

# SEX DIFFERENCES IN RETARDATION OF SKELETAL DEVELOPMENT IN RURAL GUATEMALA

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**ABSTRACT.** This is a cross sectional study of the cortical thickness of the second metacarpal as judged from radiographs of the hand and wrist of 1,409 children under 7 years of age (691 boys and 718 girls) from a rural area of Guatemala. The data were compared with standards of United States children. All the films were read by the senior author. It was found that after reaching the age of 2 years the cortices of the boys were consistently

thinner than those of the girls. Both sexes had age-specific mean values which were significantly lower than those of healthy U.S. children of the same age. However, the boys lagged further behind the U.S. standards than did the girls, and this difference in retardation between the sexes was significant.

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THE ingenious animal experiments of McCance *et al.*<sup>1-3</sup> in which he and his colleagues maintained young animals, which normally would have been growing rapidly, at a constant weight, have taught us much about physical adaptation to starvation. Among their findings is the observation that the pig and the fowl under these circumstances form a cortex in their long bones which is dense but considerably thinned. The net effect was a reduction of calcium content of each bone as a whole. Acheson and MacIntyre<sup>4,5</sup> using a different

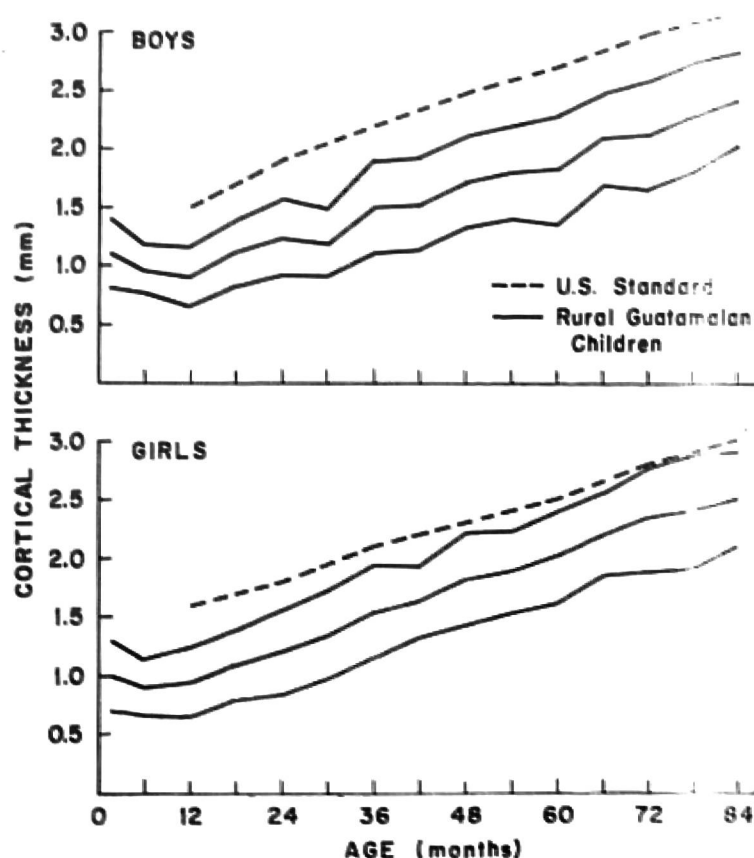


FIG. 1. Means  $\pm$  1 standard deviation for cortical thickness in Guatemalan children by age and sex compared with means for U.S. children.<sup>9</sup>

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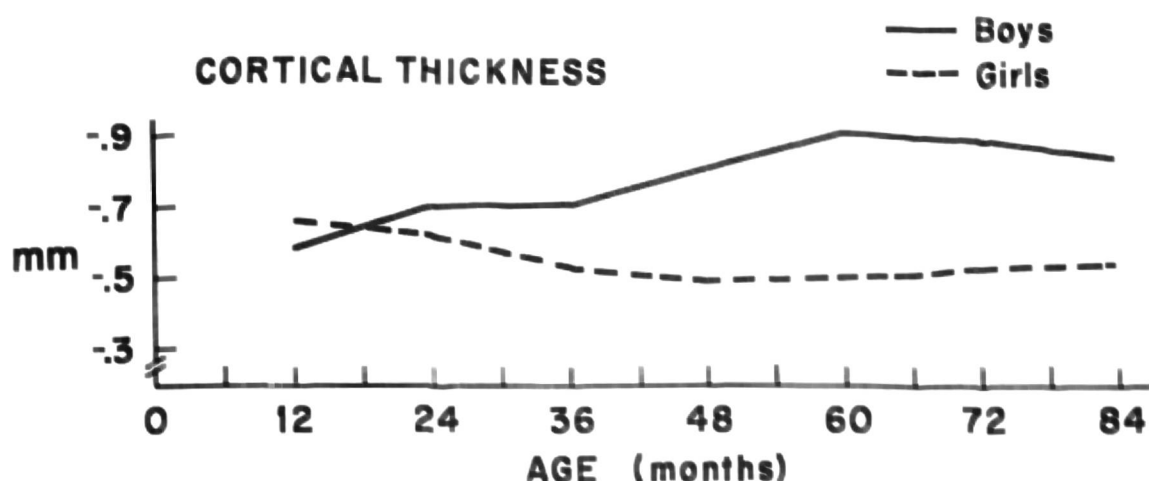


FIG. 2. Differences between the values observed in the present study population for cortical thickness and the sex-specific standards described in the text.<sup>9</sup> It can be seen that the lag is greater in boys than girls.

experimental approach to that of McCance made parallel findings in the rat.

There have been many attempts to measure calcium content of bone from the density of the shadow it casts on a radiographic plate, but because of a large number of uncontrollable factors these have proved to be unsatisfactory. Another approach has been to measure the width of the cortex of the metacarpal from radiographs of growing children. This technique has been used extensively by Garn and his co-workers,<sup>6-9</sup> who have published data from their longitudinal studies of a small population of children living in Southern Ohio. They have compared these with groups of children, the methods for the selection of which is unspecified, from a variety of countries in Central America, and have shown that their cortices tend to be thinner than those of the U.S. children.<sup>8</sup> Subsequently, Salomón *et al.*<sup>10</sup> have shown that cortical thickness relates well to hydroxyproline-creatinine ratio (the less cortical thickness the lower hydroxyproline-creatinine ratio) which Whitehead<sup>11</sup> has shown to be a good biochemical index of malnutrition.

In this paper we present data collected from children from a defined area of rural Guatemala. The group is large enough to permit detailed comparison with the American norms on an age- and sex-specific basis.

## MATERIAL AND METHODS

The sample consists of 1,409 children from nine Guatemalan rural villages. Ages of the 691 boys and 718 girls, confirmed in

the Local Civil Register, ranged from 0 to 84 months. They were studied cross sectionally. A radiograph was taken of the left hand and wrist, with portable equipment,<sup>\*</sup> using a tube-film distance of 91.4 cm. and directing the central ray towards the distal end of the third metacarpal. The same brand of film was used throughout the study. All the films were read by the senior author and the data were recorded on pre-coded forms. Cortical thickness was measured in the midpoint of the second metacarpal with a Helio's caliper graduated in 0.05 millimeters.

The data are presented by sex in six-month age groups, with the exception of the youngest children in whom the age range went from 0 to 2 months for both sexes.

## RESULTS

Table I shows the age-specific groups with the number of children in each group, and mean and standard deviations for cortical thickness and for age.

It can be seen that for the first two years of life there is no difference between the mean cortical thickness of the two sexes. Through the rest of the age range studied, the boys show a consistent tendency to have thinner cortices. That this cannot be sampling differences by age can be concluded by the close similarities between the mean ages in each group.

The differences between cortical thick-

\* General Electric.

TABLE I  
CORTICAL THICKNESS BY AGE AND SEX FOR THE GUATEMALAN RURAL CHILDREN

Range in Months	Boys					Girls				
	Age		Cortical Thickness*			Age		Cortical Thickness*		
	N	$\bar{X}$	SD	$\bar{X}$	SD	N	$\bar{X}$	SD	$\bar{X}$	SD
0-2	6	1.2	0.4	1.09	.31	10	1.8	0.4	0.99	.28
3-8	66	5.2	1.6	0.95	.22	69	5.8	1.4	0.90	.24
9-14	61	11.4	1.7	0.90	.26	57	11.4	1.6	0.95	.29
15-20	53	17.9	1.7	1.09	.29	37	17.2	1.7	1.10	.33
21-26	35	23.7	1.7	1.23	.36	37	23.0	1.7	1.20	.35
27-32	39	29.9	1.7	1.19	.31	59	29.5	1.6	1.36	.37
33-38	59	35.7	1.7	1.50	.38	50	35.9	1.4	1.57	.38
39-44	57	41.4	1.6	1.53	.38	46	41.2	1.6	1.63	.29
45-50	49	47.3	1.5	1.71	.39	53	47.9	1.4	1.82	.38
51-56	43	53.7	1.6	1.80	.46	69	53.3	1.7	1.88	.34
57-62	60	59.6	1.7	1.82	.41	54	59.6	1.7	2.02	.40
63-68	42	65.7	1.6	2.10	.46	63	65.2	1.8	2.19	.36
69-74	48	72.0	1.7	2.13	.38	51	71.4	1.7	2.35	.44
75-80	39	77.3	1.7	2.30	.47	34	77.7	1.7	2.40	.50
81-86	37	82.4	1.5	2.44	.41	29	83.1	1.6	2.50	.39
Total	691					718				

\* Cortical thickness in millimeters.

ness in our sample and that in a well-nourished population of U.S. children<sup>9</sup> is shown in Figure 1. Unfortunately, no data from healthy children under 1 year of age were available. By then the Guatemalan children already show retardation in other anthropometric measurements,<sup>12,13</sup> and at 12 months, Guatemalan children of both sexes already differ from the standard, and to the same extent. Subsequently, the boys lag further behind than the girls and show their maximum difference at 60 months. In contrast, girls decrease their difference from the standards and from age 36 months until age 84 months the difference remains constant (Fig. 2). When the lags from the norm for boys were compared with those from the norms for girls, the difference was found to be significantly different ( $t = 4.458$ ,  $p < 0.001$ ). Boys thus seem more affected than girls in the development of the cortices of the short bones of their hands.

#### DISCUSSION

In Guatemala, as in developing countries in general, the average length and weight

of children at birth are close to the values for North American children.<sup>14-17</sup> There is no reason to believe that there are not equally close similarities for cortical thickness. The majority of other studies offering such comparisons indicate that adverse effects of environment on height, weight, and skeletal maturation tend to be more marked in boys than in girls. This study provides further evidence of that tendency. It is reasonable to assume that in man, as in the pig and fowl, an increase in the density of the bony cortex in response to undernutrition occurs simultaneously with the thinning of the cortex shown here and by others.<sup>9</sup> Thus, adaptation to an unfavorable environment is much more complex than a differential economy in the formation of new tissue. Therefore, the extent to which the adjustment differs between the sexes in bone composition and in other studies of physical development, is of considerable interest.<sup>18-20</sup>

#### SUMMARY

Cortical thickness of the second metacarpal was measured in radiographs of hand



and wrist of 1,409 children under 7 years of age (691 boys and 718 girls) from a rural area of Guatemala. All the films were read by the senior author. It was found that after the age of 2 years the cortices of the boys were consistently thinner than those of the girls. Both sexes had age-specific mean values significantly lower than those of healthy U.S. children of the same age. However, the boys lagged further behind the U.S. standard than did the girls, and this difference in retardation between the sexes was significant.

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