The Introduction of Anthropometrics into Development and Labor Economics

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Abstract: We trace the introduction of anthropometric indicators into development and labor economics in the late 1970s.

We trace the introduction of anthropometric indicators into the economic development and labor economics literature. The correlation between such an anthropometric measure as height and economic conditions was noted already in 1829. Louis R. Villermé, a statistician of public health was the first to realize that the height of a population correlated positively with wealth: „physical stature is greater, and men grow faster, the wealthier is the country; in other words, misery produces short people, and delays the achievement of final height“ (Villermé 1829:353).[1] Subsequently, as industrialization proceeded in England, and social differences in height could reach as much as 22 cm (8.6 inches) (Komlos 2004), there was quite a lot of discussion about the relationship between social status and physical stature. Some of the reports on child height actually led to the abolition of the most severe forms of child labor in England about 1840 (Tanner 1981:142-68).

Of course, ever since the 19th century medical doctors, clinicians, nutritionists, epidemiologists knew the biological basis of human growth and used it to analyse and improve conditions in various parts of the world. In our own time, Emmanuel Le Roy Ladurie, was the first historian (in the Annales tradition) to examine systematically the geographic variation and the socio-economic correlates of human height in France. In 1969 he showed, for instance, that the physical stature of recruits born in the late 1840s correlated positively with their education and wealth (Ladurie 1969:260-308).[2] The transfer of the methodology to the cliometric branch of economic history, beginning in the mid-1970s, has been fairly well documented (Bilger 2004; Engerman 2004, Floud 2004; Fogel and Engerman 1982, Komlos and Baten 2004, Steckel 1998). However, the introduction of this methodology to the development and labor economics seems to have all but eluded attention.

The foundations for the integration of anthropometrics into the sub-disciplines of development and labor economics were laid essentially by medical doctors and nutritionists, such as Nevin S. Scrimshaw, who was for many years head of the Department of Nutrition and Food Science at the Massachusetts Institute of Technology, and founded the Insititute of Nutrition of Central America and Panama (INCAP) in 1949. During the course of the 1950s he and his collaborators conducted influential field studies on the synergism between malnourishment, infection and growth retardation (Aguirre and Scrimshaw 1955; Guzman et al. 1958; Keusch 2003; Scrimshaw 1970, 2003; Scrimshaw et al. 1955; Scrimshaw and Guzman 1953; Scrimshaw et al. 1959). The INCAP documented retarded growth in malnourished children, for example in field studies conducted in Guatemalan villages (Scrimshaw et al. 1967:659). Scrimshaw showed that children from Central America and Panama were of decidedly shorter than American children, and argued in economic terminology:

“It should be obvious from the data presented that the nutritional damage which the child suffers after weaning represents a very serious human and economic loss to the country, loss not only in cost hospitalization, or of burial, but in terms of health and resistance to disease and consequently in capacity for learning and working” (Scrimshaw et al. 1959:183).[3]

His efforts lead to the integration of nutrition into the field of economic development. In 1970, Alan Berg, Senior Fellow at the Brookings Institution and formerly Chief of Food and Nutrition Division in the US Agency for International Development from 1966 to 1970 in India, and another very important advocate of nutritional planning, put it succinctly:

"Until recently, the concept of nutrition as an integral part of national growth was largely academic. An article in the 1967 issue of *Foreign Affairs* explored the relationship between malnutrition and economic development.[4] It sought to justify on development grounds a field of activity traditionally viewed as humanitarian. The point was made that the staggering mortality resulting from malnutrition and the reduction of mental and physical performance (caused by the malnutrition-related retardation of most survivors) constitute a major impediment to national development." (Berg 1970:1396)

Berg quoted Indian public health officials who complained about "malnutritional dwarfism" and continued:

"Nutrition need has raised basic questions about income distribution, resource allocation, and the nutritional implication of agricultural policy. A few government leaders are beginning to think of nutrition in terms of such issues as the extent of increased productivity of the properly nourished man, the added contribution to society by a child with full mental and physical capacities […]." (Berg 1970:1397)

The Indian government launched a food program in 1968, following the "Bihar famine" of 1966-67. It was the first time that a field study on malnutrition was concerned systematically with height, and not just with weight (Leslie 1987:362). Height is, after all, of considerable importance to assess the status of malnutrition. Michael C. Latham was the first to propose in 1971 the subsequently widely accepted classification for different categories of malnutrition in children: a) Acute, current, short-duration malnutrition, where weight for age and weight for height are low, but height for age is normal; b) Past, chronic malnutrition, where weight for age and height for age are low, but weight for height is normal; c) Acute or chronic or current long-duration malnutrition, where weight for age, height for age, and weight for height are all low (Latham 1987:333).

John C. Waterlow, another influential physician and nutritionist from the London School of Hygiene and Tropical Medicine, suggested in 1972 that acute malnutrition be termed "wasting", that chronic malnutrition be termed "stunting", and that the combined condition of acute and chronic malnutrition be labeled "wasting and stunting" (Waterlow 1972:566-68).

In sum, growth retardation increasingly became an accepted indicator for malnutrition. Alan Berg recounted:

"'Why are today´s Japanese children growing taller than their honorable fathers?', asks one advertisement. 'They´re getting more proteins, … Amazing how a small race is growing taller. Today´s Japanese children are an average of three inches taller than their parents – the result of protein-rich diets in postwar Japan!" (Berg 1970:1402)

An interdisciplinary conference held at MIT in October 1971 was an important step in the adoption of the methodology of nutrition science and anthropometrics in the field of economic development. The goal of the conference was:

"to stimulate nutritionists and development specialists to talk to each other, to share information on mutual tasks, and to search for ways to jointly advance the goal of national development through improving the nutritional and health status of a nation´s population – not simply on humanitarian grounds but for pragmatic economic reasons as well. The participants agreed that unless the two disciplines joined forces in planning and in implementation, neither will achieve fully its goals" (Berg et al. 1973:ix).

This conference can be seen as a milestone in the integration of anthropometrics into development economics: It was the first time that the case was made for using height as an indicator for malnutrition, and therefore for living standards, in the social sciences. José María Bengoa, Chief of the Nutrition Unit in the World Health Organization, stated:

“The need of a single indicator, or several, to assess the lasting effects of malnutrition in young children is a matter of urgency. It would be preferable to have a single indicator which would reflect, for a given community, the combined effect of a number of factors related to physical, functional, and social development. Such a single indicator should incorporate objectivity, feasibility, specificity, and sensitivity. I would suggest the possibility of using the height of children of 7 years of age as such a community indicator”[5] (Bengoa 1973:113).
Though height had been widely recognized as a viable indicator for malnutrition by physicians and nutritionists in the 1950s, development economists did not embrace the idea of using height as an important dependent variable until the late 1970s, at about the same time as economic historians began to do research on the history of human height and its implication for living standards (Komlos and Cuff 1998; Steckel 1979). Heller and Drake[6] (1979:203-35) were among the first to publish an article in an economics journal using anthropometric indicators for malnutrition relying on the nutritional science literature mentioned above. They estimated an econometric model of the nutritional and health status of pre-school Columbian children (N=1,200), using data from the Promotora program (1968 to 1974). Heller and Drake used weight for age and height for age as dependent variables – based on the classification of malnutrition developed by Latham.[7] As independent variables they used the percentage of a child´s life in the Promotora program, his position in the birth order, the education level of the parents and the exposure of the child to diarrhoe in the last month, which can be a sign of malnutrition. Many of these factors turned out to be significant explanatory variables. Heller and Drake justified their model as follows:

“Our model assumes that a child´s nutritional and health status reflects the combined impact of basic physiological development processes, genetic factors and of economic decisions made by the parents within the context of a given environment. The latter determines the quality and quantity of resources devoted to a child over the course of its early development. Our model is highly abstract and greatly simplifies extremely complex physiological, epidemiological and nutritional processes. Any one of the relationships implicit in the model has been the subject of substantial clinical research, and it would be impossible either to survey this research in this paper or to incorporate adequately the results of such research in our model. However, we believe that the structure of our model is not inconsistent with the basic medical literature and that the costs of simplification are outweighed by the gains from examining a more complete set of the factors influencing a child´s development.” (Heller and Drake 1979:204)

At the same time as the Heller and Drake article came out Chernichovsky and Coate (1980:255-63) were working on child nutrition using US data. The National Center for Health Statistics of the United States, had developed in 1969 a new surveillance system of national monitoring of health, the Health and Nutrition Examination Survey (HANES), which included data on weight and height. There was some controversy about the effect of income on height. Hamill et al. (1972:87) concluded that the difference between children at ages 6 to 11 in families in the highest and lowest quarters of the income distribution amounted to about 3 cm.[8] On the other hand, Chernichovsky and Coate (1979:18) using the same data concluded that: “Average nutrient intakes for children in households of lower economic status are very similar to intakes of children in households of higher economic status. Rates of children´s growth are also very similar in these households.”[9]

Another innovation was to incorporate anthropometrics into labor economics. The relationship between height and productivity was first measured by Spurr (1977; 1983), whose influential paper was not published in an economic development journal.[10] Spurr studied the productivity of Colombian sugarcane cutters (aged 18-34 years) and estimated to the following relationship (Spurr 1983:22):

$$\text{productivity} = 0{,}81\ V_{O_2} - 0{,}14\ F + 0{,}03\ \text{Height (cm)} - 1{,}962 \quad (r=0{,}685;\ P < 0{,}001).$$

Productivity was measured in tons per day, and V_{O_2} was the maximal oxygen consumption, measured by a bicycle ergometer, and F was the percentage body fat. Spurr emphasized the negative effects of malnutrition on V_{O_2} and therefore on productivity for physical work. Overweight had a significant negative effect on physical work. Height, as a proxy for the history of nutritional status, made a positive contribution to productivity. Spurr´s results indicated that malnutrition had an important negative effect on underdeveloped economies (Spurr 1983:2).[11]

Although Spurr's publications were not in economic journals, the concepts and methods employed eventually made their way into the economics literature. Imminck and Viteri conducted studies while working at the INCAP in Guatemala and were the first to follow up on Spurr´s findings and to publish it in an economic journal (1981:251-87). The field was also inspired by theoretical literature connecting nutrition with productivity (Strauss and Thomas 1998). They presented regression analysis which included height of sugar cane cutters as an independent variable. Height showed a significant effect on worker´s productivity among the age group of 39 and older (n=36) (Imminck and Viteri 1981:276). At about the same time Friedman (1982) and Margo and Steckel (1982) showed that slave's height correlated positively with their price – implying that taller people were also more productive.

By the 1980s the idea of studying anthropometric indicators in both historical as well as contemporary populations – both developed and underdeveloped – cascaded (Steckel 1983; Moock and Leslie 1986; Brinkman et al. 1988; Komlos 1987, 1989; Strauss and Thomas 1998). To be sure, the transfer of the methodology to economics was an extended process. Beginning with Villermé's precocious observations in 1829, anthropometric indicators were used by social critics, and physical anthropologists thereafter in the 19th century, while among economists the emphasis remained with GNP, as well as with per capita income as the variable of choice to measure living standards or labor productivity in the first half of the 20th century. After World War II nutritionists who grappled with the idea of ameliorating underdevelopment realized the importance of anthropometric indicators as a measure of malnutrition, and propagated its extensive use. As Bengoa (1973:113) put it, policy makers saw the

“…need of a single indicator, or several, to assess the lasting effects of malnutrition in young children is a matter of urgency”. The real transfer of the innovation to economics began at the end of the 1970s and its use accelerated rapidly thereafter. Today the use of anthropometric measures has become one of the standard tools in the repertoire of labor and development economists as well as cliometricians. It is now used extensively as a supplement to per capita income measures as a proxy for the biological standard of living in a wide variety of political, economic and social settings (Komlos and Kriwy 2004; Komlos and Baur, 2004; Steckel 1995), but is also extensively discussed in relation to the economic relationship to health, human development and living standards (Steckel 1995, Strauss and Thomas 1998)

References

Aguiree F. and N.S. Scrimshaw (1955). The effect of supplements of animal and vegetable protein, vitamin B12, and aureomycin on hematological values in Central American school children. *American Journal of Clinical Nutrition*, 3(3):225-9.

Aron, J.-P., Dumont, P. and E.L.R. Ladurie (1972). *Anthropologie du Conscrit Français*. Paris: Mouton De Gruyter.

Bengoa, J.M. (1973). Significance of malnutrition and priorities for its prevention. In: Berg, A., Scrimshaw, N.S. and D.L. Call (eds.). *Nutrition, National Development, and Planning*:103-28. Cambridge, Mass, USA, and London: MIT Press.

Berg, A.D. (1967). Malnutrition and national development. In: *Foreign Affairs. An American Quarterly Review, 46(1)*:126-36.

Berg, A.D. (1970). Nutrition as a national priority. Lessons from the Indian experiment. *American Journal of Clinical Nutrition*, 23:1396-1408.

Berg, A., Scrimshaw, N.S. and D.L. Call (eds.) (1973). *Nutrition, National Development, and Planning*. Cambridge and London: MIT Press.

Bilger, B. (2004) The Height Gap. Europeans are getting taller; why aren't we? *The New Yorker*, April 5, pp. 38-45.

Boström, G. and F. Diderichsen (1997). Socioeconomic differentials in misclassification of height, weight and body mass index based on questionnaire data. *International Journal of Epidemiology*, 26 (4):860-6.

Brinkman, H.J., Drukker, J.W. and B. Slot (1988). Height and income: A new method for the estimation of historical national income series. *Explorations in Economic History*, 25(3):227-64

Chernichovsky, D. and D. Coate (1979). An economic analysis of the diet, growth, and health of young children in the United States. *Working Paper No. 146, National Bureau of Economic Research*:18.

Chernichovsky D. and D. Coate (1980). The choice of diet for young children and its relation to children's growth. *Journal of Human Resources,* 15:255-63.

Chernichovsky, D. and D. Coate (1983). An economic analysis of the diet, growth, and health of young children in the U.S.A. In: Salkever D., Serageldin I. and A. Sorkin (eds.). *Research in human capital and development. Vol. 3*: 111-26. Greenwich, Conn, USA: JAI Press.

Engerman, S. L. (Summer 2004, forthcoming). Personal Reflections on the 1982 Special Anthropometric Issue of Social Science History. *Social Science History*.

Floud, R., (Summer 2004, forthcoming). The origins of anthropometric history: a personal memoir. *Social Science History*.

Fogel, R. W. and S. L. Engerman (1982). Guest Editors‘ Foreword. *Social Science History*, 6:395-8.

Friedman, G. (1982). The Heights of Slaves in Trinidad. *Social Science History* 6: 482-515.

Guzman, M.A., Scrimshaw, N.S. and R.J. Monroe (1958). Growth and development of Central American children. I. Growth responses of rural Guatemalan school children to daily administration of penicillin and aureomycin. *American Journal of Clinical Nutrition,* 6(4):430-8.

Hamill, P.V.V., Johnston, F.E. and S. Lemeshow (1972). Height and weight of children: socioeconomic status: United States. *US Department of Health, Education and Welfare Publication No. (HSM) 73-1606, Vital and Health Statistics Series 11, No. 119*. Rockville, Maryland.

Heller, P.S. and W.D. Drake (1979). Malnutrition, child morbidity and the family decision process. *Journal of Development Economics,* 6:203-35.

Imminck, M.D.C. and F.E. Viteri (1981). Energy intake and productivity of Guatemalan sugarcane cutters. *Journal of Development Economics*, 9:273-87.

Keusch, G.T. (2003). The history of nutrition: malnutrition, infection and immunity. *Journal of Nutrition*, 133(1):336S-340S.

Komlos, J. (1987). The height and weight of West Point cadets: Dietary change in antebellum America. *Journal of Economic History*, 47(4):897-927.

Komlos, J. (1989). Nutrition and economic development in the eighteenth century Habsburg monarchy. Princeton: Princeton University Press.

Komlos, J. and T. Cuff (eds.) (1998). *Classics in Anthropometric History*. St. Katherinen, Germany: Scripta Mercaturae Verlag.

Komlos, J. and P. Kriwy (2003). The Biological Standard of Living in the Two Germanies. *German Economic Review,* 4(4):493-507.

Komlos, J. and M. Baur (2004). From the tallest to (one of) the fattest: The enigmatic fate of the size of the American population in the twentieth century. *Economics and Human Biology*, 2(1):57-74.

Komlos, J. and J. Baten (Summer 2004, forthcoming). Looking backward and looking forward: Anthropometric research and the development of Social Science History. *Social Science History*.

Ladurie, E.L.R., Bernageau, N. and Y. Pasquet (1969). Le Conscrit et l'ordinateur: Perspectives de recherches sur les archives militaires du XIXe siècle français. *Studi Storici,* 10:260-308.

Ladurie, E.L.R. (1979). *The Territory of the Historian* (trans. by Ben and Sian Reynolds). Chicago: University of Chicago Press.

Ladurie, E.L.R. and N. Bernageau (1971). Etude sur un contingent militaire (1868). Mobilité géographique, délinquance et stature, mises en rapport avec l'autres aspects de la situation des conscrits. *Annales de Démographie Historique*:311-37.

Ladurie, E.L.R. and M. Demonet (1980). Alphabétisation et stature: un tableau comparé. *Annales ESC*, 35:1329-32.

Latham, M.C. (1987). Strategies for the control of malnutrition and the influence of the nutritional sciences. In: Gittinger, J.P., Leslie, J. and C. Hoisington. *Food Policy. Integrating Supply, Distribution, and Consumption*:330-45. Baltimore and London: EDI Series in Economic Development.

Leslie, J. (1987). Interactions of malnutrition and diarrhea: A review of research. In: Gittinger, J.P., Leslie, J. and C. Hoisington. *Food Policy. Integrating Supply, Distribution, and Consumption*: 355-370. Baltimore and London: EDI Series in Economic Development.

Margo, R. and Steckel, R. (1982) The Heights of American Slaves: New Evidence on Slave Nutrition and Health. *Social Science History* 6: 516-38.

Martorell, R., Mendoza, F. and R. Castillo (1988). Poverty and stature in children. In: Waterlow (ed.), J.C. (1988). *Linear Growth Retardation in Less Developed Countries*:57-73. Raven Press: New York.

Moock, P.R. and J. Leslie (1986). Childhood malnutrition and schooling in the Terai region of Nepal. *Journal of Development Economics*, 20:33-52.

Satyanarayana, K., Nadamuni Naidu, A. and B.S. Narasinga Rao (1977). Body size and work output. *American Journal of Clinical Nutrition*, 30:322-5.

Scrimshaw, N.S (1970). Synergism of malnutrition and infection. Evidence from field studies in Guatemala. *JAMA*, 212(10):1685-92.

Scrimshaw, N.S. (2003). Historical concepts of interactions, synergism and antagonism between nutrition and infection. *Journal of Nutrition*, 133(1):316S-321S.

Scrimshaw, N.S. and M.A. Guzman (1953). Effect of dietary supplements and the administration of vitamin B12 and aureomycin on the growth of school children. (in Spanish) Boletín Oficina Sanitaria de Panama, 34(6):551-62.

Scrimshaw, N.S., Behar, M., Perez, C. and F. Viteri (1955). Nutritional problems of children in Central America and Panama. *Pediatrics*, 16(3):378-97.

Scrimshaw, N.S., Munoz, J.A., Tandon, O.B. and M.A. Guzman (1959). Growth and development of Central American children. II. The effect of oral administration of vitamin B12 to rural children of preschool and school age. *American Journal of Clinical Nutrition,* 7(2):180-4.

Scrimshaw, N.S., Guzmán, M. and J.E. Gordon (1967). Nutrition and infection field study in Guatemalan villages 1959-1964. *Archives of Environmental Health*, 14:657-662.

Spurr, G.B., Barac-Nieto, M., Maksud, M.G. (1977). Productivity and maximal oxygen consumption in sugar cane cutters. *American Journal of Clinical Nutrition*, 30:316-21.

Spurr, G.B. (1983). Nutritional status and physical working capacity. *Yearbook of Physical Anthropology*:1-35.

Spurr, G.B. (1988). Body size, physical work capacity, and productivity in hard work: Is bigger better? In Waterlow (Ed.), J.C. *Linear Growth Retardation in Less Developed Countries*:215-39. New York: Raven Press.

Steckel, R. (1979). Slave Height Profiles from Coastwise Manifests. *Explorations in Economic History*, 16(4):363-80.

Steckel, R. (1983). Height and per capita income. *Historical Methods*, 16(1):1-7.

Steckel, R. (1998). Strategic Ideas in the Rise of the New Anthropometric History and Their Implications for Interdisciplinary Research. *Journal of Economic History*, 58(2):803-21.

Strauss, J. and Thomas, D. (1998) Health, Nutrition, and Economic Development. *Journal of Economic Literature*, 36: 766-817.

Tanner, J.M. (1981). *A History of the Study of Human Growth*. London:Cambridge University Press.

Villermé, L.R. (1829). Mémoire sur la Taille de L`Homme en France. *Annales D'Hygiène Publique et de Médecine Légale*, 1:351-97.

Villermé, L.R. (1840). *Tableau de l'état physique et moral d'ouvriers dans les fabriques de coton, de laine, et de soie*.

Waterlow, J.C. (1972). Classification and definition of Protein-Energy-Malnutrition. *British Medical Journal*, 3(5826):566-8.

Endnotes

[1] Villermé (1829:353) concluded that taller men tended to be healthier: “The difference is striking; where people are tall, there are very few rejections for military service even on account of ailments; where people are short, there are many rejections on medical grounds...; so the advantage seems to be entirely for the tall people.” „the inhabitants of the plains in [the department of Gard], benefit from all advantages of nutrition, clothes, lodging....“ He observed also that in the former department of Bouches de Le Meuse,... a rich countryside, with expanding commerce and industry, where people were well nourished and did not have to work at a young age, the average height of recruits at their 20th birthday was 1,677 m in 1808-1810, and very few were rejected for military service on account of medical disorders, or because of being shorter than the minimum height requirement (of 1,544 m). In contrast, in the former department of the Apennins, with Chiavari as a center, a poor, mountainous country, where people were undernourished and had to work very hard, the average height during the same three years was 1.56 m, and rejections for military service was as high as 30 percent (Villermé 1829:352). See also Villermé (1840).

[2] Illiterates averaged 164.3 cm, while those able to read and write were 1.2 cm taller. Presumably literate men came from wealthier families, and spent more time at education and less at work than did illiterates. Moreover, those able to avoid military service by paying for replacements were one cm taller than those who actually enrolled in the military. See also Ladurie et al. (1969), Ladurie and Bernageau (1971), Ladurie (1979), Ladurie and Demonet (1980), Aron et al. (1972).

[3] At that time, however, there was still some open questions about the mechanisms that cause stunted growth: In a study on the effect of an 18-month long administration of vitamin B12 to

rural children of preschool and school age in Guatemala in 1958-59 Scrimshaw and his colleagues found that vitamin B12 had no significant effect on the children's growth. The children in the INCAP study were already too old for vitamin B12 supplements to have a significant effect on their growth (Scrimshaw et al. 1959:183).

[4] Berg stated that even if children in some parts of the developing world survive diseases caused by malnutrition, there is evidence that: „For a sizable portion of the survivors, malnutrition permanently retards physical growth. In many countries the average twelve-year old has the physical stature of an eight-year old in Europe and North America. Indian nutritionist Dr. C. Gopalan reports that 80 percent of preschool-aged children in the rural areas of his country suffer from malnutritional dwarfism. The effect of this on productivity and the limits it places on the individual's potential contribution to his society are obvious." Berg claimed: „It is now suggested that malnourished children are basically dull." (Berg 1967:126-7)

[5] Bengoa emphasized the need for a single indicator of malnutrition to assess the social significance of protein-calorie malnutrition (PCM), sometimes called protein-energy malnutrition (PEM) and listed the advantages of height as the most relevant indicator of malnourishment: " 1) The height of children 7 years old summarizes with objectivity the past history of the community in terms of nutrition (usually associated with other health problems). 2) Children of 7 years are entering school, which facilitates the task of measurement. The age of 5, or 6, years would be equally suitable, if this is the age of entrance into school. 3) Height represents a good indicator of physical development and in many respects it also reflects some parameters of functional development. Short boys have a significant reduction in average hemoglobin, protein, and albumin levels in comparison with control boys of the same geographical area,... 4) There is also some evidence of a relationship between height and schooling performance in low social groups… 5) The index is sensitive, as suggested by the great differences among social groups in a given country. In Costa Rica, for example, which is a country

of great homogeneity in racial origins, the percentile 50 of the height of boys 7 years old in urban areas is 118.7 cm. But the percentile 10 is 109.2 cm, and the percentile 90 is 126.2. This range is apparently greater than can be accounted for by genetic differences, but can be explained by environmental factors among which nutrition is the most important in this case. The sensitivity of the index is shown also by the example of Japan, where the height of 7-year-old boys increased from 112.3 cm in 1948 to 116.8 cm in 1963, paralleling improvements in the national diet and general health condition. 6) The heights of children are apparently closely related with the socioeconomic index developed by the U.N. Research Institute for Social Development […]. 7) The selection of boys, instead of girls, is justified by the fact that they seem to be more sensitive to environmental influences, at least as reflected in social class." (Bengoa 1973:113-4)

[6] Working at the International Monetary Fund and at the University of Michigan.

[7] Using height for age was justified by the fact that it "provides a measure of whether a child is physically stunted in its structural development due to *chronic* nutrient deficiency" (Heller and Drake 1979:207).

[8] H. Goldstein, a statistician at the Institute for Child Health, came to a similar conclusion in 1971, showing that 7-year old children in professional and managerial families in England were 3.3 cm taller than those whose fathers were unskilled manual workers (Tanner 1981:387).

[9] Reynaldo Martorell from the Food Research Institute at Stanford University made similar observations on the nutritional status of low compared to high income groups in the US. He argued that household income had only a negligible influence on stature in a developed country like the US, because the nutrition even of the poor was sufficient, so that growth would not be affected. He suggested that data from developed countries such as the US would be useful in studying genetic factors that influence height. In developing countries, on the other hand,

he continued, with chronic malnutrition as a common occurrence, the socioeconomic environment would loom much larger as an explanation for population differences in stature than it would be the case for genetics (Martorell 1988:64). However, more recent studies show that there is evidence that individuals from low socio-economic groups are shorter than individuals from higher socio-economic groups (Boström and Diderichsen 1997:860-6).

[10] The observations made by Spurr about height confirmed the results of a study made by Satyanarayana et al. (1977) about industrial factory work of presumably less intensity than sugarcane cutting. The subjects were nutritionally normal workers engaged in the production of detonator fuses which could be measured in terms of the number of fuses per day. Height still significantly correlated with productivity.

[11] In this publication Spurr had not mentioned that malnutrition caused stunted growth. He rectified that oversight in a later article, adding that “adult height [is influenced] by past nutritional states during the period of growth” (Spurr 1988:219).