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Linear Growth as an Index of Nutritional Status

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In an earlier publication[1], evidence to indicate that heights of populations are generally an index of their all-round development had been reviewed. While environmental factors may be major determinants of heights of populations, ethnic differences with regard to patterns of linear growth cannot be entirely ruled out. The long-limbed Sub-Saharan and Masai tribes of Africa have, for generations, been significantly taller than, for example, the tribes of Uganda. Much of the shortness of the Japanese of earlier years was attributable to the relative shortness of their lower-limbs and not to their sitting-heights[2]. Indeed the secular trend in linear growth observed in the Japanese in the post-War years has been due to increase in limb-length rather than in sitting-heights[3]. These differences in growth pattern among different ethnic groups should caution us against universal application of "International Standards" in growth, and against sweeping across-the-board, international comparisons of nutritional status of populations based on their heights. It should, however, be the endeavour of policy makers to ensure that environmental constraints on, not only linear growth, but also on other attributes conducive to productivity and well being of their populations are removed, so that their genetic potential may find full expression.

Secular Trend: The attainment of levels of linear growth, which are an expression of the full genetic potential, is a multi-generational phenomenon. Populations of the countries of Europe[4], North America[5] and Japan[3], after attaining relative affluence and freedom from poverty, had the benefit of a secular trend in linear growth (increasing heights in successive generations) for several decades before they attained their present heights. The secular trend would now seem to have plateaued off or to have slowed down considerably, in these countries. The National Centre for Health Statistics (NCHS) data apparently represent the peak levels of heights attained by populations of the USA. The subsequent Centre for Disease Control (CDC) growth charts[5] of 2000 A.D do not show any significant increase in heights of American populations, indicating that the plateauing-off stage of linear growth had been achieved in the USA by 1975. The secular trend in Japan seems to have slowed down or ceased by 1990; on the other hand the secular trend in European countries seems to continue, with the result that the heights of European men today outstrip those of the USA[6,7].

However, long before attaining their present heights, the populations of these developed countries had reached a satisfactory state of health and nutrition. They did not have to wait for the plateauing-off of the secular trend in their heights before achieving reasonable levels of health/nutrition. It would seem reasonable to argue that acceptable levels of health and nutrition can be achieved long before populations achieve maximal heights consistent with their genetic potential for growth as a result of a secular trend.

There is no evidence that increase in heights, due to a secular trend, beyond the level at which satisfactory health/nutrition status had been achieved, has resulted in further enhancement of the nutritional status of populations of USA or Europe. For example, the Swedish population, thanks to the country's social security system, had attained good health and nutritional status several decades ago[8], but are still showing signs of a secular trend in linear growth [6,7]. Indeed there is evidence that a secular trend may not be an unmixed blessing. While increase in heights to a level which represents the full expression of genetic potential may be welcome, the secular trend, in some cases, has also been characterized by increase in Body Mass Index (BMI) and an increase in prevalence of over-weight and obesity[9,10]. Increasing affluence associated with advanced development could apparently promote undesirable changes in lifestyles and dietary practices.

Inputs which facilitate the full expression of genetic potential for linear growth need not necessarily be expected to promote such full expression of genetic potential with respect to all other physical, intellectual and mental attributes relating to peak

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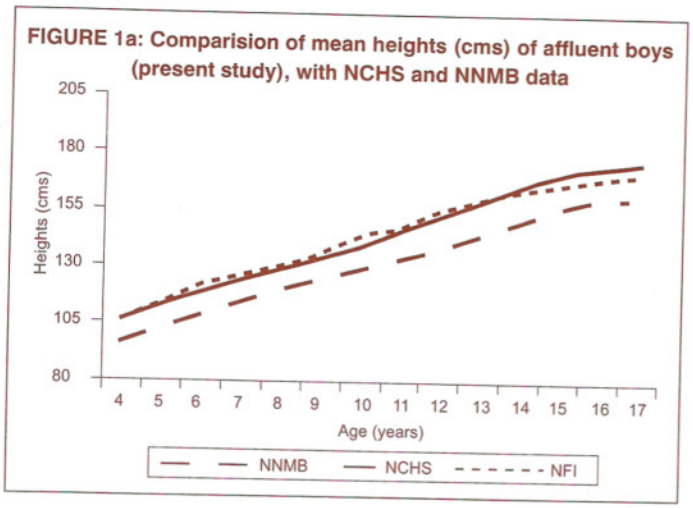
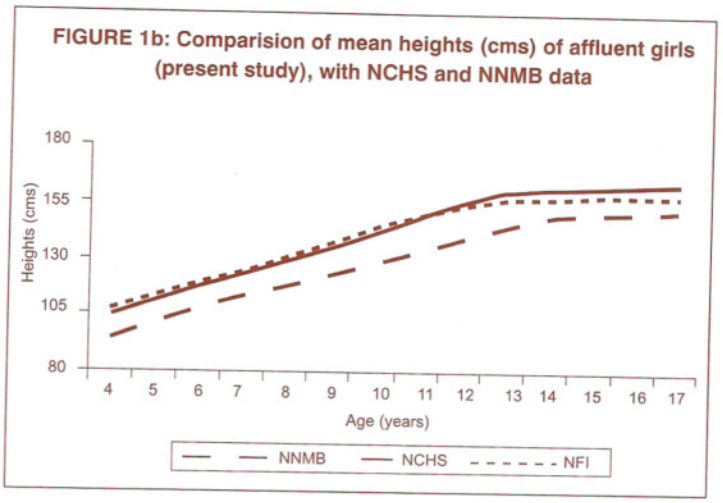




human functioning. These latter may require different physical and intellectual inputs, which may not always run parallel with inputs for increased linear growth. However, height, being easily measurable, may be a convenient index of overall development.

There is currently no evidence of a secular trend with respect to attributes relating to human functioning other than height. It may be possible for poor populations to attain acceptable levels of performance with respect to such attributes (other than heights) within one or two generations, without waiting for the multigenerational secular trend needed for near-maximal heights. That is, populations of developing countries just emerging from poverty, which, have not had the benefit of generations of secular trend (associated with relative affluence) may possibly be able to attain acceptable levels of nutrition and functional competence within one or two generations, if proper inputs are supplied, well before they attain near-maximal height consistent with their genetic endowment.

Under the circumstances, a question that has been frequently raised is : are International Anthropometric Standards (which pertain to highly developed countries which had enjoyed decades of affluence and secular trend) acceptable for the measurement of under-nutrition in poor populations of developing countries that are just emerging from poverty and which have not had the full benefit of secular trend in linear growth?

The Indian Situation: The socio-economic levels of population segments in India are widely divergent. We had shown in our earlier studies that International Standards based on NCHS are, in fact, applicable to Indian population segments of children and adolescents belonging to the affluent sections[11]. The growth pattern of the latter, unlike the growth patterns of the poor sections of the Indian population covered by the National Nutrition Monitoring Bureau (NNMB) correspond closely to International Standards (Figures 1a & 1b). Therefore, while, the acceptance of International Standards as the final long-term goal of growth and development of Indian children and adolescents may be justified, International Standards derived from populations of developed countries (which have had the benefit of decades of secular trend) may not be appropriate yardsticks against-which to measure "under-nutrition" in population segments just emerging from poverty. The use of such yardsticks could give a false, exaggerated picture of the quantum of "under-nutrition" in a poor community.

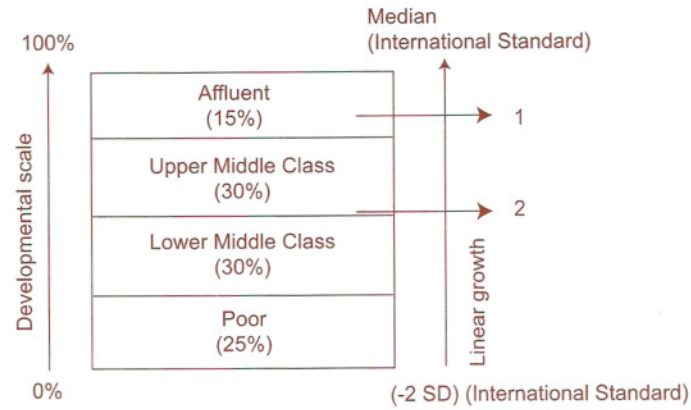
Unlike populations of developed countries, populations of agrarian and pastoral communities of the Third World had been showing no secular trend in growth[12]. Similarly, populations below the poverty line in India, unlike affluent sections, had also shown no evidence of a secular trend for several decades[13]. However, Indian population segments emerging from poverty are now beginning to show evidences of a secular trend[14]. The present gross disparity in the growth performances of Indian children of the highly affluent sections on the one hand, and those of the poor on the other, are a reflection of this situation.

Prevalence of "Stunting" – Waterlow had introduced the term "Stunting" to describe deficits in length/height of children at various ages compared against International Standards[15,16]. According to the National Family Health Survey (NFHS) Report of 1992-93[17], 52% of India's under-three-year-old children are "stunted", meaning that their lengths are below -2 SD of International Standards (NCHS). The National Nutrition Monitoring Bureau (NNMB), in its Annual Report for the year 2000-01, has reported that 49.3% of under-fives are stunted[14]. These surveys largely pertain to poor rural populations and do not generally capture the upper-middle-class and the affluent sections. Most importantly, the yardstick used in both these surveys, namely the "International Standard" (NCHS), may be inappropriate for the reasons discussed earlier, and could have led to an overestimation of the magnitude of the problem. The fact that the NCHS standard for under-threes, which is based largely on infants and children receiving artificial feeds (and not breast milk), may require downward revision has now been recognized. The WHO is coming out with such a revised standard[18] based on the growth performance of breast-fed infants of some selected countries including India[19]. However, even this revised standard will be based on data from the most affluent sections of the populations of these countries, which may be presumed to have had the benefit of a secular trend over some decades; therefore even after such downward revision, the WHO standard, may not be the appropriate yardstick for the assessment of stunting.

It is important that developing countries identify local standards for the assessment of stunting of under-five-year-old children in their populations. The National Institute of Nutrition (NIN), had proposed a local standard based on measurements of well-to-do sections of the population. How-

ever, the sections of population chosen in these studies [20,21] belonged to the affluent groups, whose growth performances nearly match the NCHS standard. The appropriate standard against which to estimate stunting could be derived from measurements on local populations belonging to the country's middle-class groups, who do not suffer from scarcity of basic necessities of food, clothing, shelter, and health care, and who enjoy good health and nutrition; these populations are unlikely to have had the benefit of decades of secular trend after emergence from poverty (Figure 2). The use of such a local standard could facilitate better targeting of nutritional intervention to really needy children. It is likely that such a yardstick for Indian populations may nearly correspond to –1 SD of the International Standard. This, however, needs to be confirmed.

FIGURE 2: Socio-economic Profile of Indian Population
A Diagrammatic Illustration



1. **Conform to international growth standard**
2. **Level of linear growth with acceptable levels of health and nutrition (yardstick for measuring stunting)?**

Etiology of stunting: There is, however, no denying the importance of the problem of stunting in children. There are apparently two components involved in stunting – a post-natal component attributable to repeated infections and poor child care, and a pre-natal component caused by intra-uterine growth retardation (IUGR) arising from poor ante-natal care and poor maternal nutrition, which could result not only in low birth weights but also in the offspring being "programmed" to grow in a sub-standard growth trajectory[22,23]. Stunting brought about by either of these components is clearly unacceptable. Reports indicate that 25% of children born in Government hospitals in India that cater to the poor segments of the population, are of low birth weight (<2.5 Kg)[24]. The incidence of low birth weight deliveries in the most affluent sections in India is, however, as low as 6%[24]. The incidence of low birth weight deliveries is apparently in conformity with the socio-economic gradient.

Nearly twenty years ago, I had rebutted the hypothesis that "smallness" in poor children of developing countries was acceptable as being "costless biological adaptation" and had emphasized the need to combat stunting[25].

The picture with regard to child health in India has changed in the last two decades. Thanks to the vigorous immunization programme and improvement in health services, infections in childhood are now better controlled; infant and child mortality have steeply declined; and significant success with regard to child survival has been achieved. The NNMB surveys show that stunting (height for age below -2 SD of International Standard) had declined from 78.6% in 1975-79[13] to 49.3% in 2000-01[14]. Since NNMB operations cover the same population groups in 5-year cycles, this would show progressive reduction in stunting in fresh crops of children. The challenge now is to accelerate this trend so that by 2010 stunting would be largely eliminated. Chen Chunming, had also shown that striking reductions in the prevalence of stunting could be achieved through appropriate preventive measures[26].

While childhood infections and poor childcare have not, as yet, been completely eliminated, it seems reasonable to argue that pre-natal factors contributing to IUGR currently predominate in the development of stunting. It would appear that in the present context, the battle against stunting has to be fought even more by the obstetrician than by the paediatrician. We must now concentrate on combating the prenatal factors contributing to IUGR, on pre-marital counselling and care of the adolescents, and also on improved antenatal care and maternal nutrition.

Combating stunting: There has been considerable confusion regarding the precise directions in which maternal diets during pregnancy should be improved, in order to overcome poor pregnancy outcomes. The results obtained with improved protein, calorie and micronutrient intakes have been either negative or unimpressive[27,28,29]. Recent studies, however, seem to provide some important leads. Indian diets are low in n-3 fatty acids. It has also been shown that the ratio of n-6 to n-3 fatty acids in Indian diets is unacceptably high[30]. Studies at the Nutrition Foundation of India have shown that administration of 15 mL of soya oil, which is a good source of n-3 fatty acid, along with 100mg of elemental iron and 500 mg of folic acid in pregnant women from the 22nd week of gestation till delivery, resulted in significant reduction in the incidence of low birth weight deliveries[31]. This observation is in line with studies carried out in other countries with other sources of n-3 fatty acids[32,33]. Since many inexpensive food sources of n-3 fatty acids are within the reach of the poor, this would be a feasible method of combating the low-birth-weight problem. Such inputs can contribute to better pregnancy-outcomes, help to overcome IUGR and minimize the problems of low birth weight and stunting. A "life cycle approach" addressed to adolescent girls, pregnant women and children, and the improvement of habitual household diets would be necessary to bring about durable results.

In children, who as a result of stunting, suffer irreversible limitations of linear growth, public health policy must be directed to ensure that these children have appropriate weights for their heights (normal BMI), and that they do not suffer from "wasting". It is becoming even more important to ensure that these children do not end up as short obese adults with abnor-

mally high BMI – "the first generation affluent" who may be potential victims of Type II diabetes, the incidence of which is now showing escalation in the present context of developmental transition[34,35,36,37]. This is a point to take note of in the implementation of the several supplementary feeding programmes which are currently being beamed to poor children.

Catch-up growth: There has been considerable debate as to whether catch-up growth adequate to completely reverse childhood stunting can be achieved. While impressive catch-up growth following ailments like coeliac disease[38] and trichuris[39,40] infection have been reported, there has been no such evidence of significant catch-up growth in under-nourished stunted children[41]. Satyanarayana's classical long-term study[42] of stunted children in South India showed that, while some degree of catch-up growth may occur, significant deficit in growth persists even in adulthood. Martorell et al[43] had also failed to find evidence of reversal of stunting in Guatemalan children. Waterlow[44] draws attention to the observation of Tanner that "at some stage before the age of five, children are locked in a trajectory from which they cannot then escape". A classical study[45] in Sweden on poor Indian adopted infants had shown that promotion of rapid catch-up growth in children born with low birth weight had actually precipitated an earlier onset of puberty and a consequent reduction in the duration available for growth. As a result these children ended up with heights even less than those attained by children of less privileged groups in India. There have been no long-term studies to investigate the effects of diets providing adequate levels of calcium and zinc on linear growth in stunted children. While the question of reversibility of stunting may need further investigation, on the basis of current evidence, it would appear that our public health policy should be directed towards prevention of stunting rather than on its reversal.

Prospects for the future: The important point, however, is that, even if the factors presently contributing to stunting in poor communities are eradicated within the next decade, the generation of children so freed from factors contributing to stunting will not automatically achieve heights comparable to current International Standards. This may need several years of secular trend, as has been the case with the affluent sections of the Indian population. The effect of generations of poverty on linear growth of offspring cannot be overcome in one generation. Several years ago Stewart et al[46] had shown that the progeny of rats, on restricted protein diets, required three generations on normal diets before they were able to attain normal size. It should, however, be possible to ensure that the growth performance of under-fives in poor countries within the next 10 years do not fall to levels below –2SD of standard. The growth performance of such children could still be between –1 and –2 SD of the chosen standard; but we would have placed this community of children and their future progeny on the ascent in the developmental scale.

The present wide disparities in linear growths between the affluent and the poor is a reflection of prevailing socio-economic inequalities and inadequate primary health care for the poor. The challenge before policy makers and public health professionals of developing countries is to narrow down these disparities through eradication of poverty, better antenatal care, promotion of better child rearing practices, and better education and health care.

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