

Growth and Socioeconomic Change

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For Meeting on Purpose, Use and Interpretation of Anthropometric Indicators  
of Nutritional Status

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## Growth and Socioeconomic Change\*

### 1. Introduction

The above title was assigned to us for this workshop. A purely descriptive paper by this title would miss the implicit objective of this workshop (A), namely "What inferences can be drawn from anthropometric data either about the need for interventions affecting nutrition in individuals or in populations, or for examining the effects of policies and programs so as to improve them."

No 15 page paper can cover that issue properly. We try nevertheless to focus on those characteristics of anthropometric indicators which are most important in arriving at inferences which will affect policies and planning. Therefore, we first review the evidence that certain growth variables, but not others, are associated with socioeconomic class and that these differences are probably due to differences in nutrition. We then examine for selected variables the likelihood that they will respond to changes in socioeconomic status, the degree of this responsiveness, and the rapidity with which one is likely to identify such response. We then discuss the implications of the findings for health and well-being. Finally, we touch upon some issues of sampling, appropriate parameters and the merits of continuous surveys. We have selected a few figures from the literature to present data where objective evidence for a statement may not be well-known, and we append writings which deal in more depth with certain statistical and epidemiological aspects of the issues brushed on in the paper.

At the outset it is crucial to be specific as to why "Not all anthropometric indicators are equally suitable for different purposes" (1).

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\*Footnotes are identified by letters; references by numbers. All are listed at the end of the paper.

which requires an examination of the uses to which the indicators are to be put. This examination (see "Indicators for identifying and counting the improperly nourished" (2) appended) reveals the need for different indicators for different purposes: e.g., identification of severe life-threatening malnutrition as opposed to less severe malnutrition (see "Anthropometric field methods: Criteria for selection" (3) appended, especially figure 1). Equally importantly this examination reveals that the parameter used (e.g. mean, prevalence) depends upon the inference one wishes to make from the parameter (see 2 appended). The inference dictates whether one is screening, estimating the prevalence of malnutrition (for what purpose?), monitoring changes in prevalence or ascertaining differences in prevalence between populations which in turn dictate the appropriate characteristics of the indicator and its parameter (B). The assigned title of this paper implies that one wishes to monitor anthropometry over time so as to infer whether or not socioeconomic conditions have changed. In this context one must identify which anthropometric variables are responsive to socioeconomic change. Very little work has actually followed changes in anthropometry over time with socioeconomic change. However, differences in anthropometry between socioeconomic classes at one time have been studied. The following section describes these differences, to lay the basis for considering response of different indicators to change in section 3.

## 2. Association of socioeconomic status and some commonly used anthropometric variables

### 2.1. Height and weight for age

Physical anthropologists usually lay great stress on genetic and climatic factors (4). However, a comparison of mean weight and <sup>in preschool children</sup> and

height among races living in different climates all of high socioeconomic class shows a much narrower variation (C) than does a comparison of populations of the same genetic stock living in the same climate but of different socioeconomic status standards

(5) (appended). Examination of the figures (1-4) in this paper (5) reveal that any variability due to genetic and climatic factors for height is about 1/5 (D), and for weight is about 1/4 smaller than is the variability across socioeconomic status within a same genetic stock living in similar climates. We conclude that in the usual environmental conditions of underdevelopment the effect of the environment is the overwhelming influence on the mean growth of preschool children.

In other words, all populations of preschool children have a similar mean weight and height growth potential within a narrow range (i.e. as found in elite groups in all populations studied) compared to the range of stunting effects due to the environment of the poor in developing countries. It is important to note that this statement about growth potential only applies to preschool children (E).

The next question is: Is the observed difference in attained weight and height growth related to socioeconomic status caused in part or in whole by differences in nutrition? If nutrition is defined as nutrients and energy utilized in the body, the answer appears to be unequivocally yes. The answer is supported by findings that poor preschool children show a response in weight and especially in height to food supplementation (see "Measurement of health and nutrition effects of large-scale nutrition intervention projects",

p. 156 (6) appended) (F). The role of diarrheal disease in stunting in poor populations is also now well substantiated (10). This stunting is not seen with the other common childhood diseases of upper respiratory and skin infections, whether with or without fever (8,9). Diarrhea affects growth primarily through reduced food intake and absorption, i.e., a nutritional effect. Diarrhea and inadequate food consumption are the most prevalent major influences unequivocally identified to date which explain the difference in growth between socioeconomic classes.

## 2.2. Weight for height

Comparison in (5) of figures 1 and 2 with 3 and 4 (appended) reveal discrepancies in the relative ordering of stunting in weight as contrasted to stunting in height. In particular, Indian preschool children are more deficient in weight relative to other populations than they are in height. A plot of weight and height of very poor and stunted two and three year old populations from Burundi, Guatemala (Santa Maria Cauque), Thailand and India (Bombay, Hyderabad, Jabalpur) shows that all the Indian populations mean weight for height fall at least one kilogram below the standard weight for height regression of the well-to-do (from figure 4 (11) appended). The Thai population is slightly less thin, and the Burundi and Guatemalan children are close to the normal weight for height. A similar lower weight for height difference is also seen between malnourished Fijians and Indians in Fiji (Virginia Yee M.P.S. thesis in progress). Does this difference represent a different genetic

response to malnutrition, or does it represent different kinds of malnutrition? What is certain is that at least one of the stunted populations with normal weight for height (see figure 4 from (11) appended) at a given age was malnourished as evidenced by a response to supplementation at that age (12,13). Because of the experimental design in this supplementation study (13) it was not possible to decide whether the major limiting nutrient was calories or protein. The Indian supplementation trials (reviewed in 6, appended) tend to indicate that calories are most limiting (although see 6 for some uncertainties in interpreting these trials). Thus one possible explanation of the difference between the Indian and other populations could be the limiting nutritional factor which stunts growth.

Another possible difference in nutrition might be that India populations might have many acute episodes of malnutrition with loss of weight followed by a recuperative phase--while the Guatemalan population might be more chronically malnourished so that weight and height are stunted together. Yet another possible explanation is that other concomitants of poverty determine the expression of the same kind of malnutrition. None of these possibilities has any evidence to support or reject them--a ripe area for unfounded theorizing and an opportunity for useful research--especially if the results reveal that different nutritional factors are limiting in different populations as we suspect.

### 2.3. Birthweight

Birthweight has also been suggested as a good measure of nutritional status associated with socioeconomic status (26).

There is little doubt that birthweight differs across socioeconomic status--however, the meaning of this difference is not clear yet (27). It is true that improved nutrition of calorie-malnourished women will increase the birthweight of their infants (14). However, other factors also affect birthweight (e.g. eclampsia, smoking) and these factors are also associated with lower socioeconomic status. The results of one study suggest that malnutrition might be the major influence on birthweight in one kind of malnourished community, where birthweight was 372 g below that found in well-nourished, upper socioeconomic class populations. Adequate energy supplementation during pregnancy apparently increased mean birthweight by about 116 g (14), and increased the median about 110 g (15). Variability in maternal height and prepregnancy weight explained three times as much of the variance as did the supplementation. If the maternal stunting and wasting seen in this population were due to malnutrition previous to pregnancy then correcting this malnutrition would presumably have made up the remaining deficit in mean birthweight of 256 g. The extent and quality of research relative to birthweight clearly needs improvement to substantiate such an extrapolation.

#### 2.4. Head circumference

Finally, growth in head circumference is very closely associated to growth in length during the first year of life. If growth in length is stunted during this period so is growth in head circumference. After one year the association between growth in length and head circumference decreases (16) (G).

3. Responsiveness and rapidity of response to socioeconomic change of some anthropometric indicators

Responsiveness is quantified by the ratio of the difference between better and less well fed groups over the pooled standard deviation within the groups. This ratio determines the power of the statistical test (H).

We have discussed some anthropometric measures which are different across socioeconomic groups and we have presented some of the evidence that inadequate dietary intake and utilization is the overwhelming contributor to the deficit in mean growth in poor populations, rather than other factors such as infections which do not affect dietary intake or nutrient absorption. This is true not only in populations which have low weight for height, but equally in populations in which weight for height is normal at all ages.

The fact that differences in dietary intake and utilization explain the differences in growth found between socioeconomic classes is extremely important when one addresses the issue of responsiveness to changes in socioeconomic conditions. The anthropometric indicators will only reflect (be responsive to) socioeconomic change if:

- a) That change results in a change in nutrition in the population (I)
- b) The magnitude of the change in nutrition is large enough in enough individuals to be picked up when one is looking at a population. Anthropometric change clearly is related both to overall socioeconomic changes and to the distribution of these changes within a population. For instance, the mean value, gross national product (GNP), may increase because a few are becoming

very wealthy or because everybody is becoming better off. In the former case no improvement in mean anthropometric indicators would be expected. In the latter a major improvement would be expected.

3.1. Responsiveness of height and weight for age

Are weight and height similarly affected by differences in SES? Comparing figures 1 and 2 with figures 3 and 4 in (5) shows that the ratio of the most extreme differences between SES to the most extreme differences between races is 5-6 for height and only 4 for weight. In fact, wherever the responsiveness of height and weight to changes in dietary intake have been investigated, height usually appears more responsive in populations. However, most of the studies in which one can have some confidence (see (6) for criteria of judgment) have been done in populations in which weight for height was normal. It would appear likely that weight for age would be more responsive in populations where weight for height is low, but that has not been substantiated.

If one needs information about changes in nutritional status which have occurred within the past year or two, one will choose ages where stunting (J) is usually greatest, e.g, somewhere between six months to two years of age. However, this age of greatest stunting should be investigated in each country to be sure. This is particularly useful because one will often find a rather narrow age range where responsiveness is likely to be at a maximum as judged by the ratio of the difference in height between the well-to-do and the poor divided by the standard deviation of height within these two groups.

If one can wait longer for the information, one can measure older children whose height reflects a stunting (e.g. in schools). One may wish to have quicker information--e.g., after a few months following a change in socioeconomic conditions. For this purpose incremental height (K) has been suggested and is probably more quickly responsive for equal sample sizes. However, experience has shown that the useful collection of these data is only possible in a research setting because it requires rigid quality control of the measurements, and, equally importantly, a very high unbiased follow up of a representative sample of children. This latter is to assure that the sample in increments is representative of the incremental growth in the population.

### 3.2. Responsiveness of weight for height

In malnourished populations with normal weight for height, this indicator will show no responsiveness to either differences in socioeconomic status or to changes in nutritional status. A comparison (figure 4 in (11) appended) shows no difference in weight at all heights from birth to seven years of age between stunted preschool populations in Guatemala and a U.S. standard. This population was stunted both because of a lack of nutrient intake (Martorell (13)) and because of diarrheal disease (10). Thus in this population weight for height was not responsive to differences in socioeconomic status in spite of the fact that stunting was nutritional in origin.

The responsiveness of attained or incremental weight for height in populations where weight for height is low has not been studied.

### 3.3. Birthweight

In one poorly nourished population (Guatemala) birthweight has been shown to be less responsive to nutrition ( $r^2=.13$ ) than is the attained growth of three-year-olds ( $r^2=.30$ , four years after an improvement in maternal and child nutrition (L). In this context, however, it is important to remember that a good proportion of the deficit in birthweight in malnourished populations is due to stunted maternal stature. That effect on birthweight will only change very slowly with improving nutrition of the population. Thus over the long range (a generation) it is probable that birthweight is a very responsive indicator indeed.

### 3.4. Head circumference

The responsiveness of head circumference is little studied (13). It may present an advantage over length during infancy. Changes in head circumference may also give insights in older children about changes in nutrition in infancy (16).

## 4. Growth as a proxy for health and well-being

In all the above considerations we have discussed the use of growth data in populations as a reflection of socioeconomic status, mediated through differences or changes in nutrition. In such a context there is no need to make a judgment about whether increased growth is good, bad or indifferent--it is simply a reflection of an absolute rise in income and/or a diffusion of income so that the population has an increased availability of nutrients and energy at the cellular level. Thus height is a useful summary indicator of

socioeconomic status. Whether or not that increase in availability is "good" depends on other considerations.

The general consensus among those who must actually decide on programs and policies is that better growth in a population is "good". This is because populations with faster growth in body size have less morbidity and mortality than populations of children who grow more slowly. The evidence shows that whatever putative ill-effects might follow from excessive height or weight due to environmental factors, these ill-effects must be minimal compared to the detrimental factors associated with poor physical growth. Some of these associated factors cause stunted growth, and are clearly detrimental in their own right: e.g., diarrheal disease and severe malnutrition. Other factors do not cause stunted growth in populations but are so similar in their determinants of the factors that do stunt growth that stunted growth can be used as a proxy for these non-stunting detrimental factors.

Among the factors which do not cause stunting in populations, some are not associated with stunting in individuals, e.g. upper respiratory and skin diseases. Some of them do cause stunting in individuals but are not of high enough prevalence to cause detectible stunting in populations--they do, however, cause morbidity and high mortality rates; e.g., tuberculosis, immunizable diseases of childhood. Until one can show that those detrimental factors can be disassociated and remedied independently of remedying those factors which offset physical growth one cannot claim that "stunted is as good as well-grown" which is implied by the statement that "bigger is not necessarily better" (19). The fallacy

of that statement is due to a lack of understanding that:

- a) It may well be that bigger of itself is not necessarily better, but the conditions which produce bigger children are desirable.
- b) In any event, there is no evidence in humans to contradict the ecological evidence (M) that attaining one's genetic growth potential in height is beneficial or at least has no detrimental effects (21) in spite of the currency given to unsubstantiated hypotheses to the contrary. The ecological evidence of particular note is the fact that Swedes, Mormons and Seventh-Day Adventists are populations which have the longest longevities recorded, and are also among the best grown. Furthermore, in the U.S.A. the longevity has increased at every age of life (22,25) in parallel with the secular increase in the height of children (Figure 9 in (24) appended). In other words, better nutrition during childhood did not shorten life in adulthood or even old age--rather life was prolonged at these older ages.
- c) Even in populations where obesity and its associated morbidity is a problem during adulthood it is minor compared to the morbidity seen in stunted populations. Even in these obese populations life expectancy at all ages is greater than it is in stunted populations, in spite of the fact that the very obese have shorter life expectancy than their thinner compatriots.

In summary, there is a close association between the mean growth of children in a population and their health. Thus mean physical growth of populations can be used as a proxy for that population's health. The

inferences for health policy and programs in the health sector and elsewhere is then obvious if the population is stunted. They relate to the formulation of policy and to the targetting of nutrition, health and development programs.

5. Other issues related to the use of anthropometry to assess changes in classification in the nutrition of populations

5.1. Sampling

The more representative the sample of the group of concern the more responsive will be the monitoring system. If the poor are the group of interest, nothing will be gained by including non-poor to "increase the sample size", or to "make the sample representative of the whole population".

An important issue in sampling is the issue of sample size. It must be large enough to detect differences between comparison groups, or a difference between one group and a standard, or a difference within a same group over time depending on the purpose for monitoring the population. It is important that the expected difference be defined before the survey to be sure that that difference will be adequate to make the relevant policy and program decisions, which thus must be defined before the survey.

5.2. Definition of socioeconomic group

In this paper we have not mentioned the classification of socioeconomic status. The functional classification concept has explored this issue (28,29) and results (30) have shown that careful choice of classifying variables is important for useful inferences. It is important to remember in this context that the causes in deficits in growth may be different in cross-sectional data (e.g.

landholding differentials) than over time (e.g. differentials in drought independent of landholding areas). Thus the choice of classifying variables must be informed by knowledge of the various likely causes of malnutrition.

### 5.3. Parameters

There are basically two ways population growth data may be presented: as means (e.g. by age, by height) or by prevalence estimates of the proportion of persons falling below some cutoff point in the distribution of values. Recent work in progress shows that the means in anthropometry are likely to be more "responsive" in malnourished populations--at least as relates to identifying changes in growth which are related to child mortality. Considerations in choosing a best cutoff for monitoring prevalences in stunting and wasting are also proceeding beyond the rather unsatisfactory conclusions discussed in reference (2) appended).

### 5.4. Cross-sectional surveys versus ongoing measurements

Single cross-sectional surveys are notoriously difficult to interpret as relates to changes in the stunting influence in the past. Attained height at adulthood is affected by shrinking with age, so that smaller older people do not imply that younger people were necessarily better nourished in childhood. Relating attained growth of children to a standard for this purpose is fraught with other difficulties--I know of no example of a useful inference about changes in stunting influences from such single cross-sectional studies.

Repeated cross-sectional studies have proven very useful (24). For instance, in the USA they have shown that the population median apparently achieved its maximum growth potential in the 1970's (25), but the poor were still about 1 cm less tall than the wealthy. The major danger with cross-sectional surveys is that they are usually performed in different areas at different times. This can result in seasonal and secular trends distorting area results, so that area differences are uninterpretable. This must be prevented in the survey design. One solution is a continuous survey in all areas over all seasons.

However, ongoing measurements have otherwise no intrinsic advantage over repeated cross-sectional studies, except possibly in countries with advanced management skills. In such countries there is a bureaucratic advantage to having a continuous rather than a sporadic activity. In most developing countries the difficulties of sustaining adequate supervision and quality control over extended periods of time render most ongoing measurement activities quite useless. This is the major reason why so little is known about the use of birthweight as an indicator of change in socioeconomic status over time, because birthweight cannot be collected easily as a cross-sectional activity.

## 6. Conclusion

Experience has shown that repeated cross-sectional surveys of child height relative to age are the most responsive and most easily interpreted measures of changes in socioeconomic status. Other methods have been proposed--a few of the more promising are reviewed here. None of these have as yet been properly investigated except in rather special situations.

References

1. Keller, W.: Letter of invitation, dated July 25, 1983, to the "Meeting on Purpose, Use and Interpretation of Anthropometric Indicators of Nutritional Status", Geneva 12-14, October 1983.
2. Habicht, J-P., Meyers, L.D., Brownie, C.: Indicators for identifying and counting the improperly nourished. *Am. J. Clin. Nutr.* 35: 1241-1254, 1982 (appended to this paper).
3. Habicht, J-P., Yarbrough, C., Martorell, R.: Anthropometric field methods: Criteria for selection. pp. 365-387. In: Jelliffe, D.G., Jelliffe, E.F.P. eds., *Human Nutrition, Vol. II, Nutrition and Growth*, New York, Plenum 1979 (appended to this paper).
4. Hulse, F.S.: *The Human Species*. Random House, New York, 1968.
5. Habicht, J-P., Martorell, R., Yarbrough, C., Malina, R.M., Klein, R.E.: Height and weight standards for preschool children: How relevant are ethnic differences in growth potential? *Lancet* 1: 611-615, 1974 (figures 1-4 from this paper appended).
6. Habicht, J-P. and Butz, W.P.: Measurement of health and nutrition effects of large-scale nutrition intervention projects. pp. 156-157. In: Klein, R.E. et al., *Evaluating the Impact of Nutrition and Health Programs*. Plenum, New York, 1979 (appended with this paper: Note errata)
7. Martorell, R.: Genetics, environment, and growth: Issues in the assessment of nutritional status. Unpublished paper presented at the International Workshop on Nutrition and Genetics in Teotihuacan, Mexico, August 1982.

8. Martorell, R.: Illness and incremental growth in young Guatemalan children. Ph.D. thesis, University of Washington, 1973.
9. Chen, L.C., Hug, E., Huffman, S.L.: A prospective study of the risk of diarrheal diseases according to the nutritional status of children. *Am. J. Epidemiology* 114: 284-292, 1981.
10. Martorell, R., Habicht, J-P., Yarbrough, C., Lechtig, A., Klein, R.E., Western, K.A.: Acute morbidity and physical growth in rural Guatemalan children. *Am. J. Dis. Child.* 129: 1296-1301, 1971.
11. Yarbrough, C., Habicht, J-P., Malina, R.M., Lechtig, A., Klein, R.E.: Length and weight in rural Guatemalan Ladino children: Birth to seven years of age. *Am. J. Physical Anthropology* 42: 439-448, 1975 (figure 4 from this paper appended).
12. Yarbrough, C., Habicht, J-P., Klein, R.E., Martorell, R., Lechtig, A., Guzman, G.: Response of indicators of nutritional status to nutritional interventions in populations and individuals. In: *Evaluation of Child Health Services*, pp. 195-206, eds S.J. Bosch and J. Aries, U.S.P.H.S., DHEW publication No. (NIH) 78-1066, Wash., D.C., 1978.
13. Martorell, R., Habicht, J-P., Klein, R.E.: Anthropometric indicators of changes in nutritional status in malnourished populations. In: *Methodologies in Human Population Studies in Nutrition Related to Health*. NIH publication No. 82-2462, U.S. Gov't Printing Office, Wash., D.C., 1982, pp. 96-110.
14. Lechtig, A., Habicht, J-P., Delgado, H., Klein, R.E., Yarbrough, C., Martorell, R.: Effect of food supplementation during pregnancy on birthweight. *Pediatrics* 56: 508-520, 1975.

15. Habicht, J-P., Lechtig, A., Yarbrough, C., Klein, R.E.: Maternal nutrition birthweight and infant mortality. In: Size at Birth, CIBA Foundation Symposium 27, Elsevier, London, 1974, pp. 353-377.
16. Malina, R.M., Habicht, J-P., Martorell, R., Lechtig, A., Yarbrough, C., Klein, R.E.: Head and chest circumferences in rural Guatemalan Ladino children birth to seven years of age. Am. J. Clin. Nutr. 28: 1061-1070, 1975.
17. Martorell, R., Yarbrough, C., Malina, R.M., Habicht, J-P., Lechtig, A., Klein, R.E.: The head circumference/chest circumference ratio in mild-to-moderate protein-calorie malnutrition. J. of Tropical Pediatrics and Environmental Child Health 21 (4): 203-207, 1975.
18. Jones, V.Y.: Associations between poverty and child growth: Analysis of cross-sectional national surveys, HANES I and HANES II. Ph.D. thesis, Cornell University, 1983.
19. Goldstein, H.: Height and weight standards. Lancet 1: 1052, 1974; see also reply Habicht, J-P., Martorell, R., Yarbrough, C., Malina, R.M., Klein, R.E.: Lancet 2: 47, 1974.
20. Last, J.M.: A dictionary of epidemiology. Oxford University Press, London, 1983.
21. Morrison, S.D.: Nutritional Longevity. Nutrition Reviews 41: 133-142, 1983.
22. Historical Statistics of the United States. Colonial times to 1957. U.S. Dept. Commerce, Bureau of the Census, Wash., D.C., 1960.
23. Statistical Abstract of the United States, 1978, U.S. Dept. Commerce, Bureau of the Census, Wash., D.C., 1978.

24. Hamill, P.V.V., Johnston, F.E., Lemeshow, S: Height and weight of children: Socioeconomic status. DHEW publication (HSM) 73-1601, U.S. Gov't Printing Office, Wash., D.C. 1972 (figure 9 from this paper appended).
25. Hamill, P.V.V., Drizd, T.A., Johnson, C.L., Read, R.B., Rache, A.F.: NCHS Growth Curves for Children Birth-18 years. DHEW publication No. (PHS) 78-1650, U.S. Gov't Printing Office, Wash., D.C., 1977.
26. Størky, G., Mellander, L.: Birthweight distribution an indicator of social development. Sorea Report No. R: 2, Swedish Agency for Research Cooperation with Developing Countries, Stockholm, 1978.
27. Uses of birthweight data in public health planning and practice. Report of a Wash. meeting, April 28-May 2, 1980, WHO, Geneva, April 1981.
28. Joy, J.L.: Food and nutrition planning. *J. Agricultural Economics* 24 (1): 165-192, 1973.
29. Joy, J.L., Payne, P.R.: Food and nutrition planning. (FAO) Nutrition Consultants Reports Series No. 35. ESN:CRS/75/35. Rome: FAO, 1975
30. Valverde, V., Trowbridge, F, Beghin, L., Pillet, B, Nieves, I., Sloan, N., Farrell, T., Payne, P.R., Joy, J.L., Klein, R.E.: Functional classification of undernourished populations in the Republic of El Salvador. Methodological Development. *Food and Nutrition* 4 (3-4): 8-14, 1978.

Footnote A: We very much hope that the workshop will not deal with the use of anthropometry in research investigating the consequences and determinants of malnutrition, which could also be implied by the title. This would distract attention from the main objective.

Footnote B: There is one conclusion ( (2) p. 1248, item 1) which has implications for screening, and which bears highlighting in this paper because one conclusion of this paper is that for all practical purposes one can, and for many purposes should, use an accepted reference for anthropometry--at least for weight and height for a given age. It would then appear that such a "standard" is necessary for screening. This is not the case ((2) p. 1248, item 1). The setting of appropriate screening cutoff levels for intervention (e.g., education, feeding, hospitalization) does not depend on such a "standard"--and "standard" cutoffs almost guarantee inefficiencies of intervention in screening programs because of poor targeting.

Footnote C: This statement does not exclude a genetic component to the growth of children. One can with some certainty say that well-to-do black American 7 year old children are almost 1 cm taller than well-to-do white Americans. One cannot be absolutely sure whether or not Asians have a somewhat lower genetic potential than other races (see page 32 from (7) because the populations measured have only reached a high socioeconomic level recently. Nevertheless, the genetic component is small compared to the effect of environmental factors in developing countries (Figures 1-4 of (5) and Figures 3-4 (6) both appended).

Footnote D: Comparison in (5) of figures 1 and 2 reveal the well-known greater plasticity of boys than girls, in that the extremes due to

differences in social class are 6 times greater than the extremes between races in boys in comparison to 5 times in girls.

Footnote E: There is no question that at older ages genetic factors (and maybe climatic factors too) play a more important role in mean growth e.g. compare adult pigmies and Watutsis. The age when this occurs has not been well-defined, although the procedure to do so is obvious (e.g. as in 5).

Footnote F: No such responsiveness is shown by mortality and morbidity data (6) (including diarrhea (Martorell (8) & Chen (9))).

Footnote G: In this population head/chest circumference ratio was not a useful measure of malnutrition (17).

Footnote H: This ratio or its square is also called sensitivity in some statistical literature. Unfortunately, sensitivity has another well accepted meaning in epidemiology (see (2) appended).

Footnote I: Thus, it is not surprising that practically no effect of socioeconomic class is seen in the anthropometry of U.S. children (18).

Footnote J: The age of interest for monitoring a change is not strictly either the age of greatest depression in growth rate or the age of greatest accumulated deficits, but the age when the accumulated deficit is most statistically significant; i.e. when the ratio, deficit/standard deviation of the population at that age, is greatest. This is because anthropometric indicators may be expected to be most responsive at that age to improved SES or nutrition.

Footnote K: The difference between before and after heights should not be used, because this may result in spurious correlations. The residual of the "after" height on its regression on the "before" height does not have this problem.

Footnote L:  $r$  = correlation coefficient; the correlation coefficients between each of various outcomes and one determinant rank the same as do the responsiveness values.

Footnote M: "Ecological" evidence is an association found between means of variables across populations, and can lead to an "Ecological fallacy": "An error in inference due to failure to distinguish between different levels of organization. A correlation between variables based on group (ecological) characteristics is not necessarily reproduced between variables based on individual characteristics; an association at one level may disappear at another, or even be reversed. Example: At the ecological level, a correlation has been found in several studies between the quality of drinking water and mortality rates from heart disease; it would be an ecological fallacy to infer from this alone that exposure to water of a particular level of hardness necessarily influences the individual's chances of getting or dying of heart disease." (From (20)) Thus it is a fallacy to believe that "ecological" evidence is proof of a causal relationship. However, a causal relationship between ill-health and stunted growth is not the main argument for using stunted growth in a population as a proxy for population health.

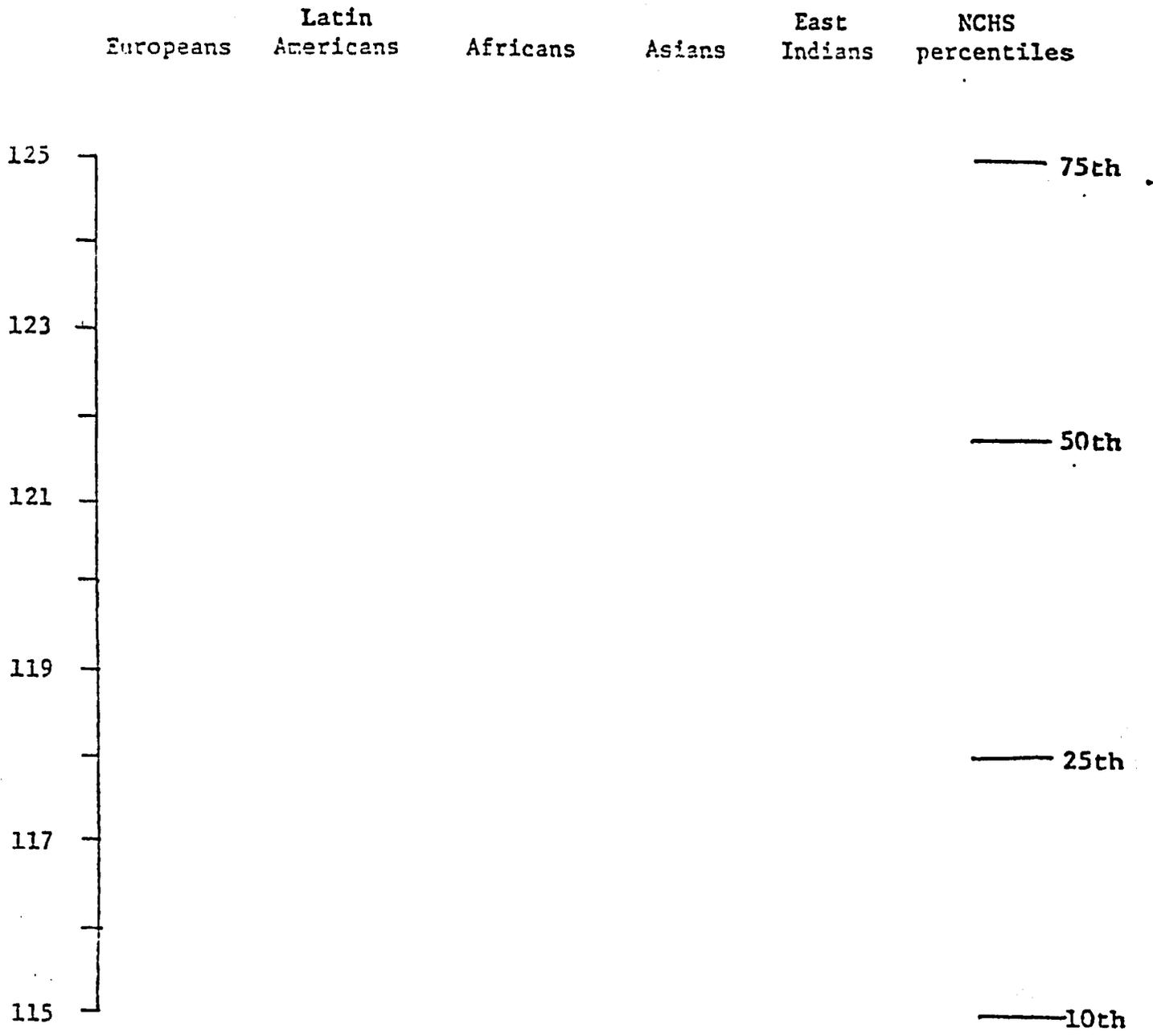


Figure 3. Mean heights for samples of well-off 7 year old boys of various ethnic origins

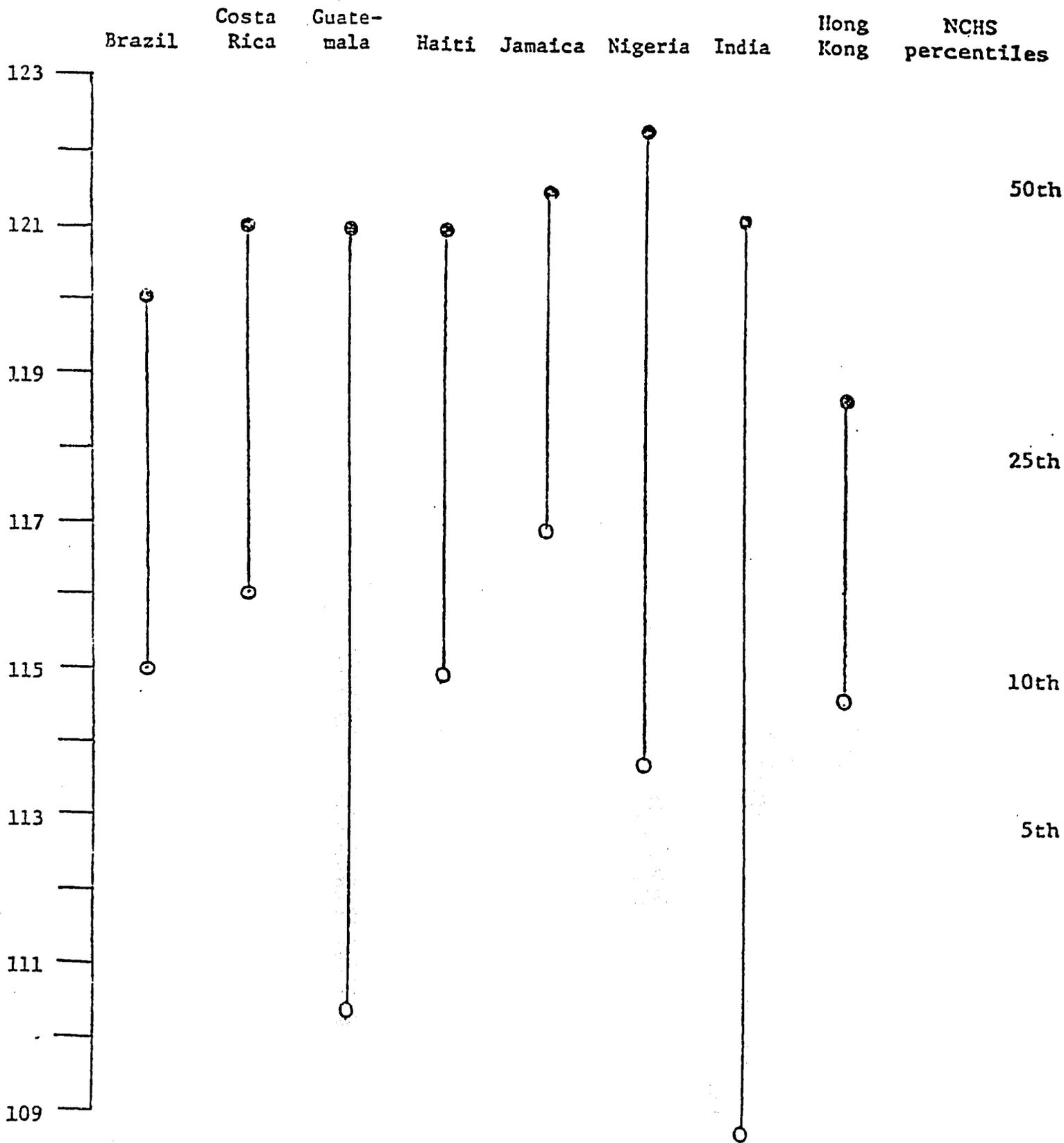


Figure 4. Mean heights of 7 year old boys of high (•) and low socioeconomic status (○)

From: Height and weight standards' for preschool children:  
How relevant are ethnic differences in growth potential?  
By: Habicht, J-P., Martorell, R., Yarbrough, C., Malina,  
R.M., Klein, R.E. in Lancet 1: 611-615, 1974.

social-class categories are rather small, and as a result the mean values are unstable. Such studies are not included in our analysis.

RESULTS

Comparative height and weight data for selected samples of children, birth through 7 years of age, are presented in figs. 1-4. Children from various ethnic groups from various socioeconomic strata, and from different geographic areas generally grow rather uniformly in length and weight during the first 3-6 months of life. After 6 months of age, the lengths and weights of children from developing countries lag behind those of children from developed countries. The high socioeconomic stratum children of Bogotá, Colombia (a developing country), compare well with children of developed countries.

The clustering of height curves for children of different ethnic backgrounds in developed countries and from higher socioeconomic strata in developing countries is obvious (figs. 1 and 2). The height curves for American Negro children from lower socioeconomic backgrounds in the United States are indistinguishable from curves of well-nourished children. The relative difference (calculated by expressing the difference between two values as a percentage of the higher value) between the high and low height values of the well-nourished children range from 1.5% to 4.6% for both sexes, with an

average difference of 2.6% and 2.7% for boys and girls, respectively, over fourteen age-groups compared between birth and 7 years of age. This would seem to indicate that among well-nourished children, ethnic differences in stature at preschool ages are relatively small.

The body-weight curves of well-nourished children show considerably more variation than noted for stature (figs. 3 and 4). Excluding birth-weight, relative differences between high and low weight values for the well-nourished children range from 2.6% to 9.1%, with an average difference of 6.3% in both boys and girls over the age groups compared between three months and 7 years of age. The weight curve for Bogotá children from higher socioeconomic strata again compares well with those of children in developed countries.

In contrast to the relative clustering of height and weight curves for children from developed countries, the height and weight curves for rural and/or lower socioeconomic class children from developing countries show considerable variation relative to the better nourished children. The variation, as expected, is considerably greater for body-weight than for height. Rural children from India and rural Guatemalan Indian children consistently lag farthest behind all the other samples. The relative difference between the rural Indian and Guatemalan Indian samples and the children from well-nourished samples, approximates 30 to 35% after 12 months

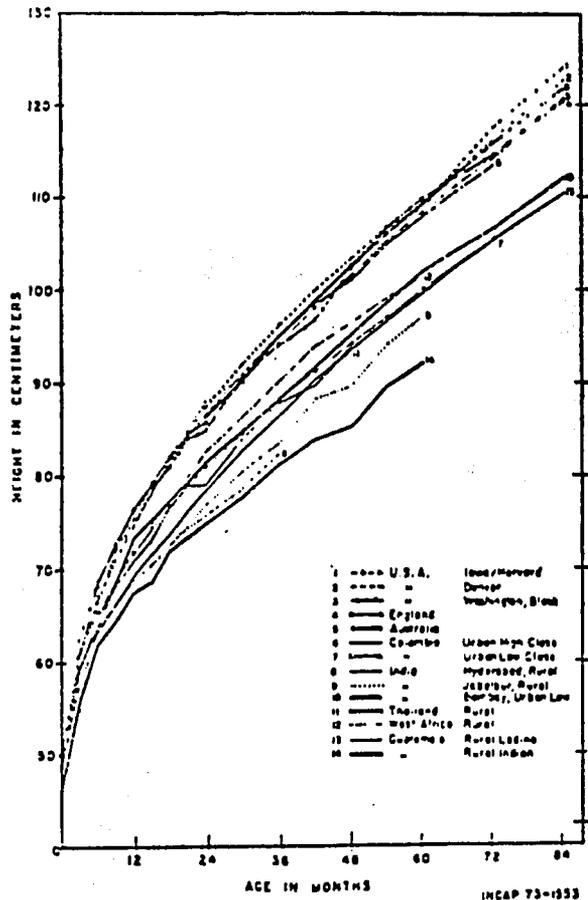


Fig. 1—Comparison of boys' heights from different parts of the world and different social classes.

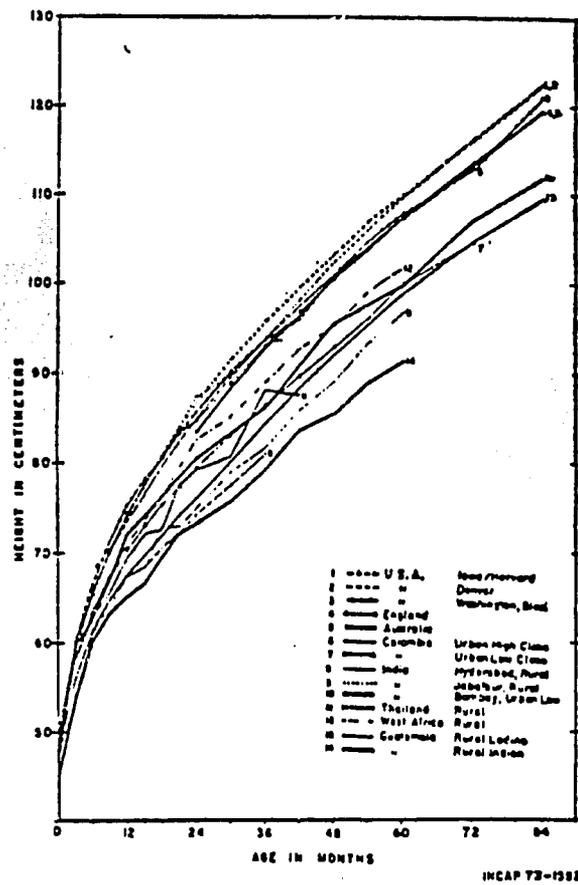


Fig. 2—Comparison of girls' heights from different parts of the world and different social classes.

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of age for body-weight. In contrast, the relative difference in body-weight for other less extreme samples of children from developing countries, as compared to the well-nourished children, varies from 20 to 30% between 12 and 84 months of age.

For stature, the relative difference between samples from developing and developed countries approximates about 10% after 12 months of age for all samples compared, except for the rural Indian and the Guatemalan Indian samples which had relative differences of 12-17% after 12 months of age. Thus, in stature as in body-weight, these samples show greater growth deficits.

DISCUSSION

The comparison of growth data from well-to-do preschool children of different ethnic groups reveals an average variation between the largest and the smallest populations of about 3% in height and about 6% in weight. In contrast, the relative differences between the economically well-to-do and the poor populations after 12 months of age are about 12%

for height and about 30% for weight. Relative differences of this magnitude, 1 cm. differences in measuring techniques for height are unimportant.

The alternative to comparing children of different ethnic groups but of similar environmental circumstances is to compare children of similar ethnic groups but differing in socioeconomic backgrounds. Comparisons of high and low social classes, "privileged" and "underprivileged", or "well-off" and "poor" children within the same ethnic population usually show the better-off children approximating to the standards from developed countries, while children in the lower and poorer social strata lag in growth relative to the standards. This pattern can be seen in the data for Bogotá children in figs. 1-4. Data from Chile,<sup>22</sup> India,<sup>15,23</sup> Ethiopia,<sup>24</sup> Nigeria,<sup>25</sup> Uganda,<sup>26</sup> and Australia,<sup>27</sup> show similar results for samples of preschool children of the same ethnic population living in different socioeconomic conditions. Although the samples in these studies are frequently combined by sex and are not large enough in both low and high socioeconomic samples to permit reliable estimates of the population means,

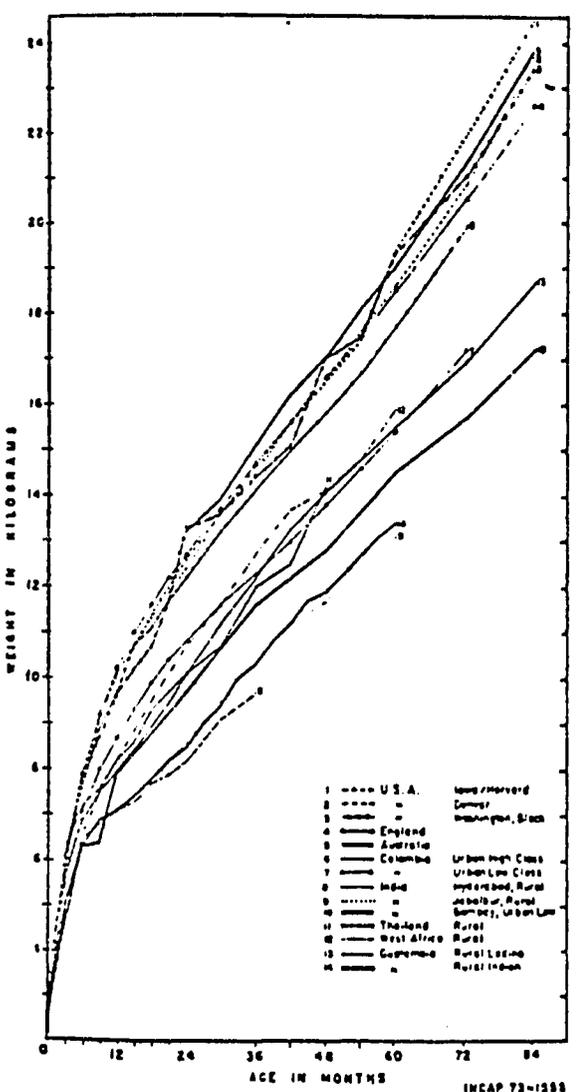


Fig. 3—Comparison of boys' weights from different parts of the world and different social classes.

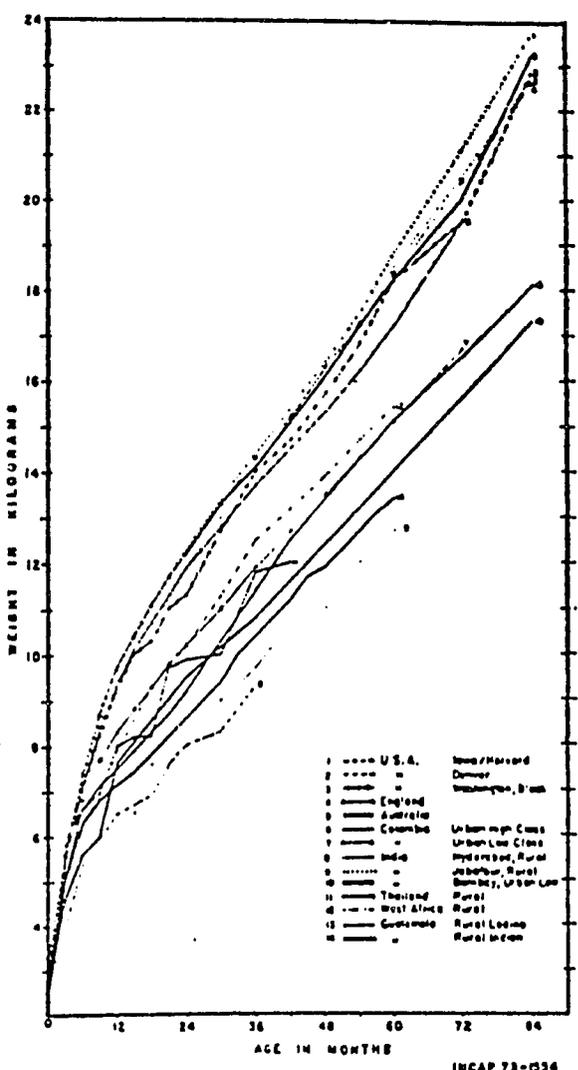


Fig. 4—Comparison of girls' weights from different parts of the world and different social classes.

From: Length and Weight in Rural Guatemalan  
 Ladino Children: Birth to Seven Years of Age  
 By: Yarborough, C; Habicht, J-P; Malina, R M;  
 Lechtig A and Klein R E in American Journal  
 of Physical Anthropology 42: 439-448  
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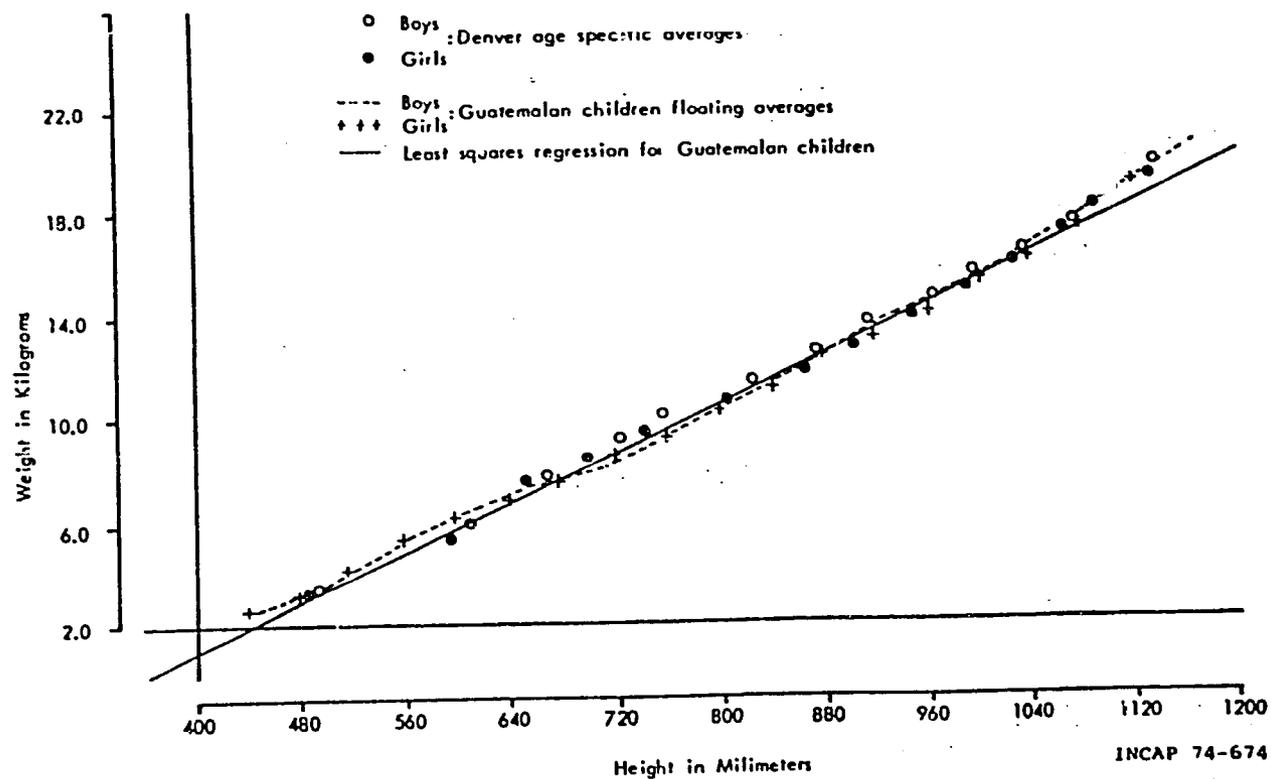


Fig. 4 The relation of weight to height for Guatemalan (present study) and Denver children from birth through six years of age.<sup>3</sup>

<sup>3</sup> 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.

From: Height and Weight of Children: Socio-Economic Status, United States  
By: Hamill, P V V; Johnston, F E; and Lemeshow, S in DHEW Publication No: (HSM) 73 - 1601, Series 11 - No: 119  
Figure 9 - pg 22

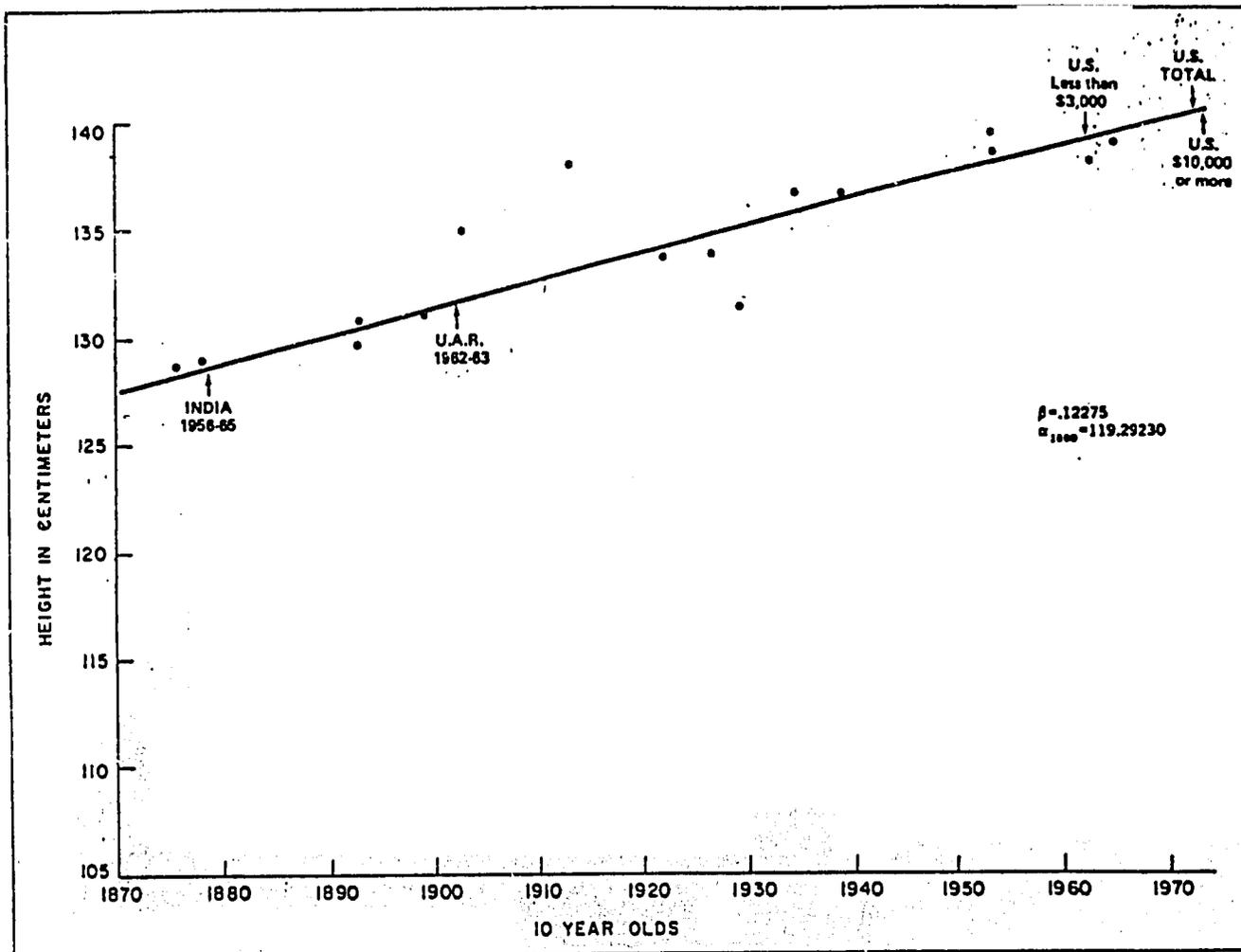


Figure 9. Regression line showing the growth of U.S. 10-year-old children during the last century by income groups, with the comparison of Indian and U.A.R. children for the years 1963-65.

and over 20 pounds in weight.<sup>v</sup> Analysis for percentage of tall men (72 inches and over) in the freshman class support this. "At Amherst only

<sup>v</sup>This is only about 60 percent as great an absolute increase in size as Meredith estimated for 10-year-olds over the same time frame. And it is even a smaller proportionate increase for this disparity. Two explanations come to mind: part of the increased size in "Meredith's 10-year-olds" might well be due to earlier maturation<sup>18</sup> and the other might be due to rising socioeconomic level of a greater proportion. That is, the college students would have rather constantly, over the 100 years, come from the highest socioeconomic strata—i.e., no relative change—whereas the much broader socioeconomic spectrum of Meredith's 10-year-olds, it can be conjectured, might allow for a greater relative improvement over the years in the lower socioeconomic strata.

one class before 1910 had as many as 10 percent tall men; from 1937 all but two classes had over 20 percent tall men; and in 1956 and 1957 tall men made up over 30 percent of the class."<sup>20</sup> There was a similar phenomenon at the other schools. And family comparisons of pairs of fathers and sons and mothers and daughters measured at the same age, i.e., when they entered as freshmen—showed the sons to be almost 1½ inches taller than their fathers had been and the daughters more than 1 inch taller than their mothers. Furthermore, table B shows that the total height difference between the first and fourth generation of Harvard men was 3 inches.

In short, this steady increase in the size of college students occurred within, presumably, a