Demography India (2017)
Vol. 46, Issue: 1, pp: 22-37

ISSN: 0970-454X

Research Article

An Appraisal of Anthropometric Data and Factors Influencing Height of Indian Population

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Abstract

In this study, an attempt has been made to examine the quality of anthropometric data for three rounds of NFHS. As India is a vast country, hence an attempt has been made to examine height of children and adult living in different agro-climatic regions. The gain in the height of children and adults also been studied over the rounds of NFHS. An attempt has also been made to examine the influence of food security, and food diversity on the height of children in the state of Maharashtra.

Introduction

According to Eveleth and Tanner (1976), "two genotypes that produce the same adult height under optimal environmental conditions, may produce different heights under circumstances of privation." Extreme poverty at the individual level results in retardation and stunting (Steckel, 1995). In the recent studies, food security and nutrition are discussed extensively (Larrea, and Kawachi, 2005; Ansari-Baig et al., 2006; Ajao et al., 2010; Osei et al., 2010). A widely used definition of food security states that "all people at all times have both physical and economic access to sufficient food to meet their dietary needs for productive and healthy life" (Coates et al., 2007). Recent evidence makes it clear that in a poor resource setting, a child experiences theadverse impact of nutritional deficiency in early life, i.e. the period beginning with the woman's pregnancy and continuing until the child is 2 years old. The deficit in height (stunting) is difficult to correct; however, a deficit in weight (underweight) can be recuperated if nutrition and health improve later in childhood.

Many studies have demonstrated it that socio-economic factors, such as poverty, water, sanitation, education and gender inequality, are determinants of the nutrition status of children (Hong and Mishra, 2006; Kamal et al., 2010; Bharati et al., 2011; Mamidi et al., 2011; Kamiya, 2011; Coeffy et al., 2013). Apart from biomedical reasons of malnutrition, it is deeply rooted in poverty and unprivileged social environments (Singh et al., 2009). On the other hand, economist taking the example of African and Indian children argued that the differences be mainly due to genetic factors (Panagariya, 2013). Within a country like India, there is much more significant variation than over the best-off groups in different countries for mortality and nutrition of children (Habicht and Martorell, 1986; IIPS and Macro, 2007, Arnold et al. 2009). Moreover, it is difficult to prove a direct relationship between height and mortality (Alter, 2004).

Looking at the current debate on nutritional status in India, there is a need to answer three questions. First, quality of nutrition data and use of international standards for India is to be examined to justify the use of nutrition data. Second, there is a need to examine the trend of nutrition status under different food availability zones and level of poverty to reply whether it is dependent on food or not. Third, how food security at household level and the disease free environment is improving the nutritional status of children.

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In the NFHS, anthropometric data quality is not discussed, and it is required to examine the quality of nutrition data and discuss the issues related to use of the actual height over the Z-score. A significant percentage of missing information may give rise to the problem of reduced sample size and less efficient estimates, and results can be biased as subjects with missing information are not necessarily the same as those with complete data (Quaranta, 2007). In the context of height and weight of children, it is crucial to have very precise training and skills to collect anthropometric data. Apart from training and skills, parents may also refuse for anthropometric data of children as an infant and young children feel uncomfortable by use of instruments and procedure or sometimes start crying. Hence, it is foremost to examine the extent of missing data of nutritional status as well as for Z-score in all three rounds of NFHS.

India is a very vast country with different agro-climatic regions, and availability of food vary in these zones. People also developed the food habits based on the availability of food. Hence, there is a need to examine the relationship of these factors rather than the use of income or political boundaries. It will also help us to examine the changes in the level of nutritional status of the children over the last 20 years. In this paper, only the height of children under-two is considered for comparison purpose.

An examination of feeding practices of children is vital to study the growth of children. Usually, due to improper infant and young children feeding practices, healthy children will fall short of standard height. Feeding practices of children will depend upon the food availability in the household. Hence, it is imperative to consider the impact of food security at household level. Household food security data is only available for Maharashtra, and this analysis is restricted to only for this state. Along with the availability of food, an attempt is made to examine the influence of disease- free environment, genetic and child characteristics on nutritional status. Height is considered in the paper as a good indicator of nutrition. It is the result of biological potential and net nutrition or diet minus the claim on it by disease and work (Prince and Steckel, 2003; Indian Genome Variation Consortium, 2008). Evidence suggests that proper feeding has a positive impact on the height of the children.

Data and Methods

The study used data from the three rounds of National Family Health Survey (NFHS) conducted during 1992-93 (NFHS-1), 1998-99 (NFHS-2) and 2005-06 (NFHS-3). NFHS is the Indian version of the Demographic and Health Survey (DHS). NFHS provides information on height and weight of children under 5 years of age (under 3 years for NFHS-2) in all the three rounds of the survey. This study focused on the height during the first two years of age to maintain uniformity in data and also because the first 1000 days of life are a crucial period regarding growth and development. Height is the product of genetic potential and net nutrition(the difference between food intake and losses due to diseases and activates) in early childhood (Deaton, 2007). The data also provide the adult height of men and women in NFHS-3 and height of women in NFHS-2. At the all India level, the trend of the height of children and adult is studied by agro-climatic regions using three rounds of NFHS. Association of food security, complementary feeding and other socio-economic factors with height is examined using CNSM data. It is done purposefully to use the Comprehensive Nutrition Survey of Maharashtra (CNSM), 2012 data, which is most recent and covers feeding practices and food security.

Percentage missing cases for actual height and Z score are calculated by age and compared. Reliability of anthropometric indicators is examined by age and sex of the child and age group of women using skewness and coefficient of variation. The states are divided into agro-climatic regions using the classification adopted by Khanna (1989). Khanna (1989) divided the country into 15 agro-climatic zones based on physiographic and climate. Purpose of considering agro-climatic zones in this paper is to explore the food availability(cereals) and its association with the nutrition of the population. In the case of NFHS-3 data, district identifier is not available. Hence for all three rounds, states are clubbed into a zone where the major proportion of state is falling. The Western Himalayan region (WHR) and Eastern Himalayan region(EHR) are same as the classification given by Planning commission except that in the EHR West Bengal is not included. In the Trans Gangetic plain region (TGPR), Delhi, Haryana, and Punjab are included. The regions namely lower, middle and upper Gangetic plain (LMUGPR) compromising the state of Uttar Pradesh, Bihar, and West Bengal are combined here. In the Eastern plateau and hill region (EPHR), Chhattisgarh, Jharkhand, and Orissa are added as one region. On the other hand for Central and Western Plateau and hills regions (CWPHR), Madhya Pradesh and Maharashtra are clubbed together (Coastal zone of Maharashtra is not possible to separate from the state). In the case of Southern plateau and hill region (SPHR), state of Andhra Pradesh, Karnataka and Tamil Nadu are clubbed (Coastal zone of these states is not possible to separate out). In the West Coast plains and ghat region, Kerala and Goa are added. Gujarat (GPHR) is a separate region along with Dadar & Nagar Haveli and Daman & Diu in agro-climatic zones. A major part of Rajasthan (MIR) comes under Western dry region, and it is kept as a separate region although some part of this state falls in TGPR and Central plateau and hill regions.

The percentage of poor is calculated by wealth index and the differences in mean height of boys and girls (6-23 months) are calculated by agro-climatic regions and percentage poor. Finally breastfeeding status of children was examined by calculating the breast feeding indices using CNSM data. Finally, a multivariate analysis for the height of children above six months is carried out using the child feeding and food security indices along with some other characteristics like safe disposal of stool, the source of water, etc.

Results

Quality of Anthropometric Data

After the 1990s when DHS data was widely available, researchers have mostly used Z-score for height that is in reference to a standard population - NCHS or WHO reference. In the case of India too, nutrition research results are presented in terms of -2sd or -3sd percentage. However, there is a serious need to consider the actual height (weight) data of children obtained from various national level surveys. Deaton and Dreze (2009) discussed the limitation of anthropometric data of NFHS and confusion about the recent changes. Rajan and James (2008) compared sibling data for nutrition and reported the inconsistencies in NFHS-3.

Collection of length data for under-two children is much problematic than weight. Length of under-two children is taken by placing them on infantometer or meter scales then knees have to be pressed to get the actual length. In this process of taking the length of the child, sometimes a child will start crying then mother or caregiver can become apprehensive and refused the measurement of length. Hence, there is a need to examine the quality of data of length/height scientifically by considering percentage missing cases. Therefore, quality of actual height data of children and its comparison with women's anthropometric data over the three rounds of NFHS is carried out in this paper before discussing the trend. Hence, as a first step in the analysis, the study examined the percentage of missing cases of actual height in the study population by different socio-economic characteristics.

Missing Cases

Missing percentages with respect to the actual height of children and Z-score are presented in Table 1. In the case of NFHS-1, data on height for two-third under-two children was not available. NFHS-2 and NFHS-3, missing information for children, are similar. In the case of NFHS-3, height data of 11.6 percent under-two children is not available (Table 1). Missing data for z-score for the same age is 18.9 per cent. The difference in missing cases by actual and Z-score exists as Z-scores are not computed by *WHO Anthro 2005 package* for the cases when anthropometric measures are of extreme nature or inconsistency is found between height- weight and age. It is expected that in a large scale data collection, around 12 per cent children are not covered due to refusal, but it is essential to consider the characteristics of these children for whom height data is not available.

Actual height data for seventeen percent children of below six month children are not available. In the same age group in NFHS-3, Z-score for 31 percent children is not available. Such a vast difference shows the inconsistency and extreme height-weight and age data for under six month children. For other age groups, 5-6 percentage points differences are noticed between actual height and height for age Z-score. High missing percentages of actual height are found for urban areas, followed by Muslims, and rich households. The Z-score for 25 percent urban children and around 20 percent for Muslim, Christian, scheduled tribe and rich households are not available. Hence, it may be said that the anthropometric data is little skewed about rural and poor children for under-two children.

Reliability and Outliers in Height Data

Percentage difference of missing information on actual length/height data and Z-scores gives an idea about the reliability of anthropometric data. A better measure of reliability would be the Coefficient of Variation (CV) which is used to highlight data quality (Ashenfelter, 2010). The choice of CV in the surveys is based on the goal to produce a standardized measure of reliability that might be easier for users to interpret (Ashenfelter, 2010). Usually, margin of error (MOE) is provided in the survey, but data users routinely ignore the MOE. The classification of the coefficient of variation suggested by Ashenfelter (2010) for examining the quality of the indicator is as follows: excellent (CV < 10), good (10 <= CV< 30), fair (30 <= CV < 61), and poor (61 <= CV < 100).

There are noticeable changes in the measure of the coefficient of variation indicator over three rounds of NFHS data of height (Table 2). Overall, the reliability of height data may be considered as good according to the above classification for boys and girls (CV is calculated separately for boys and girls as height depends on gender). Another indicator of data quality is skewness that represents the shape of the curve based on height data. This indicator had shown a drastic decline in the third round of NFHS (Skewness reduced). It may be noted that, in the second round of NFHS, skewness was quite high among some age groups of children. Based on these indicators for the reliability of height data, it may be said that anthropometric measurement improved over the last 20 years periods. Similar findings are also reported by Desai and Thorat (2013). It may be due to the better equipment and training of field staff. An attempt is also made to examine and compare the reliability of height data for women for last two rounds of NFHS (Women height data is available for NFHS-2 and NFHS-3 only). Quality of data in terms of the coefficient of variation and skewness is excellent in NFHS-3 for women and overall good in NFHS-2 (except skewness) (Table 3). It shows that there was some problem of measurement of length/height for children whereas investigators were trained properly, and equipment for measurement of the height of women/men was good.

It is also vital to examine the extent of outliers in the data. It has been done for three rounds of NFHS to show the extent of outliers in the actual height of children. Outlier's analyses of height for children are carried out by data generating indicator namely using quartile range(only for NFHS-3) as well as a percentile of height standard of WHO reference population (three rounds of NFHS) (WHO, 2006). Percentage of extreme values from the data generated inter-quartile range (IQR) is in the range of 1-3 percent in NFHS-3. However, extreme values in comparison to WHO standard is substantial. Percentage children below percentile one of WHO standard are more than 35 percent for age group 18-23 (NFHS-2, 40% and NFHS-3, 37%). It may also be noted that for children under six months, around five percent children are above 99 percentiles (NFHS-2 and NFHS-3). The extreme values of height above 99 percentiles give an indication that there is a need to collect the anthropometric data with caution in large- scale surveys.

Comparison of Mean Height with WHO Standard

Mean height for boys and girls by single month are compared with WHO median standard for boys and girls. From Figures 1A and 1B, it can be seen that, for all three rounds, median figures are more or less similar. In the early months of life of children, deviation of the median height of Indian children from WHO standard is minimal. However, as the age of children is increasing, deviations from WHO standard population are also increasing. Similar results are also found in a comparison of height with NCHS reference population (Desai and Thorat, 2013). Growth curves developed using NFHS data of healthy children living in the disease free environment also shows that the pattern is similar to Khadilkar et at (2007) whereas it was below WHO 2006 pattern (Patel and Unisa, 2014). The pattern of the growth curve of India shows that children do not have catch-up according to WHO standard as they are not living in a disease free environment or not having proper food due to socio-economic and cultural factors. Hence, there is urgent need to have Indian standard based on longitudinal data of children.

Agro-climatic Regions of India and Height of Children and Adults

A region-wise analysis of height of children and adult will help us to understand the differences within a vast country like India. For this purpose, agro-climatic regions of Indian are selected as it relates to the availability of food and food habits of the people living in these regions (Farrow et al., 2005). Apart from this they will have similar climatic conditions, occupation and other habits.

Trend of Height by Agro-climatic Regions

In Table 5A and 5B, mean height of children by age groups and agro-climatic regions are shown. Overall an increasing trend of height is seen for boys and girls over the last twenty years in all agro-climatic regions. On average 3-0.5 centimeter increment in the height of children is noticed in height from NFHS-1(1992-93) to NFHS-3(2005-2007). Improvement in height is noticed for boys as well as girls by age. Mean height of boys and girls are presented separately and arranged it according to descending order of height (Figure 3A and 3B). In all three rounds, Western Coastal (WCR) belt children compromising of Kerala and Goa states are doing well in terms of mean height followed by children from South plateau and hills regions (SPHR). Ranking of regions according to the height of boys and girls is not same. There were also some discrepancies in the data of NFHS-2 for Eastern plateau and hill region (EPHR), Rajasthan, Western Himalayan region for boys and girls. Gujarat plateau and hill region (GPHR) and Eastern Himalayan region (EHR) data for boys and Western Himalayan region (WHR) data for girls in NFHS-2 are found inconsistent.

An attempt is also made to examine the height of women in the second and third rounds of NFHS and for men forthea third round of NFHS (Anthropometric data for women are available for the last two rounds and men only for the third round). Mean height for 20-29 and 30-39 age groups women and 25-34 and 35-49 age groups men are chosen to take into consideration the physical maturity (Table 6). Differences in height by agro-climatic regions of adults are not same as children. Differences in mean height between these age groups for women in NFHS-2 and NFHS-3 are negligible. It may be noted that, mean height difference for men between two age groups is around 0.5 cm. In all agro-climatic regions, men are taller than women by 10 to 12 centimeter. The trend of women’s height shows that in all the agro-climatic regions, on average 0.5 to one-centimeter increase is found from NFHS-2 to NFHS-3. These results support that over the period, adult height of the population is increasing, and it is expected that this will influence the height of the children.

Association of Height by Level of Poverty in Agro-climatic Regions

In NFHS-3 wealth index is calculated using principal component method considering household assets and consumer durable items. For this analysis, wealth index is divided into three categories poor, middle, and rich. Percentage poor for each region is calculated, and the relationship of the mean height of children and adult are examined in Figure 4 and 5 by agro-climatic regions. From Figure 4 it may be noticed, that there is no clear pattern of association between poor and mean height of children. A similar pattern of relationship is found between the height of children and household poverty level by Nair (2007). Mean height of boys from CWPHR, TGPR, and LMUGPR regions are similar despite the fact that these agro-climatic regions have a different level of poverty. In the case of girls too, mean height of agro-climatic regions MIR, EPHR, and GPHR are same even with the different level of poverty in these regions.

Association of adult height living in different agro-climatic regions with the poverty level according to a wealth index of NFHS-3 is examined. Figure 5 shows the association between percentage poor and adult mean height of males in 25-34 and females in 20-29 age groups. Association of adult height and percentage poor shows clear negative relationship for males as well as for females. Exception in height and poverty relation is found for male as well as female for Rajasthan (MIR) and Eastern Himalayan Region (EHR). Looking at these two exceptions, we can conclude that poverty is not the sole factor, that explains the adult height and beyond this factor other things are also playing a role. The height of adult male and female in Rajasthan are similar to persons in TGHR region. Similar height in these two regions may be because of food habits, environment, and occupational factors.

Influence of Socio-economic and Child Feeding Practices on Height of Children

To understand the association of height with food security and food habits of children, in this paper, comprehensive Nutrition Survey of Maharashtra (CNSM) is used where child feeding practices and food habits are collected (IIPS and UNICEF, 2013). The survey covered a representative sample of Maharashtra taking with the representation of six divisions covering 2650 cases of under-two children. For the measurement of length/height and weight of children, the separate equipment according to the age of the child is used. Equipment for anthropometric measurement of the mother was different.. Coefficient of variation for boys and girls is less than 10 percent and skewness is less than 0.8.

Apart from giving complementary food, diverse foods are required for the growth of children. Based on feeding practices, an indicator of food diversity is constructed taking into consideration age and breastfeeding status, and it is used in the multivariate analysis (WHO, 2008). Another indicator that is used in the analysis is based on household food insecurity index (IIPS and UNICEF, 2013, Coates et al., 2007). The multivariate analysis for the height of children above six months is carried out using computed indices of feeding and food insecurity along with child and mother characteristics, safe disposal of stool, and water from the improved source. Wealth index is not considered in this analysis as it is highly associated with food insecurity. Pune region and food secure households are considered as a reference for the region and food insecurity variables. Three models are used for multivariate analyses, one with total children and other two by gender of the child. Results of the multivariate analysis are presented in Table 7.

In all three models, R square and adjusted R square are above 60 percent that shows the fit of models using the explanatory variables is good. As expected, the height of the children is increasing with an increase in age. Another critical variable is the height of mother. On average, children born to mothers of height above 145 cm are one centimeter taller than children of mothers below the height of 145 cm. Mother's height is the reflective impact on the height of girls.

Water and sanitation are significant factors. Not only that children required complementary food after the age of six months; they do require a variety of food (WHO, 2008). All those children who had consumed diverse food items based on 24 hours recall are found better than those who did not. Food security is important variables; however, it is not found significant for all categories in regression analysis. It may be because of its interactions with regions and water and sanitation conditions, and it required further analysis.

Discussion and Conclusions

The advantage of using an international standard of growth is that it can be used for comparison of the children globally. However, to monitor the progress of nutrition programmes, it is useful to consider the minute changes in the growth of children over the period. For this purpose, country specific standards for comparison or improvements in actual height and weight is necessary (Gillespie, 2013; Lodha et al., 2013; Jayachandran and Pande, 2013; de Onis 2000; Panagariiya, 2013). . Some of the developing countries have paid considerable attention to the construction of growth curve of children below 5 years through systematic and scientifically appropriate methodology of WHO (Hosseini et al., 1999 & Hosseini et al., 2009). WHO Expert Consultation (2004) also suggested having appropriate body mass index for the Asian population. Moreover, it is argued that Indian children are also included in the WHO 2006 growth standard. Children in WHO growth curve from India were not representative of the whole country, and they were only from Delhi. It may be mentioned that the Delhi falls in the Trans Gangetic region where an adult male and female height is 4-6 cm more than people living in Eastern Himalayan region. Furthermore, we need to collect height along with weight data at the time of birth; this will be possible as the majority of the deliveries (births) now are institutional in India after NRHM. This data will help to monitor the catch-up in the height of children as well as help to understand the differences from WHO median height at the time of birth.

In the era of DHS, researchers started using the -2sd concept of the reference population rather than actual height and weight of children. In this survey main emphasis is on fertility, maternal & child care, and family planning. To get infant and child feeding practices children below five years are to studies separately not as part of women's questionnaire. There is also need to collect anthropometric data with care for children, and missing information should not distort the quality of nutrition statistics. In all three rounds of NFHS, a significant proportion of child height data was missing. It may be noted that quality of anthropometric data of adults is better than children.

In this paper, for the first time, agro-climatic regions of India are considered to study the height of children and adult. Although regions were not formulated precisely same as suggested by Khanna (1989) due to data limitation. However, region-wise analysis of the height had helped in understanding the availability of food in each zone and its association with the growth of children. Moradi (2012) reported that climate fundamentally influences food intake and exposure to disease. Moreover, studies based on climate differences and its association with stature using Bergmann’s rule suggested, that when there are major differences in latitude and temperature among groups with distance more than 50 degrees of latitude and/or more than 30 Celsius for hot to cold then differences in height are noticed (Foster and Collard, 2013).

Mean height of children in the agro-climatic regions is not same. However, on average, there is an improvement in the height of children over the period 1992-93 to 2005-06. This improvement can be the result of better ANC and child care coupled with safe water and sanitation disease free environment in the country (Voth and Leunig,1996; Coffey et al., 2013). Wherever, water and sanitation improved; improvement in height is also impressive (NFHS-1 to NFHS-3). Association of poverty and height is not very clear for children living in different agro-climatic regions from NFHS-3 data. It shows that growth of children is much more complicated phenomena than a simple relationship between income and nutrition.

Adult male and female height show a negative relationship with poverty with few exceptions like Rajasthan and Eastern Himalayan regions. In the case of Rajasthan, food consumption pattern is different, and it may be because of availability of pulses due to climatic conditions (NSSO, 2012). Protein intake and calories from non-cereals food items in the rural areas of Rajasthan Punjab, Haryana and Delhi are much higher than other areas in the country (NSSO, 2012). It is also found that consumption of milk is higher in the Rajasthan in comparison to Eastern Himalayan region (IIPS and ORC Macro, 2007). In most of the states of Eastern Himalayan region have lower protein intake in comparison to other states (NSSO, 2012). Researchers argued that people at low income can be tall using available low cost but nutritious diet (Deaton, 2007). Moreover, income distribution also plays an important role in understanding stature in different regions (Steckel, 1995). It may also be noted that cultural practices among different caste and tribes are also different. In the societies where the heads or limbs of infants were repeatedly moulded or stretched, or where either ears, noses, or lips were pierced, where they were circumcized, or had tribal marks cut or burned in their skin, the mean adult male stature was over two inches greater than in societies where these customs were not practiced (Landauer and Whiting, 1964; Fogel and Costa,1997; Ruff, 2005). These factors may also be playing a role in the difference of height between males of Rajasthan and Eastern Himalayan region.

Many Studies have demonstrated the beneficial effects of breastfeeding on infant mortality and diseases and nutrition status (Alter, 2004; Deaton and Dreze, 2009; Meshram et al., 2013). Complementary feeding and age at initiation of it are also important. Too early or too late Initiation of complementary feeding at the appropriate is also important. Too early or too late complementary food to children coupled with low quality and infrequent times can also result in the undernutrition among infants and young children (Black et al., 2008; Ajao et al., 2010). The disease also reduces the potential growth of the children. From the IIPS and UNICEF report (2013), it found that some children are given complementary food before six months, and a significant proportion of children not received complementary food after six months of age. Improper complimentary food may be lagging the children in the catch-up growth.

Dataset from Maharashtra has helped us to examine the complex nature of child nutrition by using new indicators on food. As expected, age and gender influence the height of the child. Contrary to the argument of Jaychandrean and Oande (2013), in this paper birth order, is not found significant as children ever born per family is not more than 2-3. With the decline in the fertility level, care for women during pregnancies will not be dramatically different; moreover, women will physically be more mature in later pregnancies than the first one. In the case of Maharashtra, the importance of the region where the children are living cannot be ignored as it is found in all multivariate analyses that Nashik region is behind in the growth of children. It shows environmental, cultural, health facilities and development factors play a role in the nutritional status of children (Larrea and Kawachi, 2005). the second important indicator in these analyses is mother's height i.e., mother's height with the child's height has a significant positive association. It may also be noted that mothers in Maharashtra ate less than normal during the pregnancy (IIPS and UNICEF, 2013. It may be due to nausea and vomiting in the first trimester as well as a traditional practice to keep the growth of the child under control so that women will have a normal delivery. From NFHS-3 and CNSM data, it is found that 10 percent women/mothers are below 145 cm. Women of short height will have stunted children unless the women have and allowed to give birth by Caesarian section. Thus, it will enable small women to bear tall children (Rehman et al., 1993; Deaton, 2007). Women in South Asia are short and have been proved from the available historical data, and unless they have better health services and nutritional status for one or two generations then they will have an adoption of normal height (Deaton, 2007). This point has to be kept in mind before comparing the international standard of height children as child height is the product of the environment of childhood and as well as their mother's childhood (Bogin, 1998). The researchers also argue that it will take many generations for the previously malnourished population to achieve the heights of which they are capable (Coeffey et al., 2013). Hence, it is important to examine the height of sub-population of India and decadal changes in the well-nourished population against the not so well-nourished populations. There is an urgent need to think about the current nutrition standard concerning the height of the population in India and when it will attain the WHO standard.

In case of India, nutrition-specific state-level surveys are needed to capture the local food habits of people and its association with growth and catch-up of children. If a study is designed with an emphasis on the children, then the quality of the anthropometric data will be better. There is an urgent need for Ministry of Women and Child Development, Ministry of Health and Family Welfare and Rural Development to work together for the improvement of nutrition of children and to provide disease- free environment. Most of the food items distributed either by ICDS or PDS systems are of cereal based (Gupta et al., 2013). Indian food in most of the regions is dominated by cereal based diet, and it is not based on animal based food (Alter, 2004; Deaton, 2007; Abalo, 2009; Gupta et al., 2013). The diversity of food is required for the proper nourishment of children (Steckle, 1995). Therefore, ICDS and PDS have to make a provision of pulses (protein), and calcium along with cereal items.

Note: IIPS is the nodal agency for carrying out Comprehensive Nutrition Survey of Maharashtra (CNSM), and it is funded by UNICEF. Prof. Sayeed Unisa is one of the Coordinator of this project.

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Table 1: Percentages of missing cases on actual height and Z-score for stunting for children 0-23 months by background characteristics

	Percentage of missing cases (NFHS-3)		Percentage of missing cases (NFHS-2)		Percentage of missing cases (NFHS-1)	
	Actual height	Z score for stunting	Actual height	Z score for stunting	Actual height	Z score for stunting
Age in month						
<6	17.2	30.5	17.7	28.2	38.4	47.0
6-8	10.3	16.6	16.2	21.7	38.0	42.1
9-11	10.2	16.2	14.6	19.9	44.7	48.8
12-17	9.9	14.3	16.9	22.7	33.7	37.8
18-23	9.1	14.5	16.9	23.3	38.8	43.0
Place of residence						
Urban	16.5	25.1	14.0	19.3	42.5	46.6
Rural	10.2	17.1	17.5	25.0	36.3	42.1
Religion						
Hindu	10.8	18.2	16.3	23.4	38.9	44.0
Muslim	14.9	20.9	19.8	27.2	32.7	39.2
Christian	13.4	22.2	12.7	19.8	59.2	65.1
Others	11.3	21.2	13.0	15.7	25.0	31.1
Caste						
Scheduled Caste	10.7	19.1	17.6	24.2	40.3	44.6
Scheduled Tribe	12.6	22.0	14.0	25.6	42.5	46.9
Other Backward Classes	11.4	18.2	15.6	22.6		

Others	12.3	18.9	17.1	23.6	37.0	42.6
Wealth Quintile						
Poorest	10.8	18.4	16.3	22.8	36.1	40.8
Middle	10.2	17.4	16.5	23.4	37.7	43.6
Rich	14.9	21.7	17.4	25.2	40.8	46.3
Total	11.6	18.9	16.8	23.9	37.8	43.2

Table 2: Reliability of anthropometric measures for height of children below two years

Sex of the child	Age in months	NFHS-3 (2005-2006)		NFHS-2 (1998-1999)		NFHS-1 (1992-1993)	
		Coefficient of Variation	Skewness	Coefficient of Variation	Skewness	Coefficient of Variation	Skewness
Boy	<6	13.95	0.41	11.75	-0.19	15.02	2.67
	6-8	8.24	0.68	8.83	-1.5	8.44	0.17
	9-11	9.68	2.81	7.98	-0.65	22.54	26.89
	12-17	7.47	0.85	20.24	32.77	7.92	-0.65
	18-23	9.14	2.11	8.63	-1.19	8.02	-0.87
	Total	**13.86**	**0.04**	**17.1**	**18.1**	**15.81**	**8.33**
Girl	<6	13.06	-0.76	12.25	0.01	14.18	0.94
	6-8	9.29	0.52	8.78	-2.17	10.06	-2.01
	9-11	9.55	4.63	24.37	29.82	9.48	1.66
	12-17	8.44	1.88	16.62	30.12	8.11	-0.15
	18-23	7.99	1.47	8.86	-1.88	10.65	-3.13
	Total	**14.17**	**-0.04**	**17.69**	**17.18**	**14.64**	**-0.42**

Table 3: Reliability of anthropometric measures for height of women

	NFHS-3(2005-2006)		NFHS-2(1998-1999)	
age groups	**Coefficient of variation**	**Skewness**	**Coefficient of variation**	**Skewness**
15-19	3.95	0.04	4.84	-6.57
20-24	3.66	0.05	4.34	-3.57
25-29	3.90	0.19	4.01	-1.90
30-34	3.90	0.00	4.10	-1.92
35-39	3.63	0.13	4.31	-4.47
40-44	3.51	0.07	3.95	0.24
45-49	3.85	0.04	4.72	0.44
Total	**3.80**	**0.09**	**4.28**	**-3.55**

Table 4: Comparison of Anthropometric measures of height with WHO standard for children below two years

Age in months	Data generated extreme values		Comparison with WHO percentile					
	NFHS-3(2005-2006)		NFHS-3 (2005-2006)		NFHS-2(1998-1999)		NFHS-1(1992-1993)	
	Low [a]	High [b]	Below Lower Limit [c]	Above Upper Limit [d]	Below Lower Limit [c]	Above Upper Limit [d]	Below Lower Limit [c]	Above Upper Limit [d]
<6	2.51	0.93	12.57	5.61	12.79	4.60	9.21	1.95

6-8	2.65	2.33	13.11	3.17	15.17	2.75	10.31	1.08
9-11	2.71	2.30	16.22	2.79	19.93	1.58	10.05	0.70
12-17	1.31	3.25	25.82	2.39	31.00	1.49	17.00	0.82
18-23	1.26	1.29	36.68	1.08	39.99	0.69	22.77	0.47

a: % of cases outside the range Q1 - 1.5*IQR, b: % of cases outside the range Q3 + 1.5*IQR
c: P_1-1 Percentile of WHO standard for height; d: P_{99}+1 Percentile of WHO standard for height

Table 5A: Mean height (cm) of boys by agro climatic regions and age groups, NFHS-3 NFHS-2, and NFHS-1

Age in months	WHR	EHR	MUGPR	TGPR	EPHR	CWPHR	SPHR	GPHR	WCR	MIR
					NFHS-3 (2005-2006)					
<6	58.51	58.13	58.66	59.57	57.85	58.34	58.77	57.79	61.60	59.59
6-8	68.38	66.98	66.17	68.50	66.73	67.08	67.31	66.13	69.16	67.17
9-11	70.62	69.52	69.89	69.33	70.02	68.68	70.12	68.48	71.42	70.14
12-17	74.61	73.45	73.64	73.62	73.01	73.40	75.17	73.94	74.48	74.25
18-23	79.11	78.81	76.84	76.70	77.13	77.29	79.41	76.63	78.58	76.73
Total	**70.67**	**69.48**	**69.64**	**69.66**	**69.25**	**69.87**	**71.63**	**69.34**	**72.16**	**68.98**
					NFHS-2 (1998-1999)					
<6	57.39	56.26	57.84	57.89	58.05	57.84	58.91	58.41	55.69	58.27
6-8	65.89	64.95	65.02	65.68	65.52	66.14	67.16	64.15	67.99	64.58
9-11	67.30	67.44	68.11	69.90	70.51	68.90	70.74	70.13	70.54	68.80
12-17	73.12	70.33	72.77	73.67	72.91	71.95	73.66	72.01	74.64	71.54
18-23	76.83	76.70	74.68	76.66	77.44	76.29	77.75	76.25	79.91	74.89
Total	**68.60**	**67.56**	**67.36**	**68.45**	**69.42**	**68.12**	**69.59**	**67.79**	**71.43**	**67.22**
					NFHS-1 (1992-1993)					
<6	57.92	58.07	57.49	57.34	58.26	59.69	59.38	57.67	60.14	56.48
6-8	65.14	63.93	64.46	65.84	65.80	66.45	65.46	66.46	66.08	65.85
9-11	67.30	74.10	66.56	69.98	68.90	70.00	70.10	67.96	70.36	68.15
12-17	73.84	72.51	71.44	73.76	73.16	74.09	73.78	72.46	74.73	73.75
18-23	78.34	75.04	74.94	77.20	77.39	77.37	77.29	76.56	78.98	76.63
Total	**67.66**	**67.60**	**66.61**	**68.06**	**68.19**	**68.45**	**69.36**	**68.41**	**70.41**	**67.92**
Gain in height	**3.01**	**1.88**	**3.03**	**1.61**	**1.06**	**1.42**	**2.27**	**0.94**	**1.75**	**1.06**

Table 5B: Mean height (cm) of girls by agro climatic regions and age groups, NFHS-3 NFHS-2, and NFHS-1

Age in months	WHR	EHR	MUGPR	TGPR	EPHR	CWPHR	SPHR	GPHR	WCR	MIR
					NFHS-3 (2005-2006)					
<6	57.71	56.28	57.58	58.34	56.61	55.79	56.38	58.04	61.11	57.60
6-8	65.32	65.51	64.30	65.11	64.71	64.74	65.44	64.62	69.03	66.13
9-11	69.45	67.89	68.08	69.45	68.40	68.01	70.14	68.34	69.42	68.16
12-17	72.82	73.23	71.52	72.49	71.81	71.92	73.38	73.04	73.22	72.26
18-23	78.13	77.62	75.10	76.25	75.84	75.96	77.46	75.27	78.12	76.10

Total	**69.16**	**67.94**	**67.35**	**68.35**	**67.60**	**67.44**	**69.28**	**68.57**	**71.55**	**67.63**
NFHS-2 (1998-1999)										
<6	56.80	57.40	56.87	57.35	57.87	56.29	57.68	56.99	57.43	56.39
6-8	63.46	64.09	64.06	64.10	63.91	64.35	65.65	65.27	66.19	63.87
9-11	68.85	65.96	66.44	66.33	79.34	67.24	68.60	67.09	69.87	66.43
12-17	70.71	70.28	70.12	71.80	76.77	71.30	71.98	71.81	72.51	70.30
18-23	75.84	74.57	72.91	74.74	76.11	74.94	75.84	76.57	78.25	72.93
Total	**66.05**	**66.34**	**65.95**	**67.02**	**70.55**	**67.20**	**68.21**	**66.88**	**69.09**	**65.40**
NFHS-1 (1992-1993)										
<6	56.35	55.97	57.04	56.94	58.87	57.66	57.59	55.83	57.38	56.67
6-8	63.93	63.29	63.11	63.80	62.08	65.19	64.80	63.49	65.48	62.96
9-11	66.27	66.76	67.19	67.50	68.05	68.05	69.03	67.15	68.72	67.49
12-17	71.34	71.08	70.07	71.62	71.41	72.05	72.12	70.41	73.75	72.28
18-23	77.47	74.30	72.55	75.01	75.44	75.45	75.18	73.94	77.62	75.37
Total	**67.11**	**65.21**	**65.09**	**66.35**	**67.11**	**66.93**	**66.97**	**65.31**	**68.40**	**66.33**
Gain in height	**2.05**	**2.73**	**2.25**	**1.99**	**0.49**	**0.51**	**2.31**	**3.26**	**3.15**	**1.30**

Table 6: Mean adult height (cm) by agro climatic regions and age groups, NFHS-3 and NFHS-2

Agro climatic regions	**NFHS-3(Men)**		**NFHS-3(Women)**		**NFHS-2(Women)**	
	25-34	**35-44**	**20-29**	**30-39**	**20-29**	**30-39**
WHR	166.08	165.19	153.90	153.69	153.06	153.04
EHR	162.84	162.32	150.67	150.61	150.05	149.83
LMUGPR	164.15	163.57	150.72	150.77	149.88	149.88
TGPR	167.94	168.17	154.60	154.61	153.31	153.27
EPHR	163.12	162.65	150.87	150.90	150.60	150.33
CWPHR	165.47	164.85	152.41	152.25	151.42	151.33
SPHR	164.93	164.25	152.57	152.24	151.67	151.35
GPHR	165.78	165.36	152.73	152.61	151.89	152.38
WCR	166.96	165.74	154.07	152.77	153.37	153.37
MIR	167.40	166.55	154.59	154.49	153.53	153.23
Total	**164.90**	**164.30**	**152.06**	**151.95**	**151.23**	**151.02**

Table 7: Regression coefficients of different multiple regressions models for length/height of 6-23 months children, Comprehensive Nutrition Survey of Maharashtra, 2012

Independent Variables	Total	Boys	Girls
	Coefficient - B	Coefficient - B	Coefficient - B
Constant	60.470	60.352	56.787
Age in months	0.848***	0.840***	0.836***
Gender -Boys(Reference -Girls)	-1.517***	-	-
Birth order one (reference 1+ birth order)	-0.120	-0.071	-0.300
Minimum Dietary Diversity [a]	1.064***	0.755	1.310***
Height of mother –more than 145 cm (reference <145 cm)	1.521***	1.154***	1.895***
Mildly insecure household [b]	-0.375	-0.318	-0.450
Moderately insecure households	-0.847***	-0.887***	-0.595
Severely insecure households	-0.276	-0.023	-0.618

Households with improved source of water	0.977***	0.391	1.374***
Safe disposal of stool	0.511***	0.409	0.550
Amravati region [c]	-0.846***	-0.864	-0.703
Aurangabad region	-0.492	-0.598	-0.480
Konkan region	-0.558	-0.529	-0.845
Nagpur	0.305	0.698	0.050
Nashik	-1.309***	-1.472***	-0.996
R Square (%)	66.500	65.600	64.300
Adjusted R Square (%)	66.200	65.200	63.700

a: child consumed four food groups out of eight and reference is those who consumed less than four food groups

b: Reference is food secure households ; c: Reference is Pune region

Figure 1A: Comparison of median height of boys from NFHS with WHO reference population

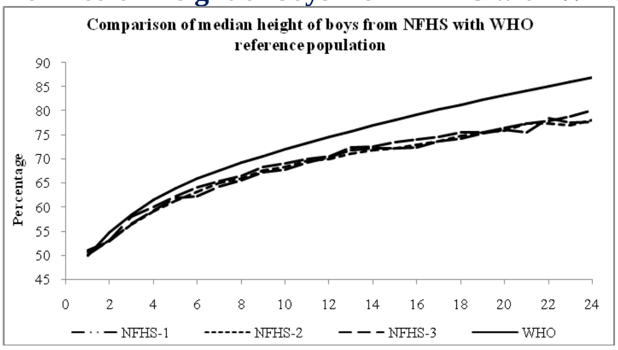

Figure 1B: Comparison of median height of girls from NFHS with WHO reference population

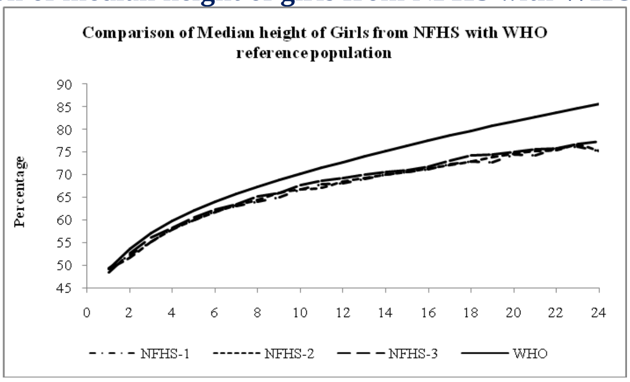

Figure 2: Agro-climatic regions/zones of India similar to Khanna (1989) classification

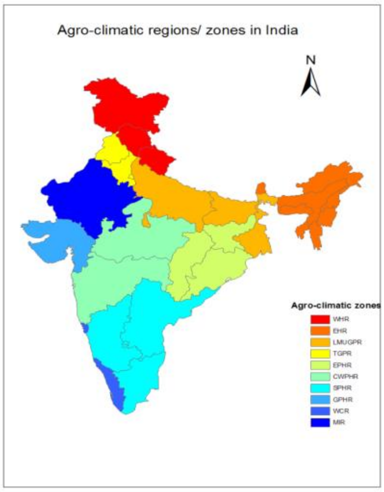

Figure 3A: Mean height of boys by agro-climatic regions, NFHS-3, NFHS-2, NFHS-1

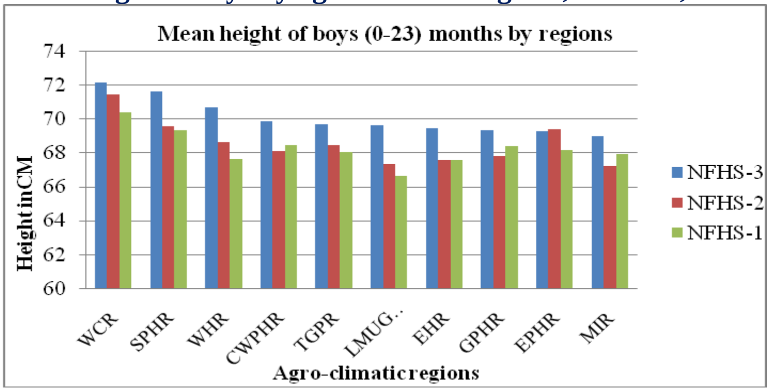

Figure 3B: Mean height of girls by agro-climatic regions, NFHS-3, NFHS-2, NFHS-1

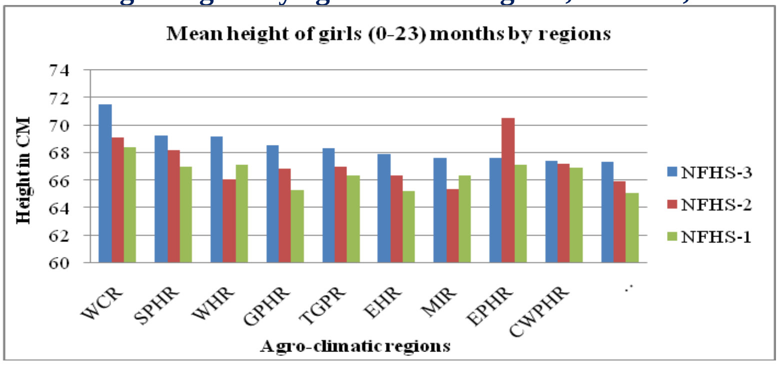

Figure 4: Mean height of children (6-23 months) by poverty and Agro-climatic regions, NFHS-3 (2005-06)

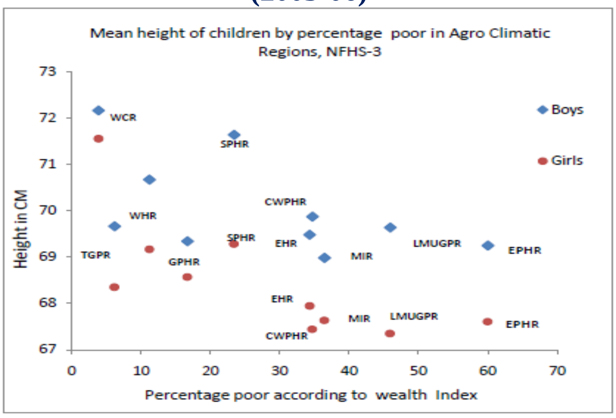

Figure 5: Mean height of adults by poverty and Agro- climatic regions, NFHS-3 (2005-06)