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Length and Weight in Rural Guatemalan Ladino Children: Birth to Seven Years of Age

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ABSTRACT The present study reports 5,029 length and weight measurements as well as percentile distributions for a mixed longitudinal series of 1,119 rural Guatemalan Ladino children. The study sample, birth through seven years, is representative of children in clinically good health, but of suboptimal nutrition.

Boys are longer and heavier than girls over the age range. Guatemalan children of both sexes are smaller than American white children from Denver. Differences are least at birth, and increase through two years of age. Between two and five years, differences between the rural Guatemalan Ladino and Denver samples are rather stable, but then increase through seven years.

Despite these differences there is a linear weight for length relationship which is the same across all preschool ages, both sexes, and for both the Guatemalan and Denver populations. This implies that age, sex, ethnic differences between the two groups compared, and mild-to-moderate protein-calorie malnutrition do not affect the relationship between weight and length in preschool children.

The size of children is frequently viewed as an indicator of the nutritional status of a community as a whole. This is especially true in rural, technically underdeveloped (pre-industrial) areas of the world, where the prevalence of undernutrition among preschool children is a major public health concern. The impact of malnutrition early in life on the subsequent development of children is such that careful monitoring of their growth status and progress in underdeveloped areas is frequently recommended (Béhar, '68; Tanner, '66; Jelliffe, '66; National Academy of Sciences — National Research Council, '66).

Length and weight are the most widely used measurements in anthropometric assessments of nutritional status, especially in field studies. They provide important information on children's growth status and progress, and are reasonably sensitive indicators of nutritional status. Their utility in estimating nutritional status is particularly important when field facilities for biochemical assessments of nutritional status are not readily available. This report considers the pattern of growth in length and weight of rural Guatemalan Ladino children from birth through seven years of age. In particular, we shall consider whether length and weight have a different relationship in the Guatemalan sample than in the U. S. Finally, we shall present data which can be used for clinical screening purposes in underdeveloped areas.

METHOD

The data reported herein are mixed longitudinal observations on 1,119 clinically normal rural Guatemalan Ladino children, presently under study by the Division of Human Development of the Institute of Nutrition of Central America and Panama (INCAP). From this basic sample, 5,029 length and weight observations are available. Medical examinations

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of all children established their clinical normality. It should be noted, however, that mild-to-moderate protein-calorie malnutrition is endemic in this population. The average diet is 30–40% below the recommended allowances for proteins and calories (Habicht et al., '73). The sample comprises 84% of all children who were 0 to 84 months of age within the period of January, 1969, through May 1, 1972 in four villages in the department of El Progreso, northeast of Guatemala City. None of these villages has been previously studied by INCAP. They are situated on the Atlantic slopes of the Guatemalan highlands at altitudes varying from 300 to 1,100 m.

The children of the study sample are participants in a longitudinal supplementation program, one objective of which is to elucidate the effects of improved nutrition on mental development (Klein et al., '73). The nutritional and health standards of these villages are consequently better than the average for rural Guatemala. Since no consistent differences were apparent in the weights and lengths of children in the four villages, data from these four localities were pooled for the present report.

Weight and length measurements were taken by trained and standardized anthropometrists (Habicht, in press). Weight was measured on a beam scale with the child clothed only in a light shift provided by the anthropometrist. The weight of each shift was measured and subtracted so that the reported values are nude weights. Supine length was measured in all children on a standard measuring table. A trained attendant positioned the child's head in the Frankfort plane and held it firmly against the fixed headboard. The anthropometrist then moved the footboard into firm contact with the soles of the feet, which were at right angles to the longitudinal axis of the body. At the same time, the anthropometrist applied pressure at the child's knees to insure full extension of the lower extremities.

There are two sources of potential error in these data: errors in measuring, and day-to-day variations in the actual size of the child. The measurement error standard deviation for immediate re-measurement of weight and length were 20 grams and 3.4 mm, respectively. At random, 10% of all children were re-measured at a one week interval with standard deviations of 240 grams for weight and 5.6 mm for length. Given the measurement errors of 20 grams and 3.4 mm, this implied a weekly within-child variation of 240 grams and 4.4 mm. Thus, most of the variation

TABLE 1

Mean length (cm) and weight (kg) of rural Guatemalan Ladino children

Age group	Males					Females				
		Length		Weight			Length		Weight	
	n	$\bar{x}$	S.D.	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Birth	34	48.4 [1]	2.5	2.97	0.52	13	47.4	1.5	3.00	0.50
15 days	117	49.5 [1]	2.5	3.36 [1]	0.53	108	48.4	2.2	3.25	0.51
3 months	208	57.6 [1]	2.4	5.55 [1]	0.81	166	55.9	2.4	5.13	0.82
6 months	195	63.1 [1]	2.5	6.87 [1]	0.95	159	61.5	2.5	6.57	0.92
9 months	191	66.3 [1]	2.7	7.50 [1]	0.96	160	64.8	2.5	7.15	0.96
12 months	188	69.2 [1]	2.9	7.94 [1]	0.99	153	67.6	2.8	7.52	1.07
15 months	184	71.7 [1]	3.2	8.44 [1]	1.03	147	69.7	3.1	7.92	1.12
18 months	176	73.9 [1]	3.3	8.92 [1]	1.04	154	71.9	3.5	8.30	1.13
21 months	165	76.4 [1]	3.2	9.46 [1]	1.05	137	74.1	3.6	8.72	1.14
24 months	182	78.6 [1]	3.3	10.10 [1]	1.10	142	76.0	3.9	9.22	1.19
30 months	165	82.8 [1]	3.7	11.19 [1]	1.15	151	80.0	4.3	10.32	1.31
36 months	170	86.5 [1]	3.6	12.17 [1]	1.17	146	84.3	4.4	11.43	1.35
42 months	167	90.4 [1]	3.8	13.26 [1]	1.24	145	88.3	4.5	12.54	1.35
48 months	160	93.6 [1]	4.0	14.05 [1]	1.38	148	92.0	4.7	13.45	1.56
60 months	144	99.7	4.2	15.52	1.55	150	98.9	4.8	15.13	1.75
72 months	128	105.4	4.4	16.91	1.61	137	104.7	4.7	16.53	1.77
84 months	118	110.4	4.4	18.69	1.87	121	109.6	3.9	18.11	1.71

[1] Boys significantly bigger than girls ($p < 0.001$).

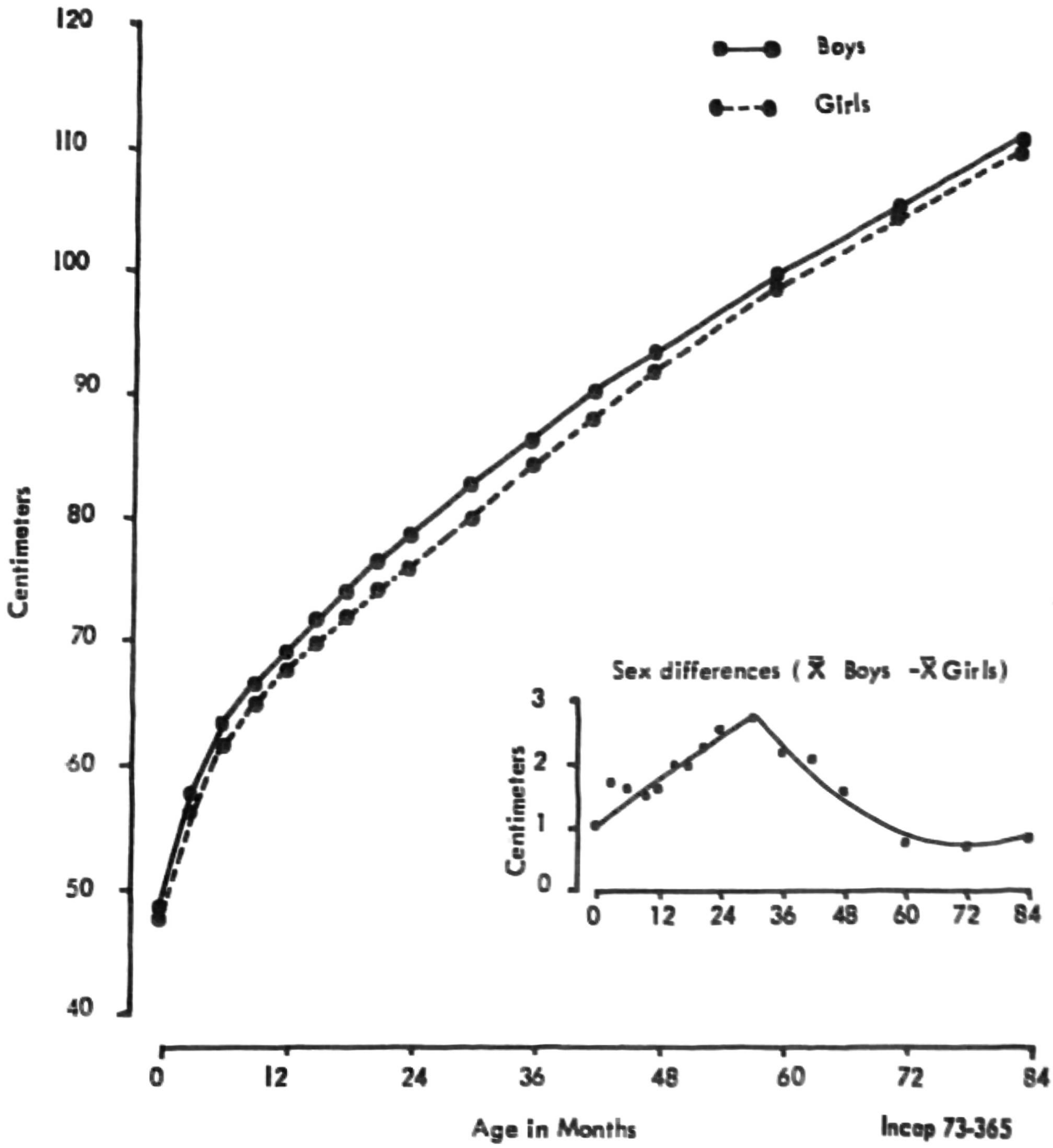

Fig. 1 Distribution of length by age of rural Guatemalan Ladino boys and girls.

in weight and length measurements is due to fluctuations within the individual child rather than to the field measurement procedures *per se*.

Weight and length were measured at 15 days of age, and at 15 specific age intervals through 84 months. The specific age intervals and sample size per age group are indicated in a later section of this paper. The permitted variation around the measurement intervals was ± 3 days at 15 days of age, ± 5 days from 3 through 24 months of age, and ± 7 days from 30 through 84 months of age.

Subsequent to measurement, length and weight values which seemed unusual for the age of the child were checked and discarded if not verified by re-measurement. The rate of discard was approximately 0.6%.

RESULTS

Sample sizes per age group, mean lengths and weights, and standard deviations about the means of rural Guatemalan Ladino boys and girls from birth through seven years of age are given in table 1. Mean values for boys and girls are also presented in figures 1 and 2 for length and weight, respectively.

Boys are taller and heavier than girls at all ages studied. This difference is also found at birth with mean values of 3.12 ± 0.54 kg for boys (n = 156) and 3.04 ± 0.41 kg for girls (n = 132). These birth measurements were made by nurses and not by the personnel who collected the

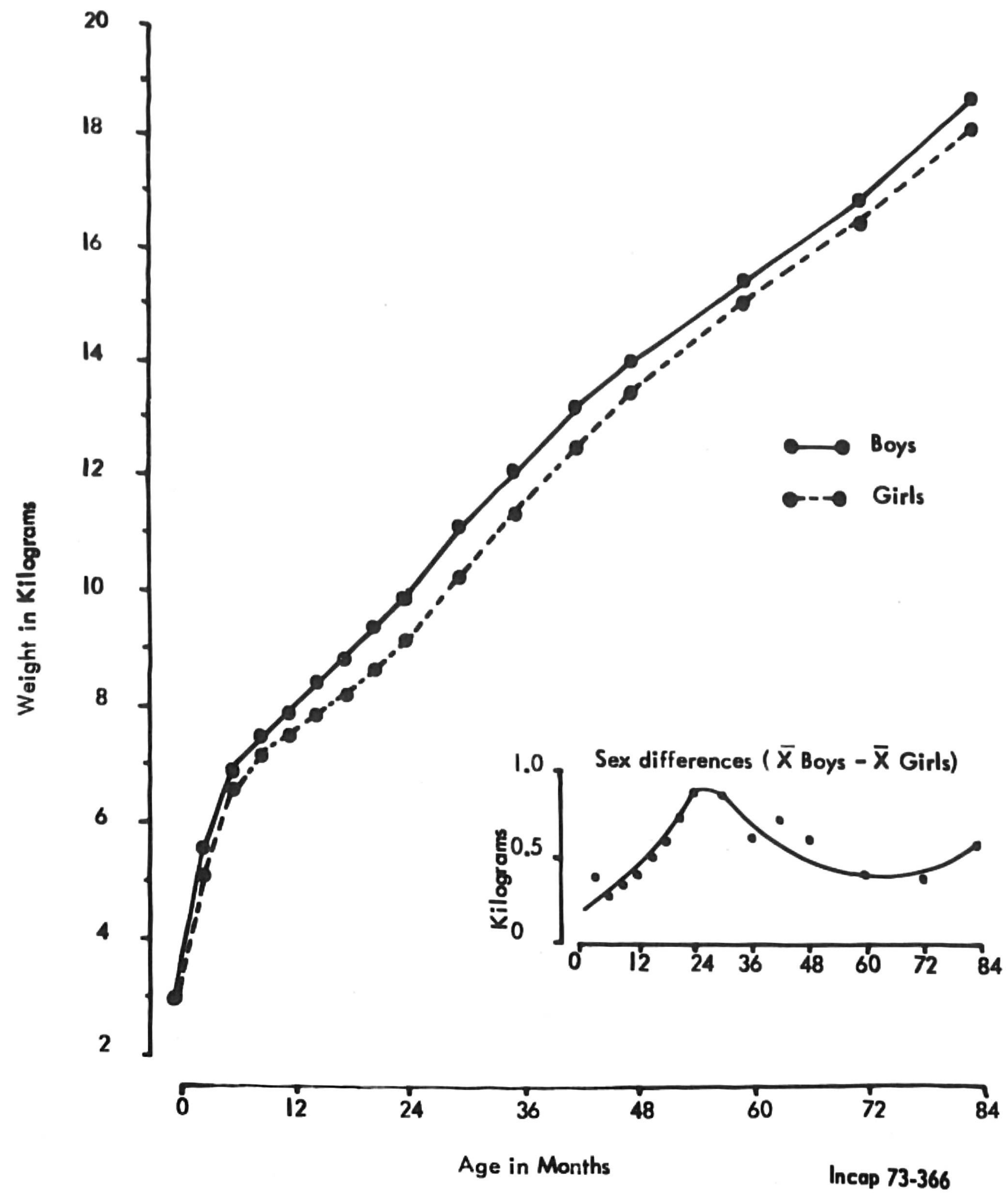

Fig. 2 Distribution of weight by age of rural Guatemalan Ladino boys and girls.

values presented in table 1. The differences between sexes are greatest at 30 months of age and are statistically highly significant ($p<0.001$) from three months till four years of age.

Extensive data for upper class, presumably better nourished Guatemalan children across the age range under consideration are not available. At six and seven years of age, however, available height and weight data for upper class Guatemalan children (Johnston et al., '73) do not differ substantially from standards for American white children from Denver (Hansman, '70). The Denver values are used throughout this paper as a comparison standard because they are more recent than other standard values, have larger sample sizes per age group, are more complete in the number of measurements and measurement distribution reported, and are currently available in computer-readable form to investigators. Differences between available weight and length standards for preschool children are so small that the choice of a standard is in fact inconsequential (Habicht et al., '74). Moreover, since secular increase has

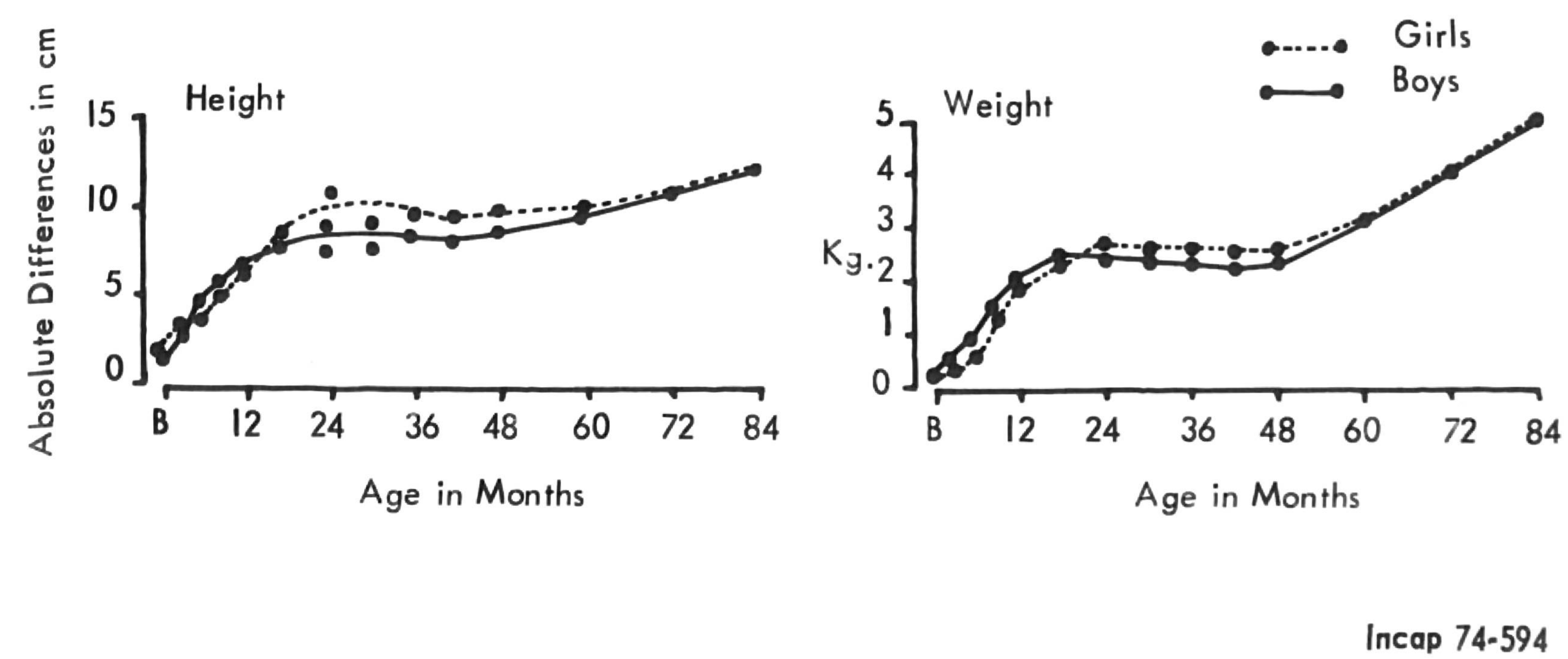

Fig. 3 Absolute differences between means of length and weight of the Guatemalan (present study) and Denver series.[2]

[2] Note: At two years of age, the Denver values for height include supine and erect height values; thus, there are four points plotted at this age.

disappeared among economically favored Americans (Damon, '68), the date of the standard seems inconsequential.

Comparisons with other data from the underdeveloped world are fraught with methodological difficulties. Nevertheless, this sample seems typical of other literature (Habicht et al., '74) differing only in its size, standardization procedures, wealth of ages, intervals and precision of age estimates. Absolute differences in length and weight between mean values of the Denver and rural Guatemalan Ladino samples are illustrated in figure 3. The Guatemalan children are shorter and lighter than Denver children at all comparable ages ($p<0.001$ at each age for each sex). There are no discernible sex differences in the pattern and magnitude of the deficit in growth of the Guatemalan children as compared to the Denver sample. Guatemalan boys are thus similar in their growth retardation in height and weight to Guatemalan girls. Differences for both sexes between the Guatemalan and Denver samples increase gradually from birth through two years of age for both length and weight, are stable between two and five years for length, and two and four for weight, and then increase gradually through seven years of age.

It is often believed that when growth is retarded, body weight is more affected than length. However, for the Guatemala sample the regression of weight (W) on length (L): W(kg) = 0.242 L (cm) − 8.85 (r = 0.979; n = 5029), is linear (fig. 4). There is no significant difference between sexes. Furthermore, the Denver means for age specific height and weight values superimpose themselves almost perfectly on the regression line.

DISCUSSION

It is generally observed that urban and rural children from lower socioeconomic backgrounds in developing countries are considerably shorter and lighter than their age and sex peers in the upper social strata of their own countries and their age and sex peers in developed countries (Habicht et al., '74). Although a child's size at any given point in time is the product of the complex interaction between his genetic potential and environmental influences, available data suggest that suboptimal nutrition during infancy and early childhood delays and even stunts growth (Béhar, '68; Jackson, '66; Woodruff, '66). The role of suboptimal nutrition in affecting growth is possibly enhanced by interactions with infectious diseases (Scrimshaw et al., '68). The effects of malnutrition on growth may also vary depending on whether proteins or calories are the main limiting nutrient.

In the present study sample, however,

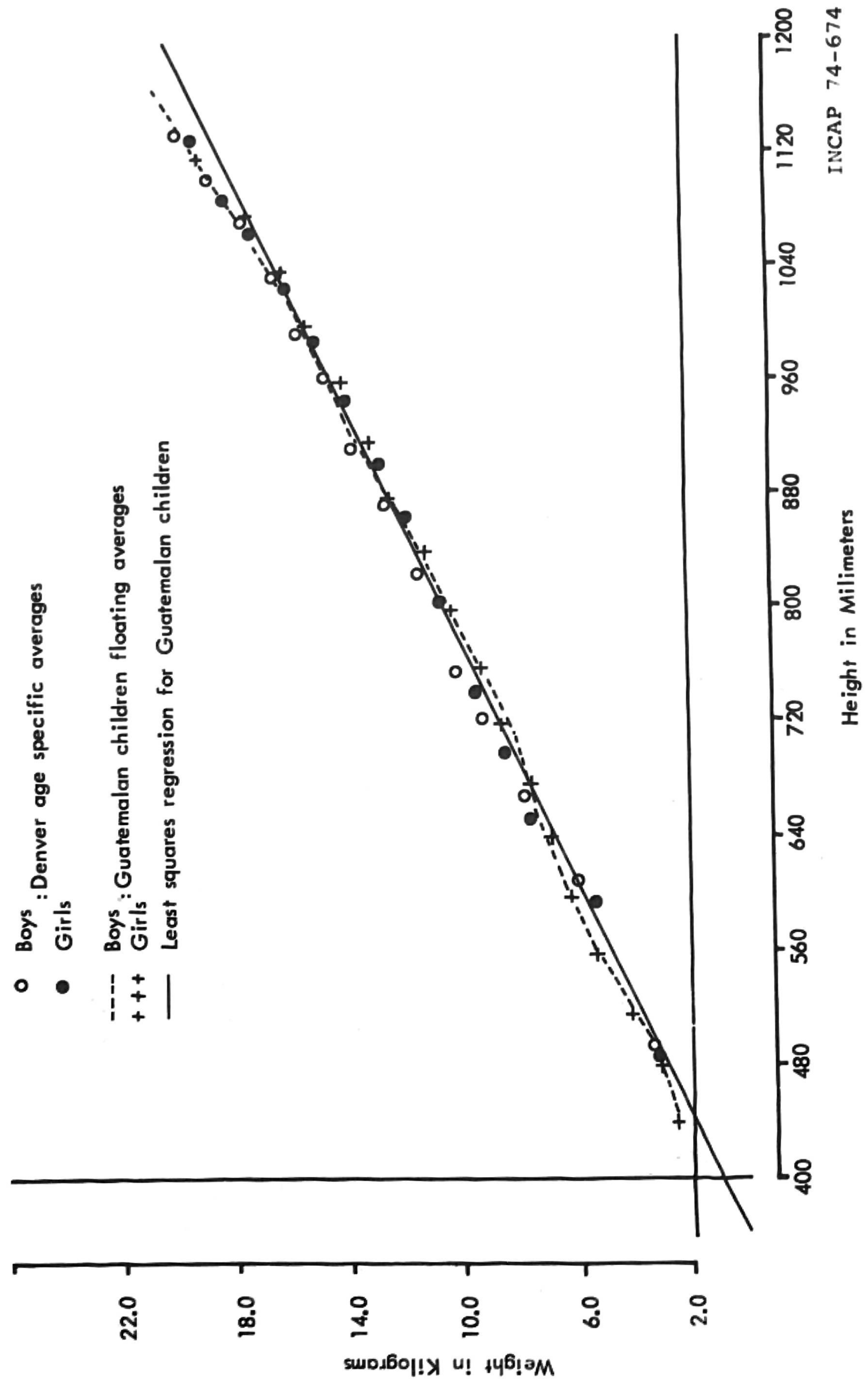

Fig. 4 The relation of weight to height for Guatemalan (present study) and Denver children from birth through six years of age.[3]

[3] Note: This regression is calculated on the Guatemalan individual data, not on the averages illustrated. The weights plotted for the Guatemalan children are 1 cm floating averages. In other words, the weight plotted for a given length is the average weight of all children whose length is within 1 cm of the given length. The averages plotted for the Denver are the age specific length and weight means. Thus, Denver boys at one year were 75.8 cms tall and weighed 10.0 Kgs on the average. The Denver length data were augmented by 1 cm after two years of age to make it comparable to the Guatemalan recumbent length data.

TABLE 2

Rural Guatemalan Ladino boys: percentiles for length (cm)

Age	n	Percentiles						
		3	10	25	50	75	90	97
15 days	117	44.8	46.0	48.0	49.8	50.9	52.3	53.2
3 months	208	52.0	54.3	56.7	57.6	59.2	60.5	61.1
6 months	195	58.0	60.0	61.7	63.2	64.5	66.2	67.3
9 months	191	59.9	62.8	64.7	66.7	68.1	69.5	70.5
12 months	188	63.2	65.2	67.6	69.3	71.1	72.8	73.6
15 months	184	64.5	67.8	69.7	71.9	73.8	75.5	77.1
18 months	176	66.8	69.9	72.0	74.2	76.3	78.1	79.0
21 months	165	70.5	71.8	74.5	76.6	78.7	79.8	81.5
24 months	182	72.2	74.1	76.4	78.9	80.9	82.6	84.1
30 months	165	76.5	78.5	80.4	82.8	85.0	87.3	88.8
36 months	170	80.3	82.3	84.1	86.5	88.9	91.2	93.1
42 months	167	83.7	85.3	88.0	90.3	93.1	95.0	97.0
48 months	160	86.3	88.2	91.0	93.8	96.3	98.5	101.0
60 months	144	90.7	94.3	97.0	99.5	102.5	104.6	106.3
72 months	128	96.6	99.6	102.8	105.4	108.0	110.4	112.6
84 months	118	102.7	105.1	107.6	110.2	112.9	115.2	118.3

TABLE 3

Rural Guatemalan Ladino girls: percentiles for length (cm)

Age	n	Percentiles						
		3	10	25	50	75	90	97
15 days	108	43.8	45.5	47.3	48.5	49.6	51.0	51.6
3 months	166	51.0	52.6	54.5	56.0	57.4	58.6	59.4
6 months	159	56.5	58.2	60.0	61.5	63.0	64.4	66.2
9 months	160	59.2	61.8	63.4	65.0	66.3	67.8	69.2
12 months	153	62.2	63.6	65.9	67.8	69.2	70.8	72.7
15 months	147	63.4	65.3	67.8	70.1	72.0	73.2	74.5
18 months	154	65.0	67.5	70.0	72.4	73.9	76.0	78.3
21 months	137	68.5	69.6	71.4	74.4	76.7	78.3	79.4
24 months	142	68.2	79.8	73.7	76.3	78.5	80.9	82.6
30 months	151	71.1	74.2	77.7	80.0	82.8	85.4	86.9
36 months	146	74.9	78.7	81.6	84.6	86.8	89.2	91.6
42 months	145	78.0	82.7	86.1	88.6	91.0	93.7	95.6
48 months	148	82.4	86.1	89.2	91.8	94.6	97.7	100.5
60 months	150	89.2	93.6	96.2	98.6	102.2	104.9	107.7
72 months	137	96.3	98.4	101.7	104.7	107.6	110.7	113.8
84 months	121	102.2	104.6	107.0	109.3	112.0	114.9	115.9

the prevailing mild-to-moderate malnutrition does not lead to children who are lighter than Denver children of the same length. Rather, the relationship between length and weight is linear among preschool children, it is the same for both sexes, and is also apparently the same for our Guatemalan Ladino sample and the Denver children. The often reported relative differences[4] between well and poorly nourished children are greater for weight than for length because the ratio of weight over length is not constant for different lengths. This is because the linear function of these two variables does not pass through the origin. Guatemalan children are the same length and weight as Denver children of a younger age, and the weight for length relationship is exactly the same for Guatemalan and Denver samples at all preschool ages. This suggests that relative differences are not in fact appropriate for comparison although this finding may depend on the kind of malnutrition and its severity. Indeed, we believe that it is different when calories

[4] The relative difference is calculated by taking the difference between two values as a percentage of the larger value, i.e., $\frac{\text{Denver } \bar{x} - \text{INCAP } \bar{x}}{\text{Denver } \bar{x}} \times 100$.

TABLE 4

Rural Guatemalan Ladino boys: percentiles for weight (kg)

Age	n	Percentiles						
		3	10	25	50	75	90	97
15 days	118	2.3	2.7	3.1	3.3	3.7	3.9	4.2
3 months	207	3.8	4.5	5.1	5.7	6.0	6.4	6.8
6 months	195	5.0	5.7	6.3	6.9	7.4	7.9	8.5
9 months	190	5.4	6.3	6.9	7.6	8.1	8.5	9.2
12 months	189	5.7	6.6	7.3	8.0	8.5	9.2	9.5
15 months	185	6.3	7.2	7.8	8.5	9.1	9.6	9.9
18 months	179	7.0	7.6	8.2	9.0	9.6	10.1	10.5
21 months	166	7.5	8.1	8.8	9.4	10.1	10.7	11.1
24 months	182	8.2	8.7	9.4	10.0	10.7	11.4	12.1
30 months	165	9.2	9.7	10.5	11.2	11.8	12.4	13.1
36 months	168	10.0	10.6	11.5	12.2	12.7	13.5	14.3
42 months	166	10.9	11.7	12.4	13.2	14.0	14.7	15.3
48 months	160	11.3	12.4	13.0	14.1	14.8	15.8	16.6
60 months	145	12.5	13.8	14.4	15.4	16.6	17.3	18.2
72 months	128	14.1	14.8	15.7	16.8	18.0	18.8	19.8
84 months	118	15.7	16.3	17.5	18.5	19.8	20.7	21.9

TABLE 5

Rural Guatemalan Ladino girls: percentiles for weight (kg)

Age	n	Percentiles						
		3	10	25	50	75	90	97
15 days	108	2.2	2.6	2.9	3.2	3.5	3.8	4.1
3 months	166	3.6	4.2	4.6	5.1	5.6	5.9	6.7
6 months	159	4.8	5.4	6.0	6.5	7.0	7.7	8.4
9 months	161	5.2	5.9	6.5	7.2	7.6	8.1	8.9
12 months	153	5.6	6.1	6.8	7.6	8.1	8.8	9.2
15 months	147	5.5	6.5	7.1	8.0	8.6	9.1	9.7
18 months	153	6.2	7.0	7.5	8.4	8.9	9.5	10.4
21 months	137	6.7	7.3	8.0	8.7	9.4	10.0	10.4
24 months	142	7.0	7.7	8.4	9.2	9.9	10.5	11.3
30 months	149	7.7	8.7	9.4	10.3	11.2	11.9	12.5
36 months	147	9.0	9.8	10.5	11.4	12.3	13.2	13.7
42 months	147	10.2	11.0	11.6	12.4	13.3	14.4	14.9
48 months	147	10.7	11.6	12.3	13.3	14.4	15.4	16.1
60 months	150	12.0	12.9	14.0	15.1	16.2	17.6	18.1
72 months	136	13.4	14.5	15.4	16.4	17.7	19.1	20.0
84 months	120	15.2	15.9	16.9	17.9	19.0	20.1	21.7

(and not proteins) are limiting. This is the subject of a paper now in preparation.

The health care and supplementation program which was recently introduced into the four villages under study make the present sample unique in rural Guatemala. But because of Guatemala's geographic, climatic, and agricultural diversity, it is not clear that any village could be said to be typical of all rural Guatemalan children. The present sample yields slightly larger heights and weights than previously reported data for rural Guatemalan children (INCAP/ICNND, '71).

Since the medical care provided to the villagers has reduced the previous high mortality and morbidity figures to values which approximate those of developed countries in the late 1930's, we believe these data are typical of the growth of children in clinically good health but with suboptimal nutrition. They are useful as a base of comparison or clinical screening in populations with prevalent undernutrition. This is because in undernourished populations, the distribution of heights and weights are essentially below the bottom percentiles of standards from the developed world. Of course, either height or weight will do for population comparisons.

Since the ease of obtaining one or the other varies with field conditions, we present age specific percentiles for both length and weight in tables 2 through 5. It remains for someone to present distribution from severely malnourished populations. This would permit evaluation both of populations and of individuals within populations — without recourse to inappropriate expressions such as "percent retardation."

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