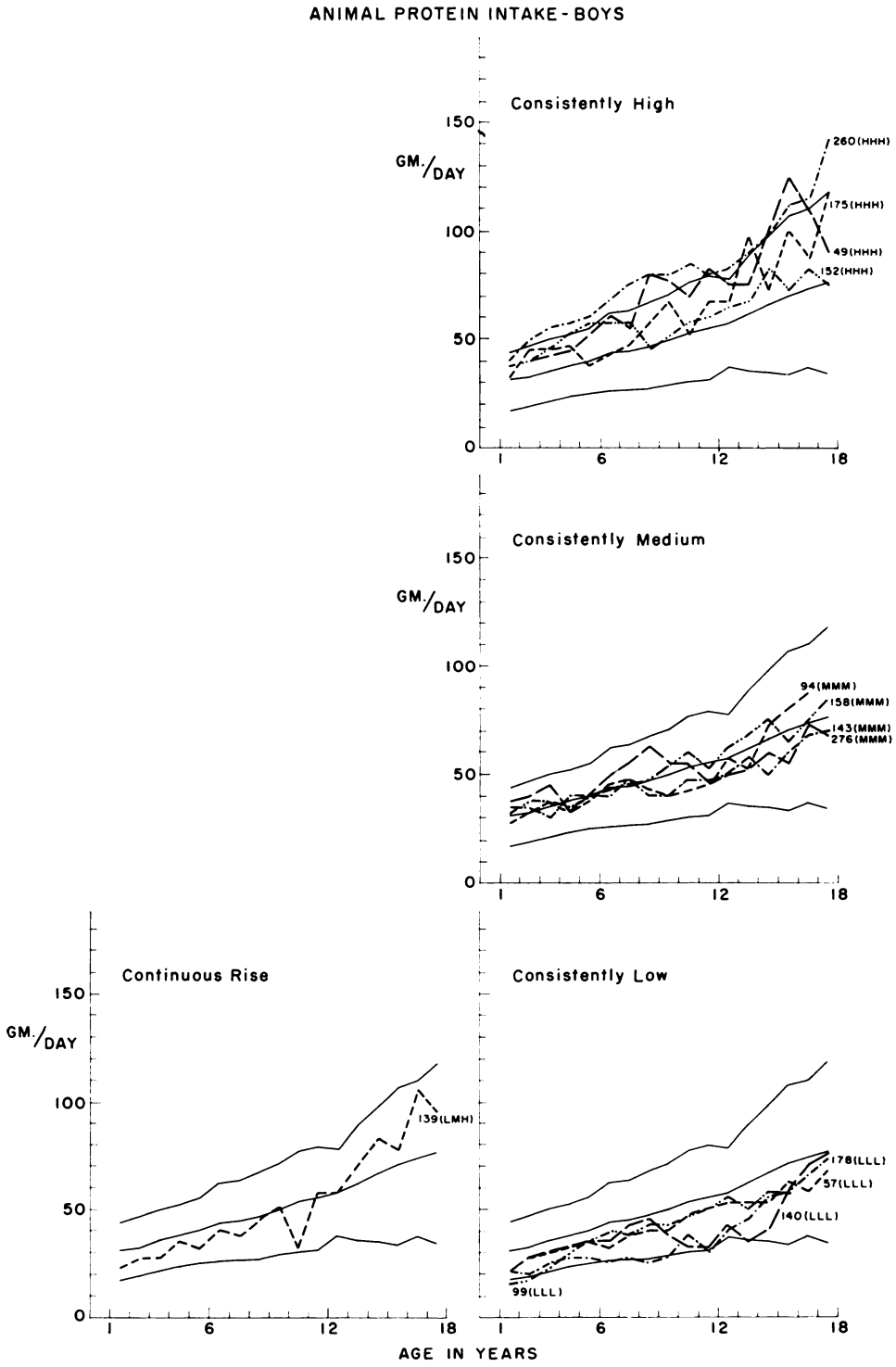
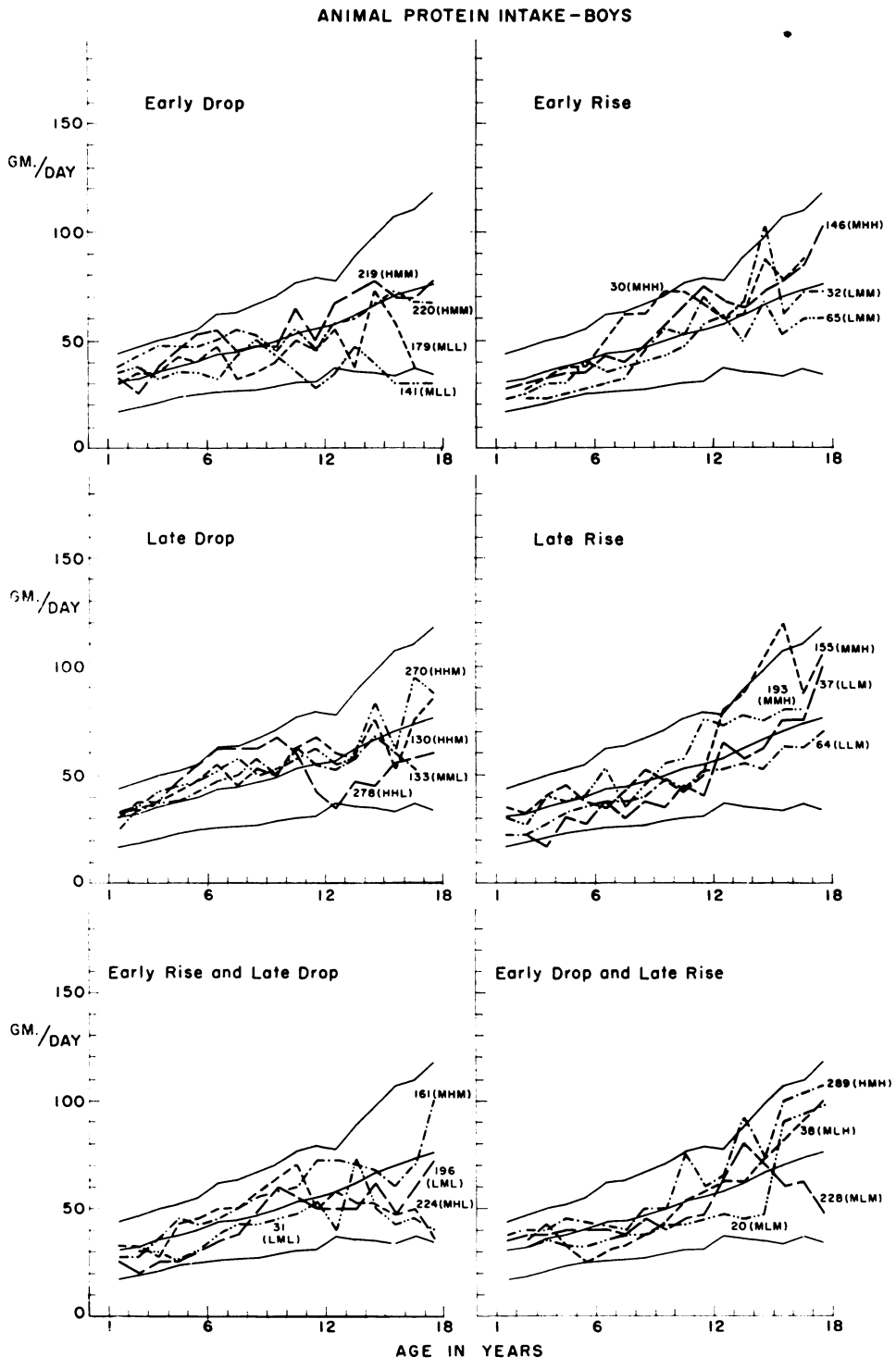


FIG. 2. Selected individual curves of boys' animal protein intake shown in the pattern groups



to which they conform, plotted against the cross-sectional norms for the Maturity Series.

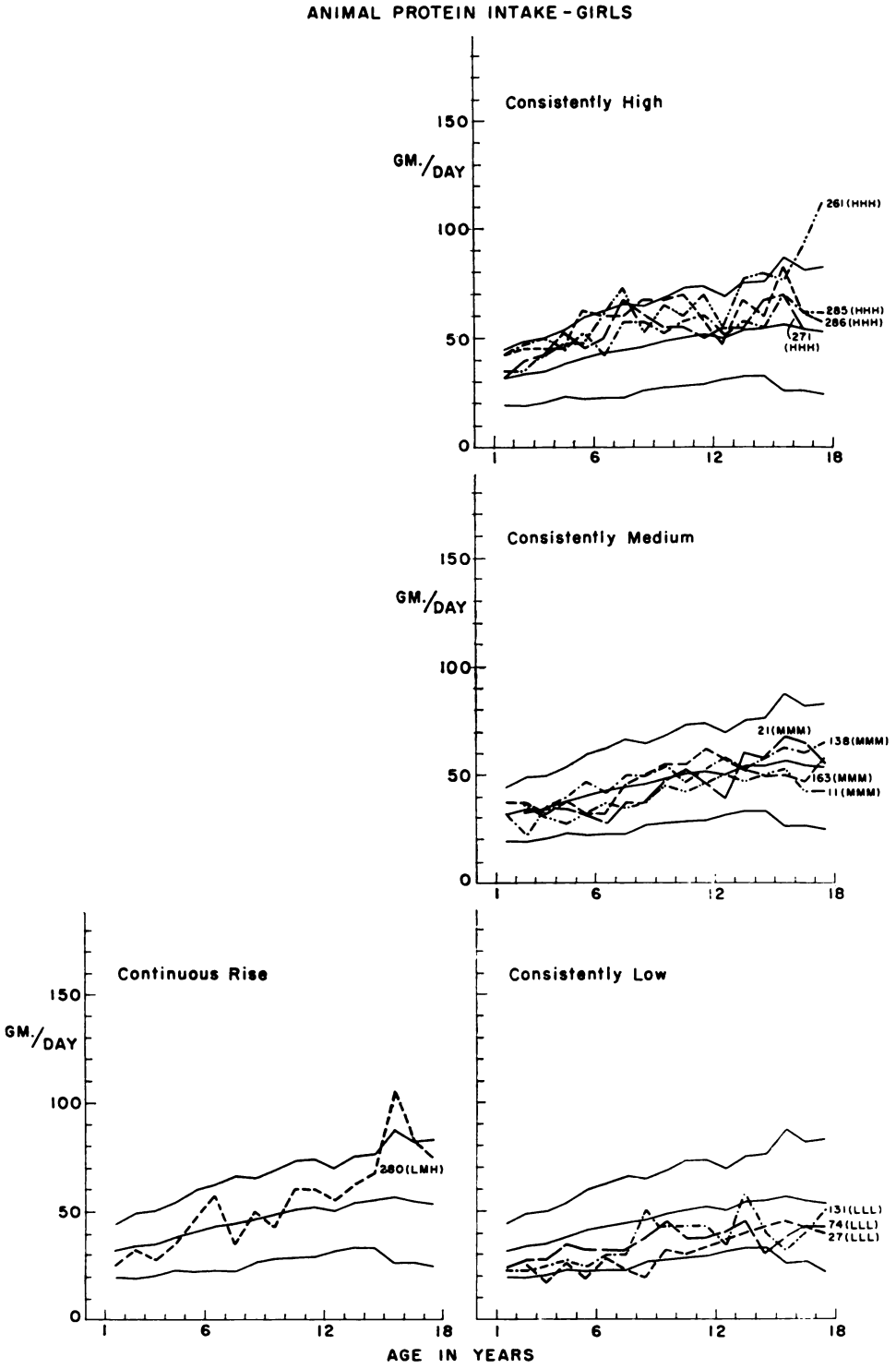
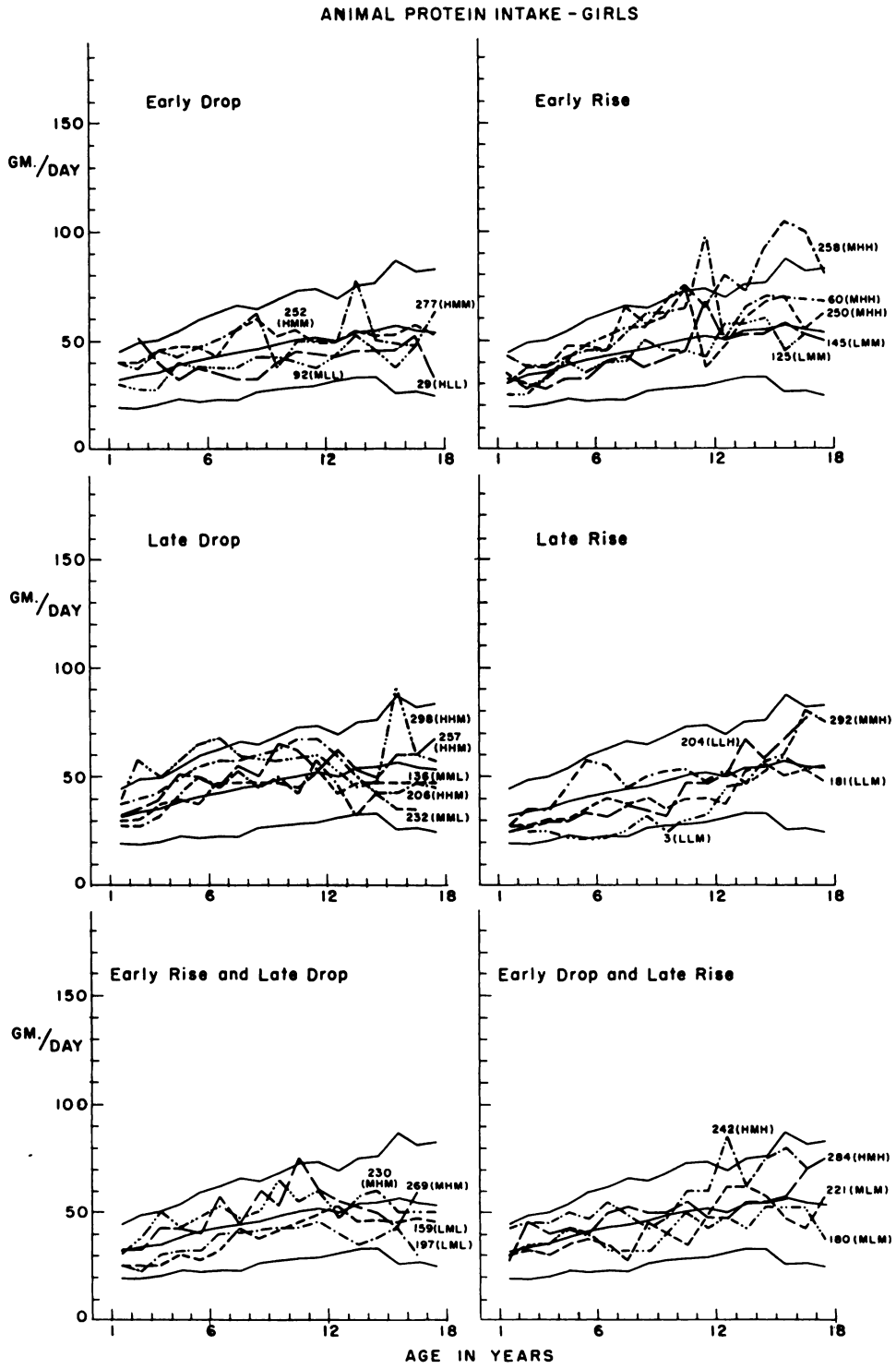


FIG. 3. Selected individual curves of girls' animal protein intake shown in the pattern groups



to which they conform, plotted against the cross-sectional norms for the Maturity Series.

intakes with age, but display a wide range in level of intake with many intermediate variations between extremes of over-all intake as presented in Cases 178 (LLL) and 260 (HHH) in the "consistently low" and "consistently high" categories, respectively. The boys in the other pattern groups show widely different patterns of change in intake. There are differences in direction of change, see, for example, Case 220 (HMM) in the "early drop" category in contrast to Case 146 (MHH) in the "early rise" category and Case 133 (MML) in the "late drop" versus Case 37 (LLM) "late rise" category or Case 224 (MHL) versus Case No. 38 (MLH). There are also differences in the timing of change; compare, for example, Cases 141 (MLL) and 133 (MML), respectively, in the "early drop" and "late drop" categories. Differences in amount of change are well illustrated by cases in the rise and drop categories; compare, for example, the intake in Case 278 (HHL) with the intakes in Cases 270 (HHM) and 130 (HHM).

The gradations of difference in levels and in direction and rate of change within patterns and pattern groups as well as between different pattern groups should be noted. In the "consistently medium" category, for example, there is a relatively high over-all animal protein intake in Case 138 (MMM) in relation to Case 11 (MMM). In level of intake Case 11 occupies an intermediate position between Case 138 (MMM) and Case 74 (LLL) which falls in the "consistently low" category.

In Case 21 (MMM), also in the "consistently medium" category, there is a lower over-all level of intake than in Case 138 (MMM), but this child proceeds with a comparatively rapid increase in intake, particularly in the later years, from a relatively low intake in the one- to six-year interval to a relatively high intake in the twelve- to eighteen-year interval. Thus, with regard to pattern of change, Case 21 (MMM) tends to occupy an intermediate position between Case 138, also in the "medium category," and children in a rising category such as Case 3 (LLM) in the "late rise" and Case 145 (LMM) in the "early rise" category.

SUMMARY

The cross-sectional distributions of the animal protein intakes of sixty-four boys and sixty-one girls of the Maturity Series of this longitudinal research are described for the age period one to eighteen years. Wide variations in intake with age and sex are clearly shown. The average intakes are very similar for the two sexes in the preschool years. During the school years, especially the late school years, the boys displayed a high rate of increase compared to the girls. The boys' animal protein intakes were highest at eighteen years of age, when the average value was 76 gm. per day; the girls reached their maximum, 57 gm. per day, during the fifteen- to sixteen-year interval.

A comparison with Widdowson's cross-sectional values for animal protein shows that our values are always appreciably higher than those for the British children.

In order to view our data longitudinally in terms of individual patterns of consumption of animal protein, the boys and girls in the Maturity Series were classified according to their levels of intake into pattern groups by a procedure described in the text, using values for cumulative intakes of animal protein within specified age intervals. The frequency of occurrence of the individual longitudinal patterns of animal protein intake are presented in the tables, and the figures show the gradation of difference in levels of animal protein intake as well as in the direction and rate of change within patterns and between pattern groups.

REFERENCES

1. Stuart, H. C. and Reed, R. B. et al. Longitudinal studies of child health and development, Harvard School of Public Health, series II, no. 1. Description of project. *Pediatrics*, 24: 875, 1959.
2. Burke, B. S., Reed, R. B., van den Berg, A. S. and Stuart, H. C. Longitudinal studies of child health and development, Harvard School of Public Health, series II, no. 4. Caloric and protein intakes of children between one and eighteen years of age. *Pediatrics*, 24: 922, 1959.
3. Widdowson, E. M. A study of individual children's diets. Medical Research Council, Special Report, series no. 257. London, 1947. H. M. Stationery Office.