Poverty and Stature in Children

*Reynaldo Martorell, †Fernando Mendoza, and †Ricardo Castillo

*Food Research Institute, Stanford University, and †Department of Pediatrics, Stanford Medical School, Stanford, California 94305

The variation in stature among the people of the world is evident to us all. Throughout the years, numerous hypotheses have been advanced to explain differences in stature among populations. Some researchers have postulated that the differences are genetically determined, being the result of adaptations over time to particular climatic or environmental conditions. Other researchers have attributed large explanatory roles to the effects of poverty, namely, malnutrition and infection.

Most investigators would agree that both genetic and environmental factors explain population differences in stature. What remains an issue is the relative importance of genetic and environmental factors at different stages of economic development. In studying the relative importance of genetic and environmental factors, young children must be considered separately from adolescents and adults, for very different answers may be obtained for each group. For example, growth potential may be similar in prepubescent children from around the world, yet adult size may vary because of genetically determined differences in the timing and/or intensity of the adolescent growth spurt.

The main purpose of this chapter is to argue that population differences in stature in young children from around the world are more a reflection of poverty than genetics. This is so because much of the Third World is wretchedly poor. Under these conditions, the explanatory role that can be ascribed to genetics is minor. Conversely, as economic development takes place, the effects of poverty on stature diminish, and genetic explanations acquire greater prominence.

There are four lines of evidence that may be examined with regard to the relative importance of genetic and environmental determinants of stature (Table 1). Although this is not an exhaustive list, a wealth of data exists for all selected approaches. First, secular trends in stature in industrialized nations may be considered, and in this situation, the general assumptions are that genetic endowment remains unchanged while environment changes, generally from poor to better. Second, the stature of socioeconomic groups belonging to the same ancestry group may be examined. In making these comparisons, researchers usually assume that genetic endowment is unrelated to poverty and interpret differences that may be
TABLE 1. Some approaches for understanding the relative importance of genetic and environmental factors as causes for population differences in stature

<table>
<thead>
<tr>
<th>Type of data</th>
<th>Assumption</th>
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<tbody>
<tr>
<td>1. Secular trends in stature in industrialized nations</td>
<td>1. Genetic endowment is constant; hence, trends reflect stature at different stages of economic development</td>
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<tr>
<td>2. Stature of groups classified by poverty indicators in specific populations</td>
<td>2. Genetic endowment is unrelated to poverty; hence, differences among groups reflect the effects of poverty</td>
</tr>
<tr>
<td>3. Stature of populations of varying ancestry living in adequate socioeconomic conditions</td>
<td>3. Well-to-do environments allow for the expression of genetic potential; hence, the differences among groups are a reflection of genetic causes</td>
</tr>
<tr>
<td>4. Epidemiological and experimental studies of the effects of diet and infection</td>
<td>4. Direct assessment of effects are possible through appropriate study designs and data analysis</td>
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found in stature as reflections of poverty. Third, the statures of children of different ancestry or ethnic origin who are growing up under adequate environments may be compared to each other. To the extent that well-to-do environments allow for the expression of genetic potential, differences observed among groups can be said to reflect genetic factors.

In this chapter, we emphasize the three lines of evidence mentioned above. Other chapters in this volume deal with a fourth area, namely, the effects of infection and diet on linear growth. These chapters complement the present one because they provide information on the mechanisms through which poverty affects stature and adds to the persuasiveness of the data reviewed here.

SECULAR TRENDS IN STATURE

There are now considerable data from Europe, North America, and Japan documenting that children and adults are taller today than in the past. The differences observed are larger for children than for adults because maturity has been affected as well. Menarche is reached 2 to 4 years earlier; final adult size is also reached earlier, by 17 to 18 years of age instead of during the mid-20s (1).

To illustrate the magnitude of these changes, data from 19th-century British children who worked in factories are plotted on National Center for Health Statistics (NCHS) curves in Fig. 1. These curves are widely used as reference data (2). The 19th-century data are from Tanner (1) and were collected in 1833 as part of government surveys of the conditions of working children. These data are illustrative of some of the poorest, most deprived sectors of British society in the 19th century. There are several important points. First, the children are very small by modern standards, as mean values are below the NCHS fifth percentile. Secondly, the sample examined was already small at 9 years of age; in fact, its position rela-
The 1833 British children had heights similar to those that we see today in the poorest areas of developing countries like India and Guatemala.

There are two general types of explanations for secular changes. The genetic hypothesis argues that the breakdown of small, isolated breeding populations as a result of increased social and geographic mobility produced the phenomenon of heterosis or hybrid vigor; increased stature is one of its manifestations. This hypothesis has not received much support in the literature because hybrid vigor, even in rapidly evolving multiracial societies such as Hawaii, does not appear to exist in humans, certainly not to the extent observed in animals (3,4). This leaves environmental explanations the most favored. No one can deny that dramatic changes have taken place in industrialized countries with respect to environmental sanitation, rates of infection, and food consumption. It is also evident that life for the poor in 19th-century Europe had many of the same adverse features that characterize life for the poor in developing countries today. It is for this reason, we believe, that the size of yesterday’s British children is like that of today’s children from developing countries.

**POVERTY AND STATURE**

There are many studies in the literature that show that within particular societies, stature is associated with indicators of wealth such as land, income, and occupation. Some examples are necessary here to show that the magnitude of the differences associated with socioeconomic levels is very large.
POVERTY AND STATURE IN CHILDREN

Honduras Study

One example comes from Honduras, one of the poorest countries in the western hemisphere. As part of a larger investigation, about 1,000 children less than 7 years of age, in an area largely devoted to subsistence agriculture, were measured between December, 1981 and March, 1982 (5). Standard techniques were used to measure length, weight, head circumference, arm circumference, and triceps and subscapular skinfolds. Subroutines available from the Centers for Disease Control (CDC) were used to generate z scores; these subroutines use NCHS data as reference. We also collected data on simple measures of wealth including characteristics of the home and possession of tools, work animals, appliances, and machines. One of the simplest yet most informative indicators that resulted from these data is the house score (Table 2). Three items make up the score: the presence of a separate kitchen counts as one point; a separate bedroom also gets one point; and a floor other than a dirt one also counts one point. Consequently, the house score can range from 0, which would be a one-room hut with a dirt floor, to 3, a score corresponding to a larger home with a wooden or cement floor.

The first column of numbers in Table 3 shows the simple correlations between the house score and a number of anthropometric variables. The house score was most highly related to z-scores in height and weight and least associated with the weight-for-height z scores. In this sample, height z scores and weight-for-height z scores were unrelated ($r = 0.02; n = 985$). Other socioeconomic indicators were also related to the anthropometric variables, but, as might have been expected, a great deal of the variance explained by the socioeconomic indicators was shared and not unique. This is suggested by the multiple correlations that are shown in the second and third columns of numbers. These involve, respectively, the house score and three other socioeconomic scores in column 2 and the house score and six other scores in column 3. Very little additional variance is explained by including more socioeconomic variables in the case of height and weight z scores. In contrast, the correlations involving the arm variables do increase as more socioeconomic variables are considered. With the single exception of weight-for-height z scores, these simple indicators of wealth have multiple correlations of around 0.26 and thus account for a little less than 7% of the variance.

A population taller than the NCHS reference population would have an average z score that is positive. A population similar to the NCHS reference data would have an average z score of 0. Growth-retarded populations would have negative z scores. The statistical and biological strength of the relationship between the house score and the z scores for height is clear as shown in Fig. 2. Honduran children

<table>
<thead>
<tr>
<th>TABLE 2. House score components</th>
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<tbody>
<tr>
<td>Separate Kitchen</td>
</tr>
<tr>
<td>No = 0</td>
</tr>
<tr>
<td>Yes = 1</td>
</tr>
<tr>
<td>Separate Bedroom</td>
</tr>
<tr>
<td>No = 0</td>
</tr>
<tr>
<td>Yes = 1</td>
</tr>
<tr>
<td>Type of Floor</td>
</tr>
<tr>
<td>Dirt = 0</td>
</tr>
<tr>
<td>Other = 1</td>
</tr>
</tbody>
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TABLE 3. Correlations between indicators of socioeconomic status and anthropometric variables (n = 940)

<table>
<thead>
<tr>
<th></th>
<th>House</th>
<th>House and 3 other scores*</th>
<th>House and 6 other scores*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height z score</td>
<td>0.245&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.241&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.258&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight z score</td>
<td>0.215&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.221&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.233&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight/height z score</td>
<td>0.048</td>
<td>0.094</td>
<td>0.111</td>
</tr>
<tr>
<td>Arm muscle area</td>
<td>0.106&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.175&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.247&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arm fat area</td>
<td>0.098&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.166&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.259&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arm circumference</td>
<td>0.120&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.199&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.292&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*House and appliances and machines, agricultural tools and work animals, type of iron.

**House and appliances and machines, agricultural tools and work animals, type of iron, type of house lighting, other house characteristics, field workers' impression of the house.

<sup>p < 0.001.</sup>  
<sup>d p < 0.01.</sup>

FIG. 2. Relationship between quality of the house and height z scores in preschool children from rural Honduras, (n = 940, p < 0.001).
are very retarded because they have very negative $z$ scores. The $z$ scores for height were $-2.68$ for a house score of 0, $-2.05$ for a house score of 1, $-1.82$ for a house score of 2, and $-1.21$ for a house score of 3 ($p < 0.008$). Adjusting for age, sex, and locality by analysis of covariance had little effect on the results.

These data from Honduras show that measures of stunting but not wasting are closely related to socioeconomic status and point out that the magnitude of this association is large. It is possible that, in a mestizo society such as Honduras, the proportion of Spanish/Indian ancestry varies with socioeconomic status and therefore that the differences we find among groups might be equally said to reflect ancestry. We do not consider this a credible explanation because the Honduran sample is composed of only rural children and because the variations in socioeconomic status are subtle and not marked as when one compares children from the elite urban classes and the rural poor.

Social Class and Stunting in a Number of Countries

Martorell (6) compared the heights of 7-year-old children of high and low socioeconomic class children from a number of countries. Figure 3 summarizes this work, which incorporates data from Brazil (7), Costa Rica (8), Guatemala (9–11), Jamaican black children (12,13), Nigeria (14,15), India (16), and Hong Kong (17). The NCHS percentiles and the corresponding $z$ scores are shown on the right to facilitate comparison.

Two aspects are clear. First, there are large differences associated with social class, with some countries such as India and Guatemala showing a greater differential than others such as Brazil and Costa Rica. The simplest explanation for these consistent differences is that they reflect the consequences of poverty. However, we know that in some countries, the elite groups may differ somewhat in ancestry from the very poor. Guatemala is a good example. The very poor have a greater degree of Indian admixture than the elite classes. Could the differences we see here result from genetics and not poverty? We do not think this is a likely explanation because it would have to operate in the same direction in every situation, an unlikely event. The second aspect that Fig. 3 makes clear is that differences among high-socioeconomic samples are not that large, as most groups have means that are near the 50th percentile of the NCHS curves.

COMPARISONS OF WELL-TO-DO CHILDREN FROM AROUND THE WORLD

A closer examination of this last issue is presented in Fig. 4, which shows the mean heights of samples of 7-year-old children from industrialized countries and from the highest socioeconomic groups of developing countries. The European studies are those carried out in Czechoslovakia (18), Germany (19), Switzerland (H. Budliger and A. Prader, unpublished data), and England (20) under the coor-
FIG. 3. Mean heights of 7-year-old boys of high (•) and low (○) socioeconomic status. (Adapted from Martorell, ref. 6.)

FIG. 4. Mean heights of samples of well-off 7-year-old boys of various ethnic origins. (Adapted from Martorell, ref. 6.)
ordination of the International Children’s Center. These European data, as well as most of those for other areas, are conveniently summarized in tabular form in the work of Eveleth and Tanner (14). The North American data come from major longitudinal studies at Berkeley (21), Boston (22), Cleveland (23), Denver (24), Iowa (25), and Ohio (26). The studies selected from Latin America, as well as those from other developing countries, are those carried out among the countries’ elites and represent Brazil (7), Guatemala (9, 10), Costa Rica (8), and Puerto Rico (27). The children of African origin are represented by samples from Nigeria (14, 15), Haiti (28), Jamaica (12, 13), and five studies of black children from the United States (29–34). The Asian group includes samples from Taiwan (35), Hong Kong (17), Jamaica (12, 13), Japan (14), and the United States (36, 37). The Indian sample is from Hyderabad (16). Presumably, growth and development of children in the samples just cited are not limited by malnutrition and disease but are instead a reflection of genetic differences. This assumption may be incorrect because cultural differences produce dissimilar infant-feeding and child-rearing practices. The importance of this consideration is illustrated by studies of the growth of bottle-fed and breast-fed infants in middle-class families from the United States. Although not enormous, differences of the order of 10 or more percentile points for length in favor of bottle-fed infants have been reported (38).

A second issue to consider in interpreting Fig. 4 is whether the growth of the elite classes is still free from the growth-retarding effects of poverty on previous generations. Small maternal body size, it is known, influences the growth of the next generation. It is said that the secular trend has run out of steam in the United States. It is said also that the new generation of Japanese is the tallest ever and that the secular trend has slowed down considerably (36, 39). These findings suggest that at least for some of the groups in Fig. 4, the phenomenon of secular trends should not be a major disturbing element.

In spite of the above caveats, the message in Fig. 4 is simple and clear. With the exception of the group designated as “Asians,” the mean heights of samples of diverse ethnic origins center around the 50th percentile. For Asians, the central tendency is near the 25th percentile, equivalent to −0.67 standard deviations below the median. In absolute terms, Asian children are shorter than the NCHS 50th percentile by about 3.5 cm. The data on Asians refer to samples of Japanese and Chinese origin living in Asia as well as in the Americas.

There are obviously many gaps in Fig. 4. For example, the Latin American samples do not include groups of American Indian ancestry. The reason is that, to our knowledge, there are no American Indian populations of well-to-do status, a sad reality. Though other data about Chinese children growing up in London (40) and Korean children in Japan (41) corroborate these findings, data from many other Asian countries are not reviewed. There are also no samples of well-to-do children from New Guinea, and many other exceptions as well. As we fill in the picture, we may discover well-to-do populations with similar or even smaller heights than the Japanese and Chinese. Until we do, the maximal difference in stature at ages 5 to 7 that can be ascribed to genetics is of the order of 3.5 cm. Poverty, on the other hand, can result in populations 12 cm (or more) shorter.
POVERTY AND GROWTH IN THE UNITED STATES

We have advanced the hypothesis that as economic development takes place, the role of genetic factors as explanations for population differences in stature increases. We have used cross-sectional data derived from two surveys carried out by the United States National Center for Health Statistics, HANES I and HANES II, to test this hypothesis. In Fig. 5, height z scores are presented for three age groups: 1 to 5, 6 to 11, and 12 to 17 years. Three ethnic groups are represented: Blacks, Europeans of non-Hispanic origin, and Hispanics, a group of Spanish/American ancestry. The data are presented for three poverty levels defined in terms of an index that relates income to the cost of living and adjusts the results by family size, 1 being the definition of poverty often used by the government.

Data for children 1 to 5 years old are given in the first panel of Fig. 5. Poverty is related to size in all groups, but the differences are small. For instance, the 25th percentile is equivalent to a z score of $-0.67$, and only one group approaches this level. Blacks are taller than Europeans and Hispanics at early ages. This is well known, and, in fact, Garn and Clark (42) have argued for separate growth standards for blacks, a plea that has gone unanswered because the differences are perceived as too small to consider. Another important point to emphasize is that

![Figure 5](#)

**FIG. 5.** Height z score by age, poverty, and ethnic group (B, Black; E, European; H, Hispanic). Lower-case letters refer to statistically significant t-tests ($p < 0.05$) as follows: a, Hispanic vs. Black; b, Hispanic vs. European; c, Black vs. European).
preschool Hispanics in the high-income group have average z scores nearly equal
to 0, just as Europeans of non-Hispanic origin do.

Data for 6 to 11 years of age reveal the same basic picture as for 1 to 5 years.
For 12 to 17 years, the differences are striking. Blacks become indistinguishable
from Europeans, whereas Hispanics become smaller at all income levels.

The pattern in Hispanics is consistent with data from Guatemala (9,10). A care-
ful study of two cohorts growing up in Guatemala, one with Guatemalan parents
and grandparents and one with European or North American parents, revealed ide-
tical growth patterns in both cohorts prior to adolescence. Youths of Guatemalan
origin had growth spurts of less intensity than their "foreign" playmates and fell
to the 25th percentile at the end of the adolescent growth spurt, a level similar to
that seen in U.S. Hispanics. For Hispanics, at least, genetic factors may be more
important in adolescence than earlier as explanations for adult differences in
stature.

Adolescents generally have healthier lives than younger children in poor socie-
ties. Access to food and food consumption are better, and rates of infection are
very low. According to Eveleth and Tanner (14), adolescent growth rates are not
markedly different in a variety of settings, and often differences are not larger than
the 3 to 4-cm difference observed between wealthy children of Guatemalan and
non-Guatemalan ancestry. An interesting study from India showed that increments
from 5 to 17 years were similar in Indian children when compared to the NCHS
pattern (43). The shorter stature of the Indian youths was largely the result of
events prior to 5 years of age.

SUMMARY AND CONCLUSIONS

There are many interesting aspects to consider regarding adolescent growth, but
our main concern is with preschool children. Figure 6 summarizes the following
information:

1. The first four bars refer to the relationship between characteristics of the home
and height z scores of children from rural Honduras (Fig. 2).
2. The last three bars refer to the relationship between the poverty index and
height z scores in U.S. Hispanic children at ages 1 to 5 years (Fig. 5).

This figure summarizes the major points of this chapter. Where the level of so-
icioeconomic development is low, we can expect stature to be heavily influenced
by poverty, as in Honduras. At this level of development, the environment looms
much larger as an explanation for population differences in stature than is the case
for genetics.

As the level of socioeconomic development rises, the environment becomes less
and less a factor limiting growth in stature. At this stage, it becomes easier to
establish the extent to which genetics plays a role in explaining differences in stature
among populations. For example, the information in Fig. 6 shows very clearly
that preschool children of Hispanic origin should be expected to grow in stature
as in the NCHS reference curves. Earlier we mentioned that American blacks are expected to be slightly taller than the NCHS average but that this difference is too small to be concerned with.

In the case of Japanese and Chinese children, one would expect them to be smaller than the NCHS average, and many would attribute this difference to genetic factors. However, it may be that differences in infant-feeding practices between eastern and western cultures are part of the explanation for the differences in stature. It is also possible that the secular trend in western nations has all but stopped but that it will still continue in eastern nations and that eventually average heights will be somewhat increased.

These are interesting possibilities, but instead let us take the conservative position that all of the difference in stature between European, Chinese, and Japanese samples is a reflection of genetic origin. Then we would have a situation in which the largest difference in stature attributable to genetics is 3 to 4 cm, which would make average heights at age 5 to be near the 25th percentile of the NCHS norms. This difference is no longer trivial. However, it is many times smaller than what we can easily attribute to poverty in many populations.

We lack data about the stature of well-nourished children in many parts of the world. In many areas these data may underestimate growth potential, as several
generations may be required for the effects of poverty to be removed (i.e., until the secular trend toward increased height ceases). As we collect more data, we will be able to document more clearly that genetic factors explain population differences in stature. We would be very surprised, however, if the effects we find turn out to be much larger than what we can maximally attribute to genetics by comparing European, Chinese, and Japanese children.

From what we know to date, we can clearly say that the growth potential of children from around the world is remarkably similar under conditions of adequate nutrition and health. Retardation in stature as a result of marked poverty is easy to demonstrate, and these effects are far greater than those we can possibly attribute to genetics. Stunting, we can say with confidence, is one of our best measures of social inequality. We know that its causes are deeply rooted in malnutrition and infection during the period of weaning. Thus, let us not go astray by hinging policy implications on the functional significance of stunting. Even if stunting proved to be largely harmless, let us keep in mind how children become stunted. Those who are prepared to argue that stunting has no policy implications must be prepared to defend social inequalities in income, diets, and the level of health.

ACKNOWLEDGMENTS

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DISCUSSION

Dr. Waterlow: I would like to start by referring to your Fig. 1, on the height of children in Stockport in 1833. At that time the U.K. was a developing country. Nevertheless, we had good statistics even in those days, and it is interesting to recall that at that time, as reported in the very first volume of the Lancet, about 300 children per 1,000 born failed to reach the age of 5 years (1). What is striking to me is the enormous mortality in relation to what I would have thought was a rather small degree of stunting.

Dr. Martorell: Modern public health measures may be part of the answer. However, I think the level of stunting was quite high and in fact similar to what is observed today in many developing countries. It is interesting that the key indicator used by those concerned with child welfare in the U.K. at that time, when investigating the condition and quality of life of working children, was height. This is similar to what we do today.

Dr. Guesry: Could you not say that the difference in heights of British children 150 years ago and now represents a secular trend, as has been seen in Japan?

Dr. Martorell: That may be a way of describing it, but let me emphasize that secular trends are caused by environmental factors. The evidence from the United States and from a number of European countries is that since the 1960s secular trends in stature have ceased, and it seems that today’s young people in many of the advanced countries are probably as tall as any future generation ever will be. Nevertheless, there is still a relationship between poverty and stature, as shown in Fig. 5. The same relationship is found in England. The only societies that I know of in which there is no correlation between social class and growth are Scandinavian countries such as Sweden. Presumably, if one had a classless society all the children would grow optimally.

Dr. Guesry: In your Fig. 5 it seems that the first two groups, from 1 to 5 and from 6 to 11 years, belong to the same study and the third sample, from 12 to 17 years, belongs to another study. Is it possible that the differences observed were caused by some nutritional changes during the last 15 years in all ethnic groups in the United States?

Dr. Martorell: You may be quite right. However, this figure is based on data from HANES I and II, which were separated by a number of years, but there is no evidence of a secular trend in stature during that interval. If there had been a secular trend, one would have observed changes, particularly in the Hispanic group at ages 12 to 17 years, in which body sizes are consistently smaller.

Dr. Nabarro: Is the slope of the relationship between poverty and stature the same in all ethnic groups?

Dr. Martorell: Surprisingly, yes. The regressions predicting stature from poverty have similar coefficients.

Dr. Waterlow: What is the correlation coefficient? How much of the variance is explained?
In the studies shown in Fig. 5, the correlation coefficient is 0.1 to 0.15, not very high but significant because the samples were very large—thousands of children. In the Honduras sample, to give another example, the correlation between quality of housing and height was about 0.25.

Dr. Waterlow: Although in fact you have shown very clear relationships between these environmental factors and growth, the proportion of variance explained is very small.

Dr. Martorell: Yes, but I think that the percentage of variance explained can be misleading. A relationship can be very strong in biological terms even with a correlation as low as 0.25.

Dr. Mukherjee: We have conducted a longitudinal study of growth in the lower socioeconomic groups in Calcutta (2). We have found that even in the same socioeconomic groups, statistically highly significant correlations exist between growth and many environmental factors—nutrition, episodes of illness, sanitation, housing, size of the family, overcrowding, education, and maternal competence.

Dr. Martorell: That does not surprise me. In the final analysis, all these factors affect stature by limiting nutrient availability.

Dr. Waterlow: If I understood Dr. Mukherjee correctly, there were differences within his sample in spite of its being the same ethnic and socioeconomic group. You showed this very clearly within your Honduras sample.

Dr. Martorell: Yes, the sample of Honduran children belonged to the same ethnic group, and all were from the rural area. The differences in socioeconomic status that we identified are variations in what some call the microenvironment.

Dr. Aponso: It is not only poverty that determines the development of the child. My country, Sri Lanka, is one of the 12 poorest countries in the world. We all know that a high infant mortality rate (IMR) has been recognized not only as a yardstick of good health; it has been said to be an eloquent indicator of development. [Editor’s note: Infant mortality rates are deaths during the first year of life per 1,000 live births.] Now in Sri Lanka, per capita income is only US$ 300, and our IMR is 34; in the United States, where the per capita income is US$ 4,000, the IMR is about 10. But in Saudi Arabia, with a per capita income only a little less than that of the United States, they still have an IMR of around 100; Pakistan, on the other hand, which has a per capita income only a little higher than that of Sri Lanka, still has an IMR of around 80 or 90. This is why people talking about development no longer talk only about per capita income or only about IMR; they talk about the physical quality of life based on IMR, life expectancy, and literacy. The social environment, customs, and village traditions could be modified by literacy. I think this is where poor countries can do something about this problem of malnutrition; the physical quality of life can be influenced by literacy. I submit to you that this is very important in addition to housing.

Dr. Martorell: I agree absolutely with you; it is not only a question of level of national income but of distribution of the income, of provision of health care, and so on. Certainly Sri Lanka and a number of other countries are really exceptions: they have used their resources wisely.

Dr. Waterlow: I have always found it astonishing that in the last 10 years Sri Lanka has shown such a large reduction in IMR and preschool children mortality without any increase in income, even with a decrease.

In support of what Dr. Aponso said about literacy, it is worth recalling that in Cravioto’s study of a rural community in Mexico, the factors most clearly associated with good nutrition in the child were, as I recall, maternal literacy and listening to the radio.
Dr. Keller: In Sri Lanka a high correlation between IMR and female literacy has been found (3). It is the highest one can find. But there is a low correlation between IMR and stunting.

Dr. Waterlow: That is a very important point in relation to the efforts that are being made to develop a set of indicators of the quality of life.

Dr. Kraisid: I agree that poverty has to be defined at the microlevel as well as at the macrolevel. In the last 6 years we have had a national study on poverty and malnutrition in Thailand, in which we define poverty not only in economic terms, such as production per hectare of land, but also using a range of social indicators. These include prevalence of low birth weight and malnutrition: newborn babies in rural poor areas are 400 g lighter and 1.5 cm shorter than those born in Bangkok. At school age the difference in height is 10 to 15 cm. For 4 to 5 years now, the government has implemented “poverty eradication programs” in rural poor areas. The growth of children in terms of weight gain shows significant changes, and the prevalence of protein-energy malnutrition in children based on weight for age has also remarkably reduced from 51% to 30% (4). There were no data on height gain. Dr. Aree has done a study in one area in the northeast region where one of these poverty eradication programs was operating and showed that growth in weight and height showed little change until the program had been set up.

Dr. Waterlow: In this very intensive program, is there any relationship between indicators such as the nature of the house and more direct indicators of food intake and food availability?

Dr. Kraisid: Yes. When we looked at indicators such as soil quality, agricultural production, health statistics, social organization of people in clubs or groups, housing, or other indices of the quality of life, there was a good relationship between growth and housing conditions.

Dr. Keller: I want to warn against concentrating exclusively on one socioeconomic variable. The importance of housing as an indicator varies in different populations.

Dr. Martorell: This is good advice. However, in Honduras, the quality of the house is an excellent indicator of family resources and at the same time is easy to measure.

Dr. Milner: We have been discussing the interacting variables related to poverty. At the other end of the scale, in Western Europe today, the most common cause of stunting is probably psychosocial.

Dr. Rappaport: We have put emphasis so far on the effect of malnutrition on growth during the prepubertal period, but final height depends also on the pubertal growth spurt. Are you saying that during puberty nutrition is not important? There are some models that would not agree with that.

Dr. Martorell: Professor Waterlow referred to a very interesting Indian study (5) that showed that children who were short at 5 years were also short at 17 years. However, the amount of growth between 5 and 17 years was the same in short and tall children. This implies that adult stature in this area of India is determined by events before 5 years of age.

Dr. Waterlow: This is an important question. Is the growth that occurs at puberty affected differently from the growth occurring at earlier ages? This brings up the question of skeletal maturation.

Dr. Martorell: In Guatemala, mildly malnourished children are slightly retarded in biological age, so we would expect them to have some capacity for catch-up.

Dr. Waterlow: I was under the impression that maturation is less delayed than actual linear growth, so that it will be impossible to catch up completely once maturation is complete.
Dr. Davies: We have been discussing nutritional effects and secular trends in the growth of the skeleton, but there are also secular trends in head growth. British children have a head circumference about 1.5 cm greater than 25 years ago (6). Since an increase in head circumference of 1 cm is equivalent to an increase in intracranial content of approximately 20 to 30 ml, I wonder whether the brain size of children has also increased.

Dr. Martorell: You are right; there is a trend in head circumference, and maybe Dr. Colombo will comment on the possible significance for mental development.

Dr. Waterlow: Dr. Martorell has made a strong case for the overriding importance of environmental factors, summed up in the one word poverty, in determining linear growth, at least in young children. However, this does not entirely dispose of the genetic factor. As Monckeberg in Chile pointed out many years ago, some people may be poor because they are genetically less well endowed to cope with the problems of life. Hence, there would be a kind of indirect genetic selection for short stature.

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