Growth Charts for Monitoring Physical Change of Nepalese Children

Usha Acharya (ORCID)

Faculty of Social Sciences and Education, Nepal Open University, Manbhawan, Lalitpur, Nepal

Author e-mail: usha.acharya@nou.edu.np

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Abstract

This study aimed to develop growth standard charts of Nepalese children by analyzing their anthropometric measurements. The research focused on assessing physical growth variations among major caste/ethnic groups in the Koshi Zone of Nepal. Six key anthropometric indices- height, weight, chest circumference, sitting height, bi-acromial breadth, skin-fold thickness - were measured to determine differences across caste/ethnic groups in Sunsari and Sankhuwasava districts. For growth charts development, height and weight measurements from 646 boys and 645 girls aged 2-6 years were analyzed. The LMS method (Cole & Green,1992) was applied to calculate standardized percentiles and generate smooth growth curves. Based on the clustered analysis of seven caste/ethnic groups, two distinct clusters were identified: (i)Brahman-Kshetri and Yadav-Koiri, and (ii) Kami-Mushar. Separate height and weight growth charts were developed for each cluster. The different percentile values revealed that the children from the Brahman-Kshetri and Yadav-Koiri clusters were taller and heavier than those from the Kami-Mushar cluster. These findings highlight the need for distinct growth standards to accurately monitor the growth of children in multi-ethnic nations like Nepal. The study provides recommended growth charts tailored to Nepal's caste/ethnic diversity, emphasizing the importance of population specific references in child growth assessment.

Keywords: Anthropometric measurement, growth monitoring, height and weight charts, physical growth, Nepalese children

Introduction

Many countries apply nationally derived physical growth monitoring standards to evaluate the child physical development. However, Nepal currently relies on international growth charts such as those from the World Health Organization (WHO) (Child Health Card, 2003-2004), which were not based on Nepalese child data. Furthermore, the existing physical growth monitoring charts for on the other hand, the for Nepalese infants and children lack height/length measurement scales. Although the recent Health Management Information System (HMIS -2.1) chart distinguishes weight scales by sex, there remains a critical need for comprehensive, Nepal specific growth references.

While evaluating the growth status of infants or children, it is essential to use appropriate growth monitoring standards. These standards should be based on valid and relevant data from the same or closely related race/caste/ethnic groups to avoid inaccurate evaluations. Previous studies consistently report that Nepalese children are smaller in physical dimensions compared to international benchmarks. For example, Sunaga (1984) carried out study on 398 children (3-14 years) in urban and rural areas of Kathmandu valley and reported that Nepalese children found significantly smaller in height, weight, upper arm and skinfold thickness. Evaluating criteria of that study was made with the standard of the National Center for Health Statistics (NCHS, 1979). Likewise, Martorell et al. (1984) carried out study to determine the nutritional status of Nepalese children by taking 510 samples of 3-10 years aged groups by measuring, height, weight, upper arm circumference and triceps skinfold thickness in Rautahat district (Terai). The study pointed out that body weight for height of Nepalese infants and children were referred as average low 1 to 1.5kg. The skinfold thickness was also found lower. Evaluation criteria of that study was based on the US National Center for

Health Statistics (NCHS, 1979) as reported by Frisancho (1981).

Panter-Brick (1997) observed the 0 to 4 years aged infants and children of 71 samples by measuring height and weight considering with the relation to physical growth and seasonal variation in remote village of Nuwakot district and reported that Nepalese children were found delayed growth. Evaluating criteria of that study was also based on US National Center for Health by the United States. Another study of Huijbers et al. (1996), which conducted by measuring anthropometric measurement such as: height, body weight, and upper arm circumference in order to evaluate the relationship in between socio cultural factors and nutrition status and mortality of highland children in Koshi zone in elevation of 1,700-3,000m based on 438 samples (infants and children) below the age of 14 years concluded that both infants and children in Nepal referred delayed growth. Similarly, Hosono et al. (1998) reported that Nepalese infants and children referred as smaller or delayed growth on the observation of height and body weight measurements on 759 infants and children age ranges 5-12 years growth monitoring was compared with WHO -1986 standard of body weight and Japanese growth monitoring standard -1990. Likewise, Bhandari and Kshetri (2013) stated that more than 60% children had any kind of malnutrition and nearly one fourth children of Nepal were found critically malnourished (below -3SD) and needed immediate intervention, study randomly selected 450 children under five years in Kapilvastu district. In this study analyzing software was used World Health Organization (WHO) Anthro 3.2.2 version for the anthropometric data.

Studies on physical growth and nutrition status of Nepalese children concluded that Nepalese children are smaller in physical structure, underweighted the and stunting on the basis of international standards of WHO, NCHS, and Japan. Ohsawa et al. (1996) reported that impact of life style and residing environmental factors play a significant role in the physical characteristics of people. That study was carried out by measuring seven anthropometric measurement on age ranges 7 to 18 years children and adolescents of three (Thai, Wa and Lahu) Chinese minority ethnic residing in Kunming district China. Evaluation criteria were made with Han ethnic group as principal ethnic group of China. Subsequently, a well status of physical growth, followed in Thai ethnic and growth status of other two ethnic Wa and Lahu were found significantly lower than Han and Thai ethnic groups. Among them Wa ethnic was inhabiting in the mountainous areas, which showed relatively broad body shape and chest circumference. Lahu ethnic residing in hilly zone who practiced inner family marriage were reported small in their physical structure. Thai ethnic inhabiting in plane area had slender physical structure. This study defined the relation that vertical distribution of ecology, different environmental and social factors impacted in physical structure.

Natale and Rajagopalan (2013) carried out study by comparing the secondary data of WHO's Multicenter Growth Reference Study (MGRS) with data from studies performed in 55 countries with several nations and ethnics. The findings of the study indicated that height and weight curves may not be optimal fits in all cases. Similarly, the use of a single international standard for head circumference was not justified. The differences average values of head circumference between different nationality and ethnic group had a large difference. Based on the WHO charts for monitoring

head circumference of children in different nationality and ethnic, that difference would put many children at risk for misdiagnosis of macrocephaly. Growth pattern within caste/ethnic of Nepalese infants and children was observed big variation; while developing growth monitoring charts there should be considered distinguished physical characteristics of Nepalese infant and children. (Acharya et al. 2014).

Nepal is a multi-caste/ethnic and ecologically highly diversified nation. Life style and living pattern of people have been observed highly diverse too. These distinguished characteristics of living pattern may reflect on the physical growth of infants and children and physical features of adult. So, it is concerned as main issue recommending appropriate physical growth monitoring charts for Nepalese infant and children.

The main objective of this study is to recommend appropriate physical growth monitoring charts based on the anthropometric data of Nepalese children in order to prevent the monitoring by unsuitable standards that concluding the result of stunting, underweight or malnutrition.

Methods

Measurement Indices

Six measurement indices (height, sitting height, weight, triceps skinfold thickness, chest circumference and bi-acromial breadth) were applied in order to define the anthropometric characteristics of children.

Measurement Instruments

Measuring equipment were used anthropometer (manufactured by GPM) to measure height, sliding caliper (manufactured by GPM) for bi-acromial breadth, Tajima pit measure (manufactured by [PIT-20BL] TAJIMA) to measure sitting height, weighing scale ([UC-321-SV reciprocal sensitivity 50g] made by A & D) for weight, skinfold thickness caliper (manufactured by HOLTAIN Inc.) for skinfold thickness, FUTABA rotary measure [MODEL R-280] used to measure chest circumference.

Anthropometrics Measurement Method

As the measurement method of physical structure, Fujita's (1954) method was followed for measuring height, sitting height, weight and bi-acromial breadth. For chest circumference and triceps skin fold thickness, method of Lohman et al. (1988) was followed as reference. To maintain uniformity, all samples were measured in day time during the school time. Clothing at the time of measurement was done as light as possible maximum a single piece top and down. All anthropometric measurements were carried out by the author.

Interview and Additional Documents

Along with anthropometric measurement accurate age or date of birth of children was necessary to make confirm, so that mother of the child was asked to bring Child Health Card, provided by Ministry of Health, Department of Health Service and Birth registration certificate of child together with their child. Data of each child taken in 3 different sections in the study area: registration section, anthropometric measurement section

and interview with mother section. Around 45 minutes of each individual set (child & mother) was taken to obtain data. At the registration section, child provides survey form by filling up the general information regarding name, age, sex, address. Then child moves to anthropometric measurement section, after measuring the anthropometric indices, child and mother moved to interview section, in the interview section, mothers were interviewed by using structured and semi structured questions regarding no of children, birth spacing, breast feeding, feeding meals and frequencies to children, educational and socio-economic condition of parents etc.

Study Area and Data Collection Procedures

Sunsari and Sankuwasabha district from Koshi Province were selected purposively in this study representing lowland to highland residing inhabitants. Descriptive cross-sectional study was conducted from May 2012 to August 2013. The research proposal was approved by the Graduate School of Human Culture Studies, Otsuma Women's University, Japan. Letter of authority was provided from district education office of each district. From Sunsari district, 10 administrative clusters out of 52 and Sankuwashabha district 10 administrative clusters out of 35 were selected by purposive sampling on the basis of majority number of principal caste/ethnic residing.

During the data collection mother and child accompanied as a set in the study area, where described a purpose of study and contents sufficiently including the privacy security that it would not be published the personal information such as personal name. Mother of the infants/child and authorized persons were informed regarding on the objective, method and benefit of the study and verbal informed consent was taken before anthropometric measurements of child and interview of mother. Data collection was conducted at public health centers, schools and kindergarten or ECD (Early Childhood Education Centers). Data collection was conducted without sorting out the infant/child because pilot survey has already warned about difficult to measure the small children. In fact, approximately could complete all anthropometric measurements 4-5 children out of 10, almost half of the children deny to measure and sometime most of them start crying. Accurate measurement is impossible till the measured person take the correct position and posture. So, the measurement was done on all children who were agreed to participate. Thence, 2,219 data from the 36 caste/ethnic has been collected.

Data Management and Analysis

Sorting the Caste/ethnic Groups

While collecting data, 2,219 samples were collected from the 36 caste/ethnic groups who cooperated in the survey period as mentioned above. However, prior to consider in developing the growth charts, reviewed the data by the sex, the caste/ethnic groups, having less variation in the number by age or highly stable groups were decided to use. While attempting to obtain those data on growth standard dividing by sex and age, it would not be applicable by statistical standardization analysis if not contended 0-10 samples in each cell. Therefore, as a result of examining the data, the group containing 0-10 samples in each cell were editing from the aggregation. Then it had to be adopted data only the

corresponded caste/ethnic groups whose data observed stable in some extent were remaining as representative caste/ethnic group in this study.

Finally, six caste/ethnic (Brahman, Kshetri, Yadav, Koiri, Kami and Mushar) children aged 2-6 years, boys 646, and girls 645 a total of 1,291 were used as samples in this study. The age of samples indicated by in the complete year. Data were sorted from the methods described above; as the result six Caste/ethnic groups remained as consideration. These remained groups were representative caste/ethnic groups as high caste (Brahman & Kshetri), middle caste (Yadav & Koiri) and low caste (Kami & Mushar), and then average and standard deviation of 6 anthropometric measurement indices value were calculated by sex and age of each caste/ethnic group (Table 1). These values were as represent primary values to determining caste/ethnic characteristics of physical growth in order to develop growth monitoring standards. Then sex wise, average of average value of each caste/ethnic group (named here: childhood average value) (Table 2) was calculated to over view the childhood overall anthropometric characteristics. By this trace caste/ethnic wise anthropometric characteristics revealed. Having several numbers of growth charts can be complexity in practical utilization, also very few growth charts could be difficult to represent for many groups. Therefore, on the basis of six representative caste/ethnic groups further tried to accumulate to a small number of groups. Then, to accumulate the groups by defining the euclidean distance 'Ward's method' of cluster analysis was done on the basis of childhood average value (Table 2). As the result, two main caste/ethnic groups' cluster were clearly distinguished as high and middle caste groups (Brahman, Kshetri, Yadav and Koiri) and Low caste groups (Kami and Mushar) of both sexes (Figure 1 and 2). Caste/ethnic classification is referencing from National Planning Commission (2002). Statistical process for above analysis was done using Microsoft Excel 2010 and IBM SPSS Statistics 21.

Considerations for Developing Growth Monitoring Charts

When developing growth monitoring charts for children, it is better to evaluate all main indices (height, weight, circumferences, and skinfold thicknesses) alternatively. Among them, height and weight are the basic indices which should be monitoring regularly in order to evaluate the health status, physical growth status and nutrition status of small children. Hence, this study priorities to develop height and weight monitoring standards focusing on the practicality and applicability of usage.

In this study, analyzing anthropometric characteristics of children average values of six physical measurement indices were used but in the purpose of developing growth monitoring standards percentile values were applied. These values were found more appropriate method to evaluate by minimizing the biases in between age ranges. There were many studies regarding the method of smoothing of the curve of percentile value. And the literatures on fitting smooth percentiles references data were developed in the last three decades (Cole, 1990; Cole & Green, 1992; Thompson & Theron, 1990; Cole, 1994; Wei et al., 2006 etc.).

Regarding the development of growth standards of Nepalese children, LMS method has been used as the reference (Cole

& Green 1992). The LMS method and maximum penalized likelihood estimation yielded percentiles in terms of three age-sex-specific curves. Analyzed percentile values (3rd, 10th, 25th, 50th, 75th, 90th and 97th). In the LMS method: L (box Cox power to correct the skewness), M (the median), S (coefficient of variation), assume now that, the distribution of y varies with covariate t, and that λ, μ and σ at t are read off the smoothed curves L (t), M (t) S (t) it follows that

$$z = \frac{[y/M(t)]^{L(t)}-1}{L(t)S(t)}, \quad L(t) \neq 0$$

Or

$$z = \frac{\log\,[y/M(t)]}{S(t)} \quad L(t) = 0$$

Rearranging (1), shows that the percentile 100 α of y at t is given by

$$C_{100\alpha}(t)=M(t)(1+L(t)S(t)Z_\alpha)^{1/L(t)} \qquad L(t) \neq 0$$

Or

$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (2)$$

$$C_{100\alpha}(t)=M(t)\exp\,[S(t)Z_\alpha] \qquad L(t) = 0$$

Where, Z_α is a normal equivalent deviation of size α. This shows that if the L, M and S curves are smooth, and then so are the percentile curves. The maximum penalized likelihood: for the case of an independent observation (yi) at corresponding covariates value (ti), the log likelihood function 1 derived from (1) is given (apart from the constant) by

$$1 = 1\,(L, M, S) \quad = \Sigma\left(L(t_i)\,\log\,\frac{y_i}{M(t_i)} - \log S(t_i) - \frac{1}{2}\,z_i{}^2\right) \qquad (3)$$

Where, {zi} are the SD scores corresponding to {yi}. The curves L (t), M (t), and S (t) are estimated by maximizing the penalized likelihood.

$$1 - \frac{1}{2}\alpha_\lambda\int\{L''(t)\}^2 \quad dt - \frac{1}{2}\alpha_\mu\int\{M''(t)\} \quad ^2 dt - \frac{1}{2}\alpha_\sigma\int\{S''(t)\} \quad ^2 dt \qquad (4)$$

Where, α_λ, α_μ and α_σ are smoothing parameters. The three integrals provide roughness penalties according to the squared second derivatives of the L, M, and S curves, hence maximizing (4) strikes a balance between fidelity to the data and smoothness of the L, M, and S curves. It can be shown that these forms of penalty lead to normal cubic splines with knots at each distinct value of t. Thus, only smoothing parameters α_λ, α_μ and $\alpha\sigma$ needed to be chosen in order to fit the model.

*VGAM package of 'R' program for the LMS model was utilized for calculation.

Results

Growth Monitoring Standards of Nepalese Children

By using the sex, age and caste/ethnic group wise measured values of height and body weight of age ranges 2 to 6 years children obtained the percentile value (signed %) 3rd, 10th, 25th, 50th, 75th, 90th, 97th which is converted into growth standards curve line by using the LMS method mentioned above and depicted into the growth monitoring charts, these are showed in figures 3-10.

Height Monitoring Charts of Boys and Girls

Table 3 and Figure 3 (see Appendix) indicate the value of height growth evaluation of boys of high - middle caste/ethnic group similarly the same table 3 and figure 4 (see Appendix) is the height growth evaluation of boys for low caste/ethnic group. The height growth evaluation chart of 50th percentile value of boys for the high/middle caste/ethnic group at the age of 2, 2.5, 3, 3.5 4, 4.5, 5, 5.5 and 6 years were shown that 82.3 cm, 85.7 cm, 89.2 cm, 92.6 cm, 95.9 cm, 99.0 cm, 101.9 cm, 104.8 cm and 107.7 cm respectively. For the low caste/ethnic group, at the age of 2, 2.5, 3, 3.5 4, 4.5, 5, 5.5 and 6 years were showed that 80.0 cm, 84.0 cm, 87.8 cm, 91.3 cm, 94.4 cm, 97.3 cm, 100.3 cm, 103.6 cm and 106.6 cm respectively. With an overview of the monitoring chart of boy of two caste/ethnic groups, across in all ages of 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentile values, the high-middle caste/ethnic group were found bigger without any exception. Over the entire areas of distribution, high-middle caste/ethnic group are taller than low caste/ethnic group. While comparing the height monitoring charts of high- middle caste/ethnic group (figure 3) and low caste/ethnic group (figure 4), between these 2 groups, at the 50th percentile value curve of the 2 to 2.5 years of age high-middle caste/ethnic group has remained approximately equal to the 75th percentile value curve of the low caste/ethnic group, followed that in the 3-6 years, transiting the values as from 60th percentile to 75th percentile. Based on the general interpretation for the both caste/ethnic groups, below the 3rd percentile is high risk group or low growth, if evaluation was done the 10th percentile of 2 to 2.5 years low caste/ethnic group by using the chart of high-middle caste/ethnic group it should be determined that the low caste/ethnic group boys stunting or delay growth.

On the other hand, if evaluation was done the high-middle caste/ethnic group by 3rd percentile of the low caste/ethnic group chart, it should not be determined as low growth or malnutrition. In this way, even if it is compared only with 50th percentile value; high-middle caste/ethnic group boys were found 2.3 cm, 1.7 cm, 1.4 cm, 1.3 cm, 1.5 cm, 1.7 cm, 1.6 cm, 1.7 cm and 1.1 cm in 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5 and 6 year taller than low caste/ethnic group boys respectively. Particularly observing the 97th percentile, value large difference seen in between two groups, the differences shown in between the two groups 2.5 cm already at the age of 2-year, 2.4 cm at 2.5-year, 2.3 cm at the age of 3, 3.5 and 4 years, 2.5 cm at the age 4.5 year, 3.1 cm at the age of 5 year, 3.9 cm at the age of 5.5 year and 5.3 cm at the age of 6 years. From these results, it would be really unreasonable to evaluate both caste/ethnic groups by using the same growth evaluation chart.

Table 4 and Figure 5 (see Appendix) show the value of height growth evaluation of girls of high-middle caste/ethnic group, similarly the same table 4 and figure 6 (see Appendix) is for the height growth evaluation of girls' low caste ethnic group. 50th percentile growth standard value of height for high-middle caste/ethnic group girls at the age of 2, 2.5, 3, 3.5 4, 4.5, 5, 5.5 and 6 years were showed that 82.3 cm, 85.7 cm, 89.2 cm, 92.6 cm, 95.9 cm, 99.0 cm, 101.9 cm, 104.8 cm and 107.7 cm respectively. For the low caste/ethnic group girls, at the age of 2, 2.5, 3, 3.5 4, 4.5, 5, 5.5 and 6 years were shown that 80.0 cm, 84.0 cm, 87.8 cm, 91.3 cm, 94.4 cm, 97.3 cm, 100.3 cm, 103.6

cm and 106.6 cm respectively. When comparing the two statistical values obtained here, very large differences is seen in both sexes, it is obviously clear that, it cannot be evaluated these two different caste/ethnic groups on the same basis.

Body Weight Monitoring Charts of Boys and Girls

Table 3 and Figure 7 (see Appendix) shows the value of body weight growth evaluation of boys of high-middle caste/ethnic group similarly the same table 3 and figure 8 (see Appendix) is for low caste. 50th percentile growth standard value of body weight for high-middle caste/ethnic group girls at the age of 2, 2.5, 3, 3.5 4, 4.5, 5, 5.5 and 6 years were shown that 10.7 kg, 11.4 kg, 12 kg, 12.8 kg, 13.5 kg, 14.2 kg, 14.9 kg 15.6 kg and 16.2 kg respectively. For the low caste/ethnic group, at the age of 2, 2.5, 3, 3.5 4, 4.5, 5, 5.5 and 6 years were showed that 10.6 kg, 11.2 kg, 11.8 kg, 12.5 kg, 13.2 kg, 13.8 kg, 14.4 kg, 15.1 kg and 15.6 kg respectively. Over the entire areas of distribution, high-middle caste/ethnic group boys result was found heavier than low caste/ethnic group. 50th percentile is in all ages surpassing high-middle caste/ethnic group than low caste/ethnic group, there is 0.6 kg difference in the 6 year age. The difference increases in 90th percentile, which seems 0.7 kg at the age of 2 and expand to the 1.2 kg at the age of 6 year. Comparing the percentile curve for both caste/ethnic groups, 90th percentile curve of the high/middle caste/ethnic group boys seems almost same value of the 97th percentile curve of the low caste/ethnic group. Thus, it is obviously clear as in the case of the height, body weight is also not appropriate to evaluate for these two caste/ethnic groups by the same monitoring chart. By comparing two caste/ethnic groups, differences especially were seen in the spread of the distribution. Narrow spread of the distribution was seen in the low caste/ethnic group, but in the high-middle caste/ethnic group it was relatively wide. Between two caste/ethnic groups comparing differences of percentile values, at the age of 6 year, in the 50th percentile it was only 0.6 kg, at 90th percentile 1.2 kg and at 97th percentile was further spread to 1.4 kg differences. As a result, high-middle caste/ethnic group was observed as quite heavier group than low caste/ethnic group. Also, in the case of body weight monitoring chart of between two groups, it was largely staggered in the low caste/ethnic group than high-middle caste/ethnic group. From these results, it is clear that body weight evaluation is also essential to place in by considering the caste/ethnic classification.

Body weight growth evaluation value of the girls is shown in table 4 and figure 9 (see Appendix) for the high-middle caste/ethnic group and figure 10 for the low caste/ethnic group. In the 50th percentile value of girls high-middle caste/ethnic group at the age of 2, 3, 4, 5 and 6 years demonstrated that 10 kg, 11.4 kg, 12.8 kg, 14.1 kg, and 15.4 kg respectively. At the age of 2, 3, 4, 5 and 6 years were shown that 9.7 kg, 11.4 kg, 12.7 kg, 15.2 kg, and 14 kg respectively. Comparing to the boys' values mentioned above, in all age's girls were shown the significantly lighter body weight than boys. So that evaluation of the boys and girls by the same growth standards chart seems impossible. Moreover, it is also clear that it should not be left the issues of differences on growth between caste/ethnic groups without addressing. Comparing body weight of girls in between 2 caste/ethnic groups in figure 9 and 10, value below the 3rd percentiles in the 2-4 years did not appear large discrepancy, though followed the ages at 4.5 to 6

years observed discrepancy in judgment. In other words, it is be rated the under weighed for the low caste/ethnic group girls by using the chart of high-middle caste/ethnic group girls around at 7th -10th percentile. On the other hand, in the evaluation of bigger body weight group (high-middle caste caste/ethnic group), evaluating using a growth chart of the low caste/ethnic group of the girls, 90th to 95th percentile vicinity can be determined as the high body weighted.

Beyond the same group while monitoring the children, below the 3rd percentile value is concluded as severely underweight or stunted that requires urgent health investigation. 3rd -10th percentile is moderately wasted and stunted that requires some degree of advice regarding on nutrition or treatment issues. 10th - 90th percentile is considered as in the range of normal growth. 90th – 97th percentile is considered somehow over height or weighted and above 97th percentile is highly over weighted or height, which is sign of over nutrition or abnormal growth. It is needed to monitoring small children growth status regularly when abnormal status observed should consult to specialist immediately.

Discussion

This study explored the appropriate growth monitoring charts to evaluate height and weight growth of Nepalese children with the conclusion that the challenges from previous study of Nepalese children were determined as underweight, delay growth, stunted or suffering malnutrition. The results clearly showed that Nepalese children have variation on physical growth pattern as variation of caste/ethnic groups inhabiting in Nepal. The results clearly pointed out that there is variation on growth pattern and physical features of Nepalese children so that evaluating the growth of entire infant and children in Nepal by a single growth monitoring chart would not provide trustworthy and reasonable measurement evaluation. Similarly adopted or borrowed growth evaluation charts from WHO or other nations cannot give appropriate evaluation. Hosono et al. (1998) showed that the ranges determined to be underweight by plotting the value of Nepalese children on the WHO standard chart provided by the Government of Nepal Ministry of Health. Further, Acharya et al. (2014) clearly stated that WHO growth monitoring standard is not suitable to measure Nepalese children by comparing the plotting the value of Nepalese children on the WHO growth standard (2003-2004).

It is clearly intended the discrepancy that evaluating by the same growth evaluation standards to different ethnics is inappropriate. The physical growth of children is affected by various factors including ethnic differences, so that if it is possible better have ideal to evaluate physical growth standards specific to the bases of particular ethnic (Ohsawa et al. 2011). In the context of Nepal, it is challenges in practical sense to develop individual growth monitoring standards to all caste/ethnic. Over viewing the scientific analysis result of data and the practicability of usage, this study decided to recommend growth standards for 2 main caste/ethnic groups as high-middle (Brahman, Kshetri, Yadav and Koiri) caste/ethnic group and low (Kami and Mushar) caste/ethnic group.

Conclusion

This study aimed to develop the growth monitoring charts of

Nepalese children which was conducted under nutrition, stunted or delayed growth by various past studies. Growth monitoring standard is reliable and appropriate to use on the basis of particular caste/ethnic groups. Otherwise, the measurement results conclude mistakenly.

The main issue of this study was to determine caste/ethnic phenomena. The researcher has taken the data from mother and child as a set who wanted to cooperate in the study without sorting out. While observing the data, organizing highly stable number groups were decided to use in the context of statistically applicability. Then, on the basis of the caste/ethnic groups (cluster as Brahman - Kshetri, Yadav - Koiri = 'high/middle caste/ethnic group' and Kami and Mushar = 'low caste/ethnic group' (were decided to prepare growth monitoring standards. The study clearly states that it was necessary to develop growth monitoring charts on the basis of the data of similar caste/ethnic groups to monitor the growth status of children appropriately.

This study focused on children aged 2-6 years from six major caste/ethnic groups in Nepal (Brahman, Kshetri, Yadav, Koiri, Kami and Mushar). However, further research should expand the age range to include children from 0 to 18 years and incorporate other major caste/ethnic groups such as Magar, Newar, Tharu, Tamang, Rai, Limbu, Gurung, and Sherpa to ensure more comprehensive growth monitoring standards for Nepal's diverse population.

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Conflict of Interest

There is no conflict of interest.

Data Availability

Data will be available as per the need.

References

Acharya, U., Shimoda, A., & Ohsawa, S. (2014). Examination of physical features and caste/ethnic classification in order to recommend creating the growth standard of Nepalese children, *Japan Journal of Human Growth and Development Research*, 62, 12-23.

Beall, C. M. (1981). Growth in a population of Tibetan origin at high altitude. *Annals of Human Biology*, 8 (1) 31-38.

Bhandari, T. R. & Kshetri, M. (2013). Nutritional status of under five year children and factors associated in Kapilvastu district, Nepal. *Journal of Nutritional Health & Food Science,* Open Access

Cole, T. J. & Green, P. J. (1992). Smoothing reference centile curves: The lms method and penalized likelihood. *Statistics in Medicine*, 11, 1305-1319.

Cole, T. J. (1990). The LMS method for constructing normalized growth standards. *European Journal of Clinical Nutrition*, 44, 45-60.

Cole, T. J. (1994). *Growth charts for both cross-sectional and longitudinal data, statistics in medicine*. 13, 2477-2492.

Costello, A.M. (1989). Growth velocity and shunting in rural Nepal. *Archives of Disease in Childhood*, 64, 1478-1482.

Frisancho, A. R. (1981). New norms of upper limb fat and muscle areas for assessment of nutritional status. *The American Journal of Clinical Nutrition, 34*(11), 2540 2545.

Fujita, K. (1954). *Seitai Kansatsu.* Nansan-Do Publication.

Health Service Division (2003/2004). *Child health card.* Ministry of Health His Majesty's Government, Nepal.

Hosono, S., Okazaki, M., Kagimoto, S., Ogawa, K., Matunaga, K., Oishi, T., ... & Shakya, K. N. (1998). An evaluation of infants' growth in the Kingdom of Nepal. *Pediatrics International, 40*(4), 350-355.

Huijbers, P. M.J.F., Hendriks, J. L.M., Gerver, W.J.M., De Jong, P. J., & De Meer, K. (1996). Nutritional status and mortality of highland children in Nepal: Impact of sociocultural factors. *American Journal of Physical Anthropology:* The Official Publication of the American Association of Physical Anthropologists, 101(2), 137-144.

Lohman, T. G. Roche, A. F. & Martorell, R. (1988) *Anthropometric standardization reference manual.* Human Kinetics Books Champaign Illinois. 56-57.

Martorell, R., Leslie, J. & Moock, P. R. (1984). Characteristics and determinants of child nutritional status in Nepal. *The American Journal of Clinical Nutrition,* 39 (1), 74-86.

Natale, V., & Rajagopalan, A. (2014). Worldwide variation in human growth and the World Health Organization growth standards: A systematic review. *BMJ Open, 4*(1), e003735.

National Center for Health Statistics. (1979). *Handbook of growth and growth monitoring in health and disease*. United States.

National Planning Commission. (2002). *National Dalit strategy report (Part I): Situational analysis of Dalits in Nepal*. His Majesty's Government of Nepal. 2-4.

Ohsawa, S. & Ji, C.Y. (1996). Growth of Chinese minority ethnic children and youths (Thai, Wa and Lahu) and their living conditions in Yunnan Province of China. *Japanese Journal of School Health*, 38, 370-380.

Ohsawa, S., Shimoda, A., Sagawa, T., Nakano, T., & Kokudo, S. (2011). Growth standards for children's weight of 12 ethnic groups in Myanmar and Thailand. *Japan Journal of Human Growth*

and *Development Research, 2011*(51), 51_46-51_56.

Panter-Brick C. (1997). Seasonal growth patterns in rural Nepali children. *Annals of Human Biology, 24,* (1), 1-18.

Sunaga, H. (1984). Study on the growth and nutrition of children in Nepal. *Japanese Journal of Public Health, 31*(12), 671-680

Thompson M.L. & Theron G.B. (1990). Maximum likelihood estimation of reference centiles. *Statistics in Medicine*, 9, 539-548.

Wei, Y. Pere, A., Koenker, R. & He, X. (2006). Quantile regression methods for reference growth charts. *Statistics in Medicine*, 25, 1369-1382.
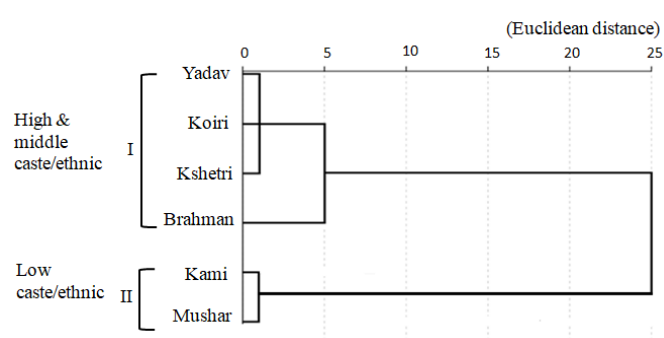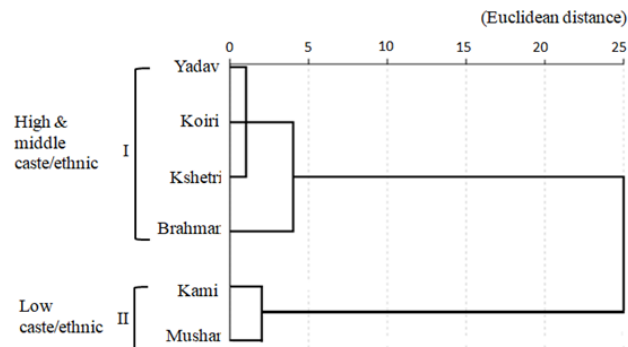
Appendix

(Tables and Figures)

Table 1: *Sex wise /caste/ ethnic wise/age wise average and standard deviation of six anthropometric measurements*

Caste/ethnic group	Age(Yr.)	Boy						Girl					
		Height (cm)			Weight (kg)			Height (cm)			Weight (kg)		
		‾x	SD	N	‾x	SD	N	‾x	SD	N	‾x	SD	N
Brahman	2~3	88.8	4.3	29	11.7	1.6	29	86.5	3.3	39	11.0	1.2	39
	3~4	95.8	4.7	45	13.3	1.3	45	93.3	4.6	47	12.4	1.4	47
	4~5	100.9	4.5	46	14.3	1.6	46	99.0	4.7	53	13.5	1.6	53
	5~6	107.1	4.7	31	15.7	1.8	31	105.4	4.9	39	15.4	1.7	39
Kshetri	2~3	86.5	3.9	24	11.2	1.4	24	84.7	2.8	19	10.5	1.0	19
	3~4	93.2	4.8	48	12.8	1.5	48	93.0	4.3	51	12.6	1.6	51
	4~5	100.0	4.8	44	14.3	1.4	44	99.3	4.6	41	13.8	1.5	41
	5~6	106.0	4.7	41	16.1	1.7	41	103.4	4.4	27	14.4	1.3	27
Yadav	2~3	87.5	3.9	15	11.2	1.2	15	85.6	4.3	9	10.8	1.2	9
	3~4	93.4	4.8	12	12.4	1.5	12	91.2	4.5	11	11.6	1.0	11
	4~5	100.0	4.8	13	14.1	1.3	13	99.1	3.8	12	13.4	1.3	12
	5~6	105.1	4.7	13	15.3	1.2	13	105.0	3.8	17	14.8	1.7	17
Koiri	2~3	88.7	3.8	19	15.3	1.3	19	84.4	4.3	38	10.5	1.4	38
	3~4	93.4	4.0	35	11.6	1.3	35	92.2	4.8	25	12.2	1.5	25
	4~5	99.1	4.8	52	13.9	1.4	52	98.7	4.5	38	13.4	1.4	38
	5~6	104.9	4.9	38	15.0	1.5	38	104.9	3.6	13	14.5	1.6	13
kami	2~3	84.7	3.4	16	11.4	1.1	16	82.7	4.2	20	10.4	0.8	20
	3~4	92.0	4.3	27	12.8	1.5	27	92.4	4.3	14	12.7	1.4	14
	4~5	99.8	4.9	23	14.2	1.7	23	96.3	4.6	31	13.3	1.6	31
	5~6	103.5	4.3	11	14.9	1.4	11	103.7	4.7	24	15.0	1.6	24
Mushar	2~3	85.1	4.6	12	10.9	1.1	12	83.6	4.8	16	10.6	1.3	16
	3~4	92.0	3.9	15	12.6	1.4	15	93.1	4.3	30	12.3	1.2	30
	4~5	99.8	4.8	26	13.4	1.1	26	96.3	4.4	24	12.8	1.3	24
	5~6	103.5	4.8	11	15.0	1.4	11	104.6	3.9	7	14.3	2.0	7
Total							646						656

Table 2: *Sex wise / caste ethnic wise average of average value of sex anthropometric measurements*

Sex	Caste/ethnic group	N	Height(cm)	Sitting height(cm)	Weight(kg)	Tricep skinfold thickness(mm)	Chest vircumference(cm)	Biacromial breadth(cm)
Boy	Brahman	151	98.1	55.8	13.8	7.0	49.8	21.8
	Kshetri	157	96.5	55.0	13.6	7.1	49.8	21.6
	Yadav	53	96.5	54.6	13.3	6.9	49.2	21.6
	Koiri	144	96.4	54.7	13.2	6.9	49.3	21.5
	kami	77	94.9	54.2	13.3	7.3	49.1	21.3
	Mushar	64	95.2	54.2	13.0	6.9	49.6	21.2
Girl	Brahman	178	96.1	54.3	13.1	7.8	48.6	21.3
	Kshetri	138	95.1	53.8	12.8	7.3	48.3	21.1
	Yadav	49	95.2	53.9	12.6	6.9	48.3	21.3
	Koiri	114	95.2	53.8	12.6	7.3	48.2	21.1
	kami	89	93.8	53.1	12.8	7.7	48.4	21.1
	Mushar	77	94.4	53.7	12.5	7.4	48.4	21.0

Figure 1: *Cluster analysis of ward's method of 6 caste/ ethic group by 6 anthopometric measurement indices (boy)*

Figure 2: *Cluster analysis of ward's method of 6 caste/ ethic group by 6 anthopometric measurement indices (girl)*

Table 3: *Caste/ethic group clusted wise, age wise height and weight percentile value of boys*

Sex	Caste/ethnic group	percentile value	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
		Age in year ranges									
		Height(cm) 3%	78.4	81.1	83.9	86.7	89.5	92.2	94.8	97.3	99.8
		10%	80.2	83.1	85.9	88.8	91.7	94.5	97.2	99.8	102.4
		25%	82.1	85.1	88.1	91.1	91.1	97.0	99.8	102.6	105.2
		50%	84.4	87.5	90.6	93.7	94.1	99.9	102.9	105.8	108.6
		75%	86.8	90.0	93.3	96.6	99.9	103.1	106.2	109.2	112.2
		90%	89.1	92.5	95.9	99.3	102.7	106.0	109.3	112.5	115.7
		97%	91.5	95.0	98.5	102.1	105.7	112.6	112.6	116.0	119.3
	High and middle Caste/ethnic										
		Weight(kg) 3%	8.4	9.0	9.7	10.4	11.1	11.7	12.3	12.9	13.4
		10%	9.0	9.7	10.4	11.1	11.8	12.5	13.1	13.7	14.3
		25%	9.8	10.5	11.1	11.8	12.6	13.2	13.9	14.5	15.2
		50%	10.7	11.4	12.0	12.8	13.5	14.2	14.9	15.6	16.2
		75%	11.7	12.4	13.0	13.7	14.5	15.2	15.9	16.7	17.4
		90%	12.7	13.3	14.0	14.7	15.4	16.2	17.0	17.7	18.5
		97%	13.8	14.4	15.0	15.7	16.4	17.2	18.0	18.9	19.7
	Boy										
		Height(cm) 3%	74.9	78.2	81.5	84.9	88.2	91.3	94.1	96.5	98.4
		10%	77.7	80.4	83.8	87.2	90.5	93.7	96.5	99.0	100.9
		25%	79.3	82.7	86.1	89.6	93.0	96.2	99.0	101.5	103.4
		50%	81.1	85.3	88.7	92.2	92.2	98.9	101.7	104.2	106.1
		75%	84.4	87.9	91.4	94.9	94.9	101.7	104.5	107.0	108.9
		90%	86.7	90.2	93.8	97.4	97.4	104.2	107.0	109.6	111.5
		97%	89.0	92.6	96.2	99.8	99.8	106.7	109.5	112.1	114.0

Low Caste/ethnic

	percentile value	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Weight(kg)	3%	8.8	9.3	9.8	10.4	11.0	11.5	12.1	12.8	13.2
	10%	9.3	9.9	10.4	11.0	11.6	12.2	12.8	13.5	13.9
	25%	9.9	10.5	11.1	11.7	12.3	12.9	13.6	14.2	14.6
	50%	10.6	11.2	11.8	12.5	13.2	13.8	14.4	15.1	15.5
	75%	11.3	11.9	12.6	13.3	14.1	14.8	15.4	16.0	16.4
	90%	12.0	12.7	13.4	14.2	14.9	15.7	16.3	16.9	17.3
	97%	12.7	13.4	14.2	15.0	15.8	16.6	17.2	17.8	18.2

Table 3: *Caste/ethic group clusted wise, age wise height and weight percentile value of Girl*

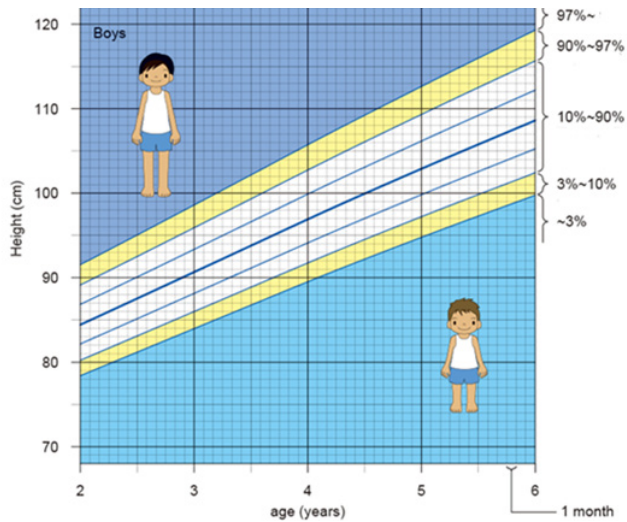|		Age in year ranges									
Sex	**Caste/ethnic group**	**percentile value**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
		Height(cm) 3%	75.9	79.1	82.3	85.4	88.4	91.3	94.0	96.7	99.3
		10%	77.9	81.1	84.4	87.6	90.8	93.7	96.5	99.2	101.9
		25%	79.9	83.3	86.6	90.0	93.2	96.2	99.0	101.8	104.6
		50%	82.3	85.7	89.2	92.6	95.9	99.0	101.9	104.8	107.7
		75%	84.7	88.2	91.8	95.9	98.7	101.9	104.9	107.9	110.8
		90%	86.9	90.5	94.2	98.7	101.3	104.5	107.6	110.7	113.7
		97%	89.1	92.8	96.6	100.3	103.9	107.2	110.4	113.5	116.7
High and middle Caste/ethnic											
		Weight(kg) 3%	8.3	8.8	9.4	9.9	10.5	11.1	11.7	12.3	12.8
		10%	8.7	9.3	9.9	10.6	11.2	11.8	12.4	13.0	13.5
		25%	9.3	9.9	10.6	11.3	11.9	12.5	13.2	13.8	14.4
		50%	10.0	10.7	11.4	12.1	12.8	13.5	14.1	14.8	15.4
		75%	10.7	11.5	12.3	13.1	13.8	14.5	15.2	15.9	16.6
		90%	11.5	12.4	13.3	14.1	14.9	15.5	16.2	17.0	17.7
		97%	12.3	13.3	14.3	15.2	16.0	16.7	17.4	18.2	19.0
Girl											
		Height(cm) 3%	73.3	77.2	80.8	84.2	87.2	90.1	93.1	96.3	99.2
		10%	75.4	79.2	83.0	89.4	89.4	92.3	95.3	98.5	101.5
		25%	77.5	77.5	85.2	91.7	91.7	94.6	97.6	100.9	103.9
		50%	80.0	80.8	87.8	94.4	94.4	97.3	100.3	103.6	106.6
		75%	82.7	82.7	90.6	97.2	97.2	1003.2	100.2	106.5	109.5
		90%	85.2	85.2	93.3	99.9	99.9	105.9	105.9	109.2	112.2
		97%	87.9	87.9	96.0	102.7	102.7	108.7	108.7	112.0	115.0
Low Caste/ethnic											
		Weight(kg) 3%	8.3	8.9	9.5	10.0	10.4	10.8	11.2	11.6	12.0
		10%	8.7	9.4	10.1	10.6	11.1	11.6	12.0	12.5	12.9
		25%	9.2	10.0	10.7	11.3	11.9	12.4	12.9	13.5	14.0
		50%	9.7	10.6	11.4	12.1	12.7	13.3	14.0	14.6	15.2
		75%	10.3	11.3	12.2	12.9	13.6	14.4	15.1	15.8	16.6
		90%	10.9	11.9	12.9	13.7	14.5	15.3	16.2	17.0	17.8
		97%	11.4	12.6	13.6	14.6	15.4	16.3	17.3	18.3	19.2

Figure 3: *Height monitoring chart for high/middle caste/ethnic (Brahman, Kshetri, Yadav and Koiri) boy*
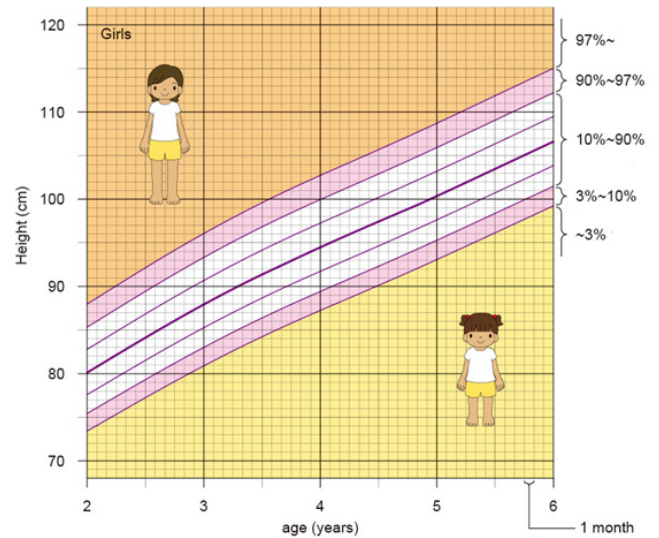

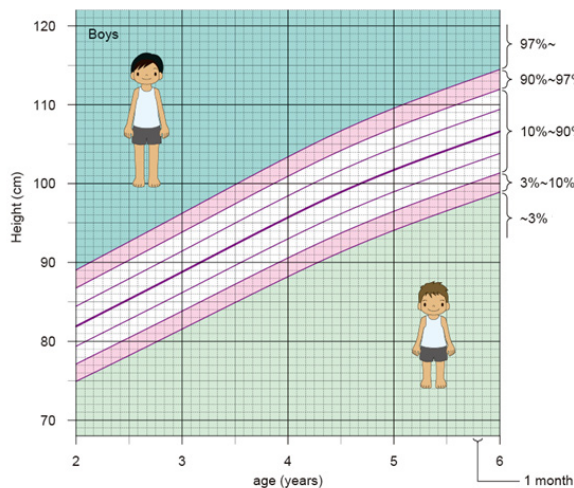**Figure 4:** *Height monitoring chart for low caste/ethnic (Kami, Musahar) girl*

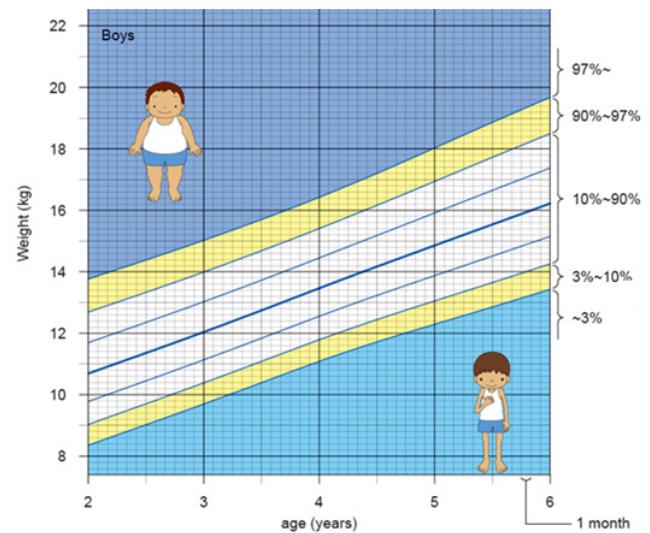**Figure 5:** *Height monitoring chart for low caste/ethnic (Kami, Musahar) boy*

Figure 6: *Weight monitoring chart for high/middle caste/ethnic (Brahman, Kshetri, Yadav and Koiri) boy*
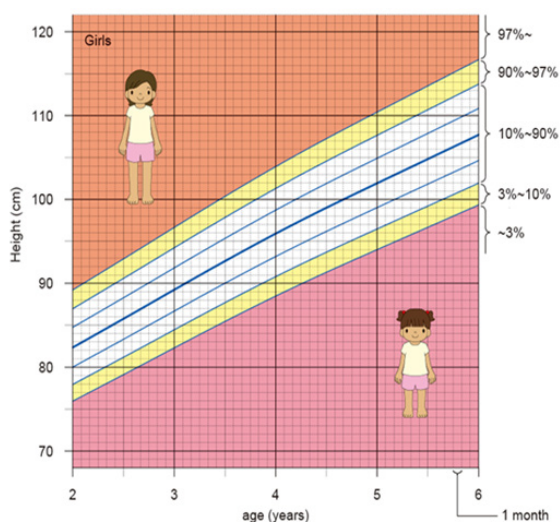

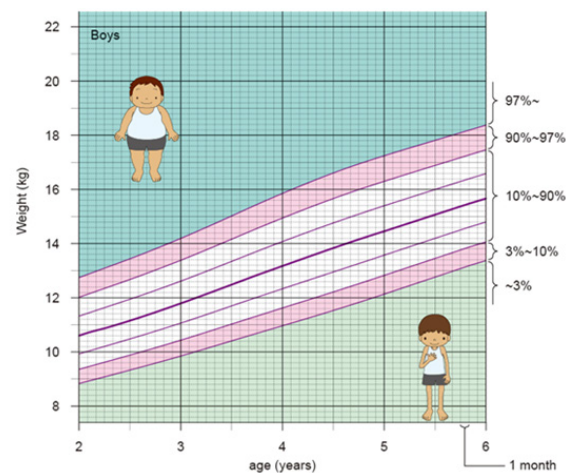**Figure 7:** *Height monitoring chart for high/middle caste/ethnic (Brahman, Kshetri, Yadav and Koiri) girl*

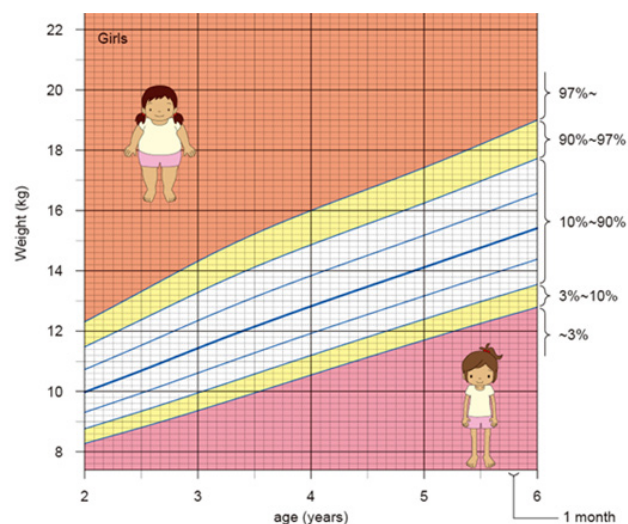**Figure 8:** *Weight monitoring chart for ow caste/ethnic (Kami, Musahar) boy*

Figure 9: *Weight monitoring chart for high/middle caste/ethnic (Brahman, Kshetri, Yadav and Koiri) girl*
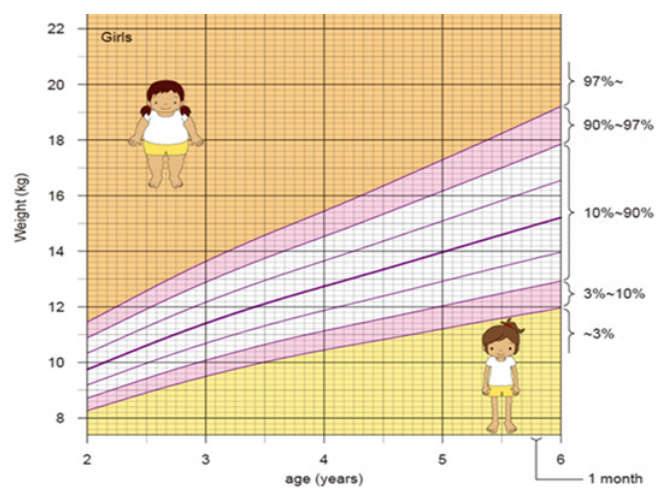

Figure 10: *Weight monitoring chart for ow caste/ethnic (Kami, Musahar) girl*