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# Anthropometric considerations for farm tools/machinery design for agricultural farm workers of Assam

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**Abstract**
Anthropometric data of agricultural farm worker is very essential for appropriate and efficient designing of farm tools and machinery. The overall working efficiency of human-machine environment and resultant discomfort has severe impact while using farm tools and machinery in field. In designing the tools for the comfort of the user, anthropometric data is required. Therefore, this study reveals the anthropometric data of the agricultural farm workers of Assam, which will help to develop/modify the improved tools and machinery suitable for people of Assam. Total 300 subjects from four different villages were selected randomly from two districts. Fifteen body dimensions useful for agricultural equipment design were selected and dimensions were taken with the help of anthropometric rod and measuring tape.

**Keywords:** Hand tools, anthropometry, agricultural worker, farm machinery

## Introduction
Anthropometric dimensions vary considerably across gender, race and age. Within a particular group also the anthropometry differs due to nutritional status and nature of work. An anthropometric dimension is a specific measurement of the human body that is used to assess physical characteristics, growth, and nutritional status. Appropriate and efficient designing of farm tools and machinery, anthropometric data of agricultural farm workers is very essential.
Machinery and tools used in agricultural operations vary from automated to manual, from industrially developed countries to underdeveloped countries. On the other hand, farm workers' manual farm tools range from advanced design, which integrates human-centered design concepts, to traditional tools across the globe. Thousands of manual tools used in farming around the world can cause musculoskeletal disorders (MSD) and injuries at workplaces due to their physical characteristics and design. Several research studies on farm tools indicated that farm tools lack ergonomics in their design and can affect the performance of farmworkers (Khidiya and Bhardwaj, 2012; Patel *et al*., 2012) [9, 10]. In order to prevent health problems, as well as to maintain the worker's productivity, hand tools should be designed so that they fit both the individual and the task. Therefore, it is very important to design for need-based tools and equipment to improve human performance in today's competitive environment. Based on the user-centred design approach, hand tools and implements, should be adjusted to user anthropometry to reduce negative health consequences, such as musculoskeletal pain and injuries. However, users are not always optimal. Humans are variables in their size, shape, characteristics, etc. Therefore knowledge of variability in databases helps to provide a baseline, how much adjustability or what ranges of forces are to be considered to accommodate the intended population of agricultural workers. Anthropometric body dimensions of Indians vary from other parts of the country. Agrawal *et al*. (2010) [1] observed that people of north-eastern region have lower body dimensions as compared to other parts of the country.
Optimal design of hand-tools requires applicable comprehensive and context-specific anthropometric or body dimensions and strength data. The anthropometric dimensions and strength data of agricultural workers are essential for designing farm tools and equipment that are safe, easy to use, and efficient (Vyavahare and Kallurkar, 2012) [4]. The capabilities and limitations of human workers need to be taken into account during the design and operation of various farm equipments in order to achieve higher productivity, enhanced comfort, and better safety as human workers play a major role in the country's agriculture (Woodson and

Conover, 1973; Yadav *et al*., 2010) [5, 8]. So, it is very much essential for the designer to consider physical dimensions and human capabilities while designing farm equipments for better output and safety, because the man-machine interface decides the ultimate performance of the tool/equipment.
Thus to achieve better performance and efficiency along with higher comfort and safety to the operator, it is necessary to design tools, equipments and workplaces keeping in view of the anthropometric data of the agricultural workers.

## Materials and Methods

Agricultural farm workers were randomly selected from the two districts namely Jorhat and Dima Hasao districts of Assam. Four villages namely Alengi Gaon, Tipomia Habi, Solakantipur and khejurband were selected randomly from the two districts for the study. A total of 300 households were selected by following Probability Proportionate to Size (PPS) technique. From the above-mentioned villages, 150 households were selected from jorhat district and 150 households from Dima Hasao district. Before collection of anthropometric data, the whole process for data collection was explained to the workers so as to maintain accuracy in its measurements and to seek full cooperation from them. For the study, an anthropometric kit, weighing scale having accuracy of 0.1 kg and capacity of 120 kg, measuring tape was used to collect data of body dimensions of the agricultural workers. In the present study, including body weight, altogether 15 body parameters useful for farm machinery design were selected for the measurement

## Results and Discussion

The anthropometric data of agricultural farm workers for the various body dimensions were analyzed for mean, standard deviation, coefficient of variation and percentile values ($5^{th}$, $50^{th}$ and $95^{th}$) are presented in Table 1.

**Table 1:** Distribution of selected anthropometric data of the respondents

| Sl. No. | Body dimensions | Mean | Min | Max | 5th | $50^{th}$ | $95^{th}$ | SD | CV |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Stature height | 162.58 | 125.3 | 179.8 | 152.4 | 163.0 | 176.8 | 10.65 | 0.066 |
| 2. | Eye height | 150.85 | 114.9 | 167.5 | 141.1 | 151.3 | 164.5 | 10.26 | 0.068 |
| 3. | Shoulder height | 134.90 | 99.8 | 150.8 | 125.4 | 135.0 | 147.8 | 9.74 | 0.072 |
| 4. | Elbow height | 103.90 | 70.3 | 119.8 | 94.4 | 103.5 | 116.8 | 9.76 | 0.094 |
| 5. | Hip height | 95.09 | 61.3 | 105.8 | 87.4 | 96.5 | 102.8 | 8.48 | 0.089 |
| 6. | Fingertip height | 60.19 | 51.4 | 67.8 | 51.4 | 60.6 | 67.8 | 4.78 | 0.079 |
| 7. | Sitting height | 83.60 | 60.3 | 101.7 | 72.5 | 83.8 | 95.0 | 6.80 | 0.081 |
| 8. | Sitting eye height | 72.57 | 49.3 | 90.7 | 61.5 | 72.0 | 84.0 | 6.66 | 0.092 |
| 9. | Sitting shoulder height | 58.14 | 36.3 | 74.7 | 48.5 | 57.0 | 70.0 | 6.32 | 0.109 |
| 10. | Knee height | 43.83 | 27 | 61.83 | 34.4 | 43.54 | 52.0 | 6.10 | 0.139 |
| 11. | Sitting popliteal height | 40.28 | 30.4 | 57.83 | 30.4 | 41 | 45.6 | 5.28 | 0.131 |
| 12. | Chest depth | 81.80 | 74.77 | 88.00 | 75.49 | 81.79 | 88 | 4.12 | 0.050 |
| 13. | Shoulder to wrist length | 74.59 | 42.27 | 96.83 | 66 | 74 | 84.821 | 6.85 | 0.092 |
| 14. | Shoulder to elbow | 31.35 | 22 | 45.78 | 28 | 32 | 36 | 3.35 | 0.107 |
| 15. | Forearm hand length | 43.25 | 10.27 | 64.83 | 37 | 42 | 52.64 | 6.19 | 0.143 |

### Stature height

Human height or stature is the distance from the bottom of the feet to the top of the head in a human body, standing erect. Regarding stature height it was seen that maximum height was 179.83cm and minimum height was 125.27cm with mean 162.74 and ±10.73 SD. The $5^{th}$, 50th and $95^{th}$ percentiles were 152.4 cm, 164.6 cm and 178 cm. The mean height was found to be slightly similar with male workers of Arunachal Pradesh i.e., 162.2 and Tamil Nadu i.e., 162.9 (Yadav *et al*., 2000, Prasad *et al*, 1999) [6, 7].

**Fig 1:** Stature Height

**Eye height (Standing)**
Eye height is measured from the ground to the inner canthus. The maximum eye height of the respondent was found 167.47 cm and minimum 114.92 cm with mean 151.01 and ±10.34SD. The Table 1 shows that the 5th, 50th and 95th percentiles having eye height of 141.05, 152.80 and 165.7 respectively.

**Fig 2:** Eye height (Standing)

**Shoulder (Acromial) height**
The vertical distance between the standing surface and the acromion. The participant stands erect looking straight ahead. The heels are together with weight distributed equally on both feet. The maximum and minimum shoulder height of the respondents were 150.83cm and 99.77 cm with mean 135.06 and SD ±9.81, which was also seen that the mean shoulder height of male worker of Orissa (134.8cm) and Arunachal Pradesh (135.1cm) were having similar shoulder height with the respondents. The shoulder height of 5th, 50th and 95th percentiles were 125.4, 136.1and 148.8 respectively.

**Fig 3:** Shoulder (Acromial) height

**Elbow height**
Vertical distance from the floor to the radiale. The mean value of elbow height of the respondents was seen to have higher than the other North Eastern states. The maximum and minimum elbow height of the respondents was 119.83 cm and 70.27cm with mean 104.06 cm and SD ±9.84. The 5th, 50th and 95th percentile of the respondent regarding elbow height was 94.4, 104.6 and 118 respectively.

**Fig 4:** Elbow height

**Hip height**
Vertical distance from the floor to the greater trochanter (a bony prominence at the upper end of the thigh bone, palpable on the lateral surface of the hip).The table 4.6 shows that the mean hip height of the respondents was found 95.25 cm and SD ±8.52. The maximum and minimum hip height was105.83 cm and 61.27 cm with mean. The 5th, 50th and 95th percentile of the respondent regarding hip height was 87.4, 96.54 and 104.

**Fig 5:** Hip height

**Fingertip height**

Vertical distance from the floor to the dactylion (i.e. the tip of the middle finger).The data shown in Table 1 revealed that the mean fingertip height of the respondents was found 60 cm with 19±4.78 SD and the maximum was 67.8 cm and minimum was 51.4 cm. Also the fingertip height of 5$^{th}$, 50$^{th}$ and 95$^{th}$ percentile of the respondent was 51.4, 60.6 and 67.8 respectively.

**Fig 6:** Fingertip height

**Sitting height**

Sitting Height is a segment length measure of the vertical distance from the crest or top of the head to the base of a seating surface. The mean sitting height of the respondents was seen to have 83.60 cm and SD of ±6.80 which is similar with the male worker of Arunachal Pradesh, i.e., 83.5 (Agarwal *et al*., 2010) [1]. The maximum and minimum sitting height was 101.7 and 60.3. The 5$^{th}$, 50$^{th}$ and 95$^{th}$ percentile of the respondent regarding sitting height was 72.5, 83.8 and 95.

**Fig 7:** Sitting height

**Sitting eye height**

Vertical distance between the sitting surface and the corner or angle formed by the meeting of the eyelids on the outer corner of the right eye. The maximum and minimum sitting eye height was 90.7 cm and 49.3 cm with mean 72.57 cm and ±6.66 SD. The 5$^{th}$, 50$^{th}$ and 95$^{th}$ percentile of the respondent regarding elbow height was 61.5,72 and 84.

**Fig 8:** Sitting eye height

**Sitting shoulder height**

The vertical distance from the top of shoulder's acromion process to the participant's sitting surface. Regarding sitting shoulder height, the mean which shown in Table 1 i.e., 58.14 cm was similar with Arunachal Pradesh (58.1) (Prasad, N. *et al*., 1999) [7] and Meghalaya (58.8) (Agarwal *et al*., 2010) [1]. The maximum and minimum sitting shoulder height was 74.7 cm and 36.3 cm Also, the 5th, 50$^{th}$ and 95$^{th}$ percentile of the respondent regarding sitting shoulder height was 48.5, 57 and 70.

**Fig 9:** Sitting shoulder height

**Knee height**

The distance between the superior surface of the patella and the floor. The maximum and minimum knee height was 61.83 cm and 27 of the selected respondents. The mean knee height of the respondent was 43.83 cm and ±6.10 SD and the 5th, 50th and 95th percentile of the respondent was 34.4, 43.54 and 52.

**Fig 10:** Knee height

**Sitting popliteal height**

The distance from the underside of the foot to the underside of the thigh at the knees. The mean popliteal height of the respondents was 40.28 cm which is quite similar to the male worker of Arunachal Pradesh i.e., 40.7 (Prasad, N. *et al*., 1999) [7]. The maximum and minimum popliteal height shown in Table 1 was 57.83 cm and 30.4 cm. The 5th, 50th and 95th percentile of the respondent regarding popliteal height was 30.4, 41 and 45.6.

**Fig 11:** Sitting popliteal height

**Chest depth**

The maximum and minimum chest depth was 88 and 74.76 with mean 81.80 cm and ±4.12 SD. The 5th, 50th and 95th percentile of the respondent regarding elbow height was 75.48, 81.79 and 88.

**Fig 12:** Chest depth

**Shoulder to wrist length**

The maximum and minimum shoulder to arm was 86.2 cm and 42.27 cm with mean 74.59 cm and ±6.85 SD. The 5th, 50th and 95th percentile of the respondent regarding shoulder to arm was 66, 74 and 84.8.

**Fig 13:** Shoulder to wrist length

**Shoulder to elbow length**

The shoulder to elbow length of the respondent shown in table 4.6 was 31.35 cm and SD ±3.35. The 5th, 50th and 95th percentile of the respondent regarding shoulder to elbow length was 28, 32 and 36 respectively.

**Fig 14:** Shoulder to elbow length

**Forearm hand length**

The Table 1 shows that the mean forearm hand length was 43.25 cm and SD ±6.19. Prasad, N. *et al*., (1999) [7] revealed that the forearm hand length of the male workers from Mizoram is 43.3, which is similar with the mean of the respondents. The 5th, 50th and 95th percentile of the respondent regarding elbow length was 37, 42 and 52.64.

**Fig 15:** Forearm hand length

**Conclusion**

While designing farm tools and implements, application of ergonomic approach is necessary to fit the user with the tool/equipment. But in the state like Assam where more than 70 per cent of the population relies on agriculture, improved tools are lacking due to lack of proper anthropometric database. There is a greater need to develop improved tools and implements suitable for the Assamese people as they mostly perform the agricultural activities manually. Therefore, in the present study anthropometric data were taken which can serve as baseline study for designing tools and implements for the people of Assam. This data will also be useful in incorporating suitable modifications in improved tools and equipment being introduced in Assam from other parts of the country.

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