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# Developing Standard Size Chart for Teenage Girls of 17-19 Years Using Anthropometry

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**Abstract**

*This paper highlights the lack of common or acceptable standards of size charts across categories in Indian fashion industry where each manufacturer follows own or foreign sizing systems. The author dwells on initiatives taken by Government of India as well as individuals that have embarked on this journey of creating India specific size charts which is ongoing process. The purpose of this paper is to develop a sizing chart for teenage (17 to 19 years) girls based on anthropometric body measurements, with the objective to ensure apt garment fitment. This pilot study captures anthropometric data of 25 teenage (17 to 19 years) girls consisting body weight, length and girth measurements, amounting to total 26 measurements. The author computes mean, mode and median values to understand the central tendency of sizing charts. Further the paper evaluates the correlations between each anthropometric measurement across all measurements to identify key correlations using coefficient correlation technique. Standard deviation is leveraged to derive size categories, intervals and separate the outliers. The author concludes and recommends a model for developing standard sizing charts to cover most of the population.*

***Keywords: Size chart, Body measurements, Anthropometry, Garment fitment***

## 1. Introduction

India is already a big market for fashion industry for both local and global designers and manufacturers. Global brands aided by online selling platforms like Amazon, Flipkart; others have shortened the time to market and established their identity and presence in Indian market. More and more Indians are becoming brand conscious and buying merchandize as per their requirements and the style or brand they identify with. Local manufacturers and smaller production units are also having fair amount of share in Indian garment industry. Fabrics-accessories, design elements, styling and fitment influences selection of the underlying fashion products. Ultimately fitment becomes a key decision point for the consumers since misfit clothes impact confidence and look for the person wearing the product. Fit is most reported issue in the context of Indian fashion industry which is due to the fact that there is yet to be developed a common and acceptable size chart for all categories across pan India. Each manufacturer is following either foreign or own sizing system. For a particular size category, sizing and fitment variations are seen across different brands beyond reasonable level of tolerance. This creates an impact on the consumers, especially those who are buying online, leading into fitment issues, followed by rejection, return and replacement of apparels. There is operational and cost impact on the sellers as well as on the ecommerce platforms. In this turmoil the brand image of manufacturer also suffers equally. Consumers get frustrated especially when they are buying for special event and occasion, with lower or no time window for replacements. For in store purchases, a lot of disappointment is observed when particular apparel is suitable in appearance

and finish for a consumer, however he/ she has to discard his/ her choice due to fitment issues.

US, UK, Germany, France, Sweden, Japan and more have tackled issues by conducted anthropometric surveys of their natives and developed nationwide standard size charts for each category. The geographical locations, food habits, ethnicity, life styles are the major components to be considered while conducting anthropometric surveys leading to accuracy in size chart developments. In India few individuals have also embarked on this journey which is still ongoing. Also "Size India", is a project sanctioned by the Ministry of Textiles, Govt. of India, an initiative to develop Indian size charts.

## 2. Need for Anthropometry

Anthropometry is the science to study measurements and proportions of the human body systematically. In fact anthropometry is useful to study variation of human figures, their progression in living and even in extinct. This science is mostly used in industrial design, ergonomics, architecture, clothing design etc. where impact of changes in body measurements reflects on end products with continuous recalibration leading to their optimization. The measurements collected by anthropometry involve human body measurements like height, weight, surface area, volumes, structures and compositions. The development of size chart using anthropometric measurements will speed up the process of mass production, reduce manufacturing time, cost due to readily available standard size chart, reduce wastage of material and can make product more comfortable, affordable and easily available to serve to fashion consumers.

India also endeavoured for collection of anthropometric measurements of population in history, but was not for developing a size chart for apparel industry but for gaining insight of primitive India. Sociological, psychographic and geographical diversities variation resulting in body patterns in India. Participation from each diversified location to represent body dimensions and recalibration is a difficult task. Further use of technology and machinery like 3D scanners, collaboration of Human resources and funding from entities like Government, Private Institutions are the obstacles for this project. In 2020 there has been impact due to Covid -19 pandemic to execute any actions for preparing sizing system. Following are measures which can remove above impediments in developing size charts for each geographical location or sub-location:

- Formation of cluster at district or city level in each geography
- Conducting anthropometric surveys by identifying of right sample size for each category considering age group, ethnicity, gender etc. representative of the population
- Collecting dataof body measurements and persistence through an application in database, further analysis using statistics and possible use of artificial intelligence -machine learning.
- Retrieval and mining data and recalibrating data periodically will be easy, less expensive and efficient technique.

This method can be used to develop sizing chart for each geographical location which then can be consolidated at national level for finalization. This approach is applied to test the model through pilot study.

## 3. Methodology for conducting Pilot Study

The pilot study of anthropometric data of Indian girl teenagers of 17 to 19 years age group is conducted. The body measurements are captured for 25 volunteers born in northern Maharashtra. As per Neuman (2000) for confidentiality, transcripts should be separated from the actual work and special codes are to be used. Using this method the participant's identities are kept confidential.[1-7] Using ISO 8559:1989 Garment construction and anthropometric surveys, body dimension guidelines, total 26 body measurements are taken of each participant starting with weight, 12 length measurements, 13 width and girth measurements leading into 650 body measurements. The supplies like flexible plastic measuring tape, body weight scale and Stadio meter used to collect body measurements and recorded the measurements. Specially constructed body clinging garments are provided to wear for taking body measurements correctly and to maintain uniformity. In similar studies researchers carried out pilot studies which helped in the determination of the sequence of measurements, management of subjects, choice and appropriateness of equipment and allocation of time during data collection (Otieno, 1998; Vronti, 2005).

## 4. Developing size charts

According to Kemsley (1957), "The usefulness of anthropometric survey will depend on the extent to which these body measurements are transformed by statistical analysis in summaries or key dimensions and used in solving design problems". Mean, mode, median, minimum and maximum values are computed using software which provides insights into the data in terms of average value, middle value, repetition and end points of the underlying data sets. The mean is the most commonly used for average value for developing size steps (Beazley, 1998; Otieno, 1999, 2008; Gupta and Gangadhar, 2004; Vronti, 2005; Kuma-Kpobee 2009). Winks (1997) points out that "The mean can be a convenient indication of obtaining central tendency". Mean shows the average value of the data set whereas median highlights the middle value of the data set. Mean values along with standard deviation helps to plot initial values of the size chart and derive the intervals. According to Le Pechoux and Ghosh (2002), percentiles of body dimensions are considered as best predictors in determining body measurements. The five major percentiles that computed are 5th, 25th, 50th, and 75th and 95th. The 5th percentile may cater for the person with the smallest measurement but it may not accommodate the person with the largest measurement. A size chart which therefore covers only 5th and 25th percentiles may not cater for larger figures. 50th percentile covers the average person and may fail to cater for variability that exists in the human population despite the limitation it is the most widely used percentile when designing clothes. 75th percentile may however ignore the thin figures while the 95th percentile may ignore the smaller person. Overall 50th percentile found to coincide with the mean values. Key measurements of height, bust girth, waist girth and hip girth show variation of less than 1% on comparison of mean and $50^{th}$ percentile values.[8-15]. Correlation Co-efficient, a statistical measure of the strength of the relationship between the relative movements of two variables is used in determining the relationships between the body dimensions. The body dimensions are made up of Length/ vertical or linear measurements and Width/ horizontal or girth measurements which can be classified into upper torso and lower torso. Height and weight are taken as additional measurements vital to the analysis of vertical and horizontal measurements. The multiple co-efficient analyses carried out to identify linear correlation between any two measurements.[16-24]

**Table.1. Comparison of mean values with 50th percentile**

| Body Measurements | Mean | 50th Percentile |
|---|---|---|
| Body weight | 44.63 | 43.60 |
| Height (head to Floor) | 155.92 | 156.50 |
| Full length (front) | 133.85 | 133.85 |
| Full length (back) | 134.41 | 134.50 |
| Neck girth | 31.90 | 31.50 |
| Cervical to waist length | 41.75 | 41.75 |
| Centre back waist length | 42.66 | 42.50 |
| Cervical height | 60.31 | 60.50 |
| Crotch length | 61.89 | 62.60 |
| Upper arm length | 31.83 | 30.50 |
| Arm length | 52.48 | 52.48 |
| Shoulder length | 37.74 | 37.80 |
| Waist to ankle length | 89.46 | 89.70 |
| Head circumference | 26.89 | 27.00 |
| Chest girth | 76.28 | 76.50 |
| Bust girth | 78.66 | 78.00 |
| Armhole depth | 35.13 | 35.00 |
| Across back (back width) | 32.20 | 32.00 |
| Upper arm girth | 23.04 | 22.50 |
| Waist girth | 70.03 | 69.00 |
| Hip girth | 88.94 | 88.00 |
| Thigh girth | 43.06 | 43.00 |
| Knee girth | 36.13 | 35.20 |
| Ankle girth | 22.63 | 22.20 |
| Elbow girth | 21.60 | 21.60 |
| Wrist girth | 15.26 | 15.30 |

**N= 25, All values are in centimetres with exception of weight which is in kilograms*

The standard specifies that:

1. If Correlation co-efficient < 0.5 then it implies that there is no relationship;
2. If Correlation co-efficient is between 0.6-0.75 then it implies that there is a mild relationship;
3. If Correlation co-efficient > 0.76 then it implies that there is a strong or high relationship.

The above classifications are applied on all body measurements to compute co-efficient correlation. The findings shows key correlations as –

- Body weight has strong correlation with chest girth, bust girth, waist girth, hip girth, thigh girth and elbow girths.
- Length measurements like full length have strong correlation with arm length, waist to ankle length.

Refer to the table below for correlations derived using Pearson method for Co-efficient.

**Table.2. Correlation co-efficient values (Pearson Method)**

| **Body Measurements** | **Correlation co-efficient > 0.76 (Strong relationship)** |
|---|---|
| Body weight | Chestgirth,Bust girth,Waist girth, Hip girth, Thigh, girth, Elbow girth |
| Height (head to Floor) | Waist to ankle length |
| Full length (front) | Full length (back), Arm length,Waist to ankle length |
| Full length (back) | Full length (back), Arm length, Waist to ankle length |
| Arm length | Full length (front), Full length (back) |
| Waist to ankle length | Height (head to Floor) Full length (front), Full length (back) |
| Chest girth | Body weight, Bust girth, Waist girth, Hip girth Thigh girth, Elbow girth |
| Bust girth | Body weight, Chest girth |
| Waist girth | Body weight, Chest girth, Hip girth, Thigh girth, Elbow girth |
| Hip girth | Body weight, Chest girth, Waist girth, high girth, Elbow girth |
| Thigh girth | Body weight, Chest girth, Waist girth, Hip girth, Elbow girth |
| Elbow girth | Body weight, Chest girth, Waist girth, Hip girth, Thigh girth |

## Inferences and Conclusion

The analysis showed length measurements has good correlations with girth measurements. Also bust, waist and hip measurements has good correlations with weight. So bust, waist and hip measurements, which had good correlations with weight, are chosen as key dimensions for developing size chart (O Brien et al, 1941; BS EN 13402-3, 2004; Beazley, 1999; Vronti, 2004; Gupta and Gangadhar, 2004; Otieno, 2008). The mean value is used as an average value and standards deviation (SD) is used to create size steps. Addition of one standard deviation (+1SD) in a mean value used to construct upper size and subtraction of one standard deviation (-1SD) in a mean is used to construct lower size. Consequently two standard deviation (+2SD) is used to construct incremental upper size and subtracting two standard deviation (-2SD) is used to construct next lower size.

1. **Method 1** – Developing size with 5 steps intervals (+2SD to -2SD)
   Using above methodology of standard deviation intervals and mean as base value, derived 5 steps size chart, the analysis points to fact that 16 measurements of 26 have 10% or more outliers for +2SD and 0 outliers for -2SD.
2. **Method 2** – Developing size with 7 steps intervals (+2.5SD to -2.5SD)

According to Otieno, 2008 “Extrapolation” is an effective way to create size chart. Using this technique 7 steps size chart can be created by adding and subtracting Two and half standard deviation (+2.5SD) (-2.5SD) in a mean values. This way 7 steps size chart is derived, where 10 measurements of 26 are found to have 10% or more outliers for +2.5SD and 0 outliers for -2.5SD. For accommodating maximum population for height considerations various authors have endorsed to use 50th percentile as base but 50th percentile values from the pilot study coincides with mean values to great extent, hence mean values has been considered as base. BS EN: 13403-4 (2004) standards insist to use 4 cm interval for trousers and 8 cm intervals for general garments. Applying these intervals by replacing standard deviation values with 4 cm and 8 cm additions in height measurements to accommodate broader population results into 10 measurements of 26 which have 10% or more outliers for +2.5SD and 0 outliers for -2.5SD.

**Method 3** – Developing size with 7 steps intervals (+3SD to -3SD)

7 steps size chart derived using the technique of adding and subtracting of +3SD, +2SD, +1SD, -1SD, -2SD and -3SD to the mean. Only 6 measurements of 26 are found to have 10% or more outliers for +3SD and 0 outliers for -3SD. This 7 step size chart accommodated most of the population; found very less outliers hence there is no need to consider height intervals of 4 cm and 8 cm.

The size chart derived (Table 3) using adding and subtracting of +3SD, +2SD, +1SD, -1SD, -2SD and -3SD method found lowest outliers and possibilities ofaccommodation of most of population captured in the pilot study.

**Table.3. Table represents Size chart derived using 7 steps intervals (+3SD to -3SD)**

| Sr. No | Dimensions | Size Intervals | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 8 | 10 | 12 | 14 | 16 | 18 | SD |
| 1 | Height | 138 | 144 | 150 | 156 | 162 | 168 | 174 | 6 |
| **2** | Bust Girth | 61 | 67 | 73 | 79 | 84 | 90 | 96 | 6 |
| 3 | Waist Girth | 50 | 57 | 63 | 70 | 77 | 83 | 90 | 7 |
| 4 | Hip Girth | 72 | 78 | 83 | 89 | 95 | 100 | 106 | 6 |

**N= 25, All values are in centimetres*

The above methodology will be helpful to develop size charts for all categories and sizes. Conduction of similar projects can provide the data to further develop a common standard size chart for all categories of Indian population.

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