Applied Ergonomics 51 (2015) 222–235

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

# Anthropometric study of farm workers on Java Island, Indonesia, and its implications for the design of farm tools and equipment

M. Faiz Syuaib

*Department of Mechanical & Biosystem Engineering, Faculty of Agricultural Engineering & Technology, Bogor Agricultural University (IPB), Kampus IPB Darmaga, Bogor 16680, Indonesia*

ARTICLE INFO

*Article history:*
Received 27 April 2014
Received in revised form
4 May 2015
Accepted 19 May 2015
Available online 6 June 2015

*Keywords:*
Anthropometry
Farm worker
Tool design

ABSTRACT

Anthropometric data are a prerequisite for designing agricultural tools and equipment that enable workers to achieve better performance and productivity while providing better safety and comfort. A set of thirty anthropometric dimensions was collected from a total sample of 371 male and female farm-workers from three different regions (west, central and east) of Java Island, Indonesia. The mean stature is 162.0 cm and 152.5 cm, the sitting height is 82.9 cm and 77.4 cm, and the body weight is 57.1 kg and 52.3 kg for male and female subjects, respectively. The index of relative sitting height (RSH) was 0.51 on average for both male and female subjects. Significant differences are found in most of the anthropometric dimensions between gender and regional data groups as well. Compared with groups of people from several other countries, the anthropometric dimensions of Indonesian people are quite similar to Indian people, but are relatively smaller than Filipino, Chinese, Japanese, British, and American people. An attempt was conducted to illustrate the use of this anthropometric database and ergonomic considerations in refining the design of traditional tools and equipment commonly in use for rice farming operations.



## 1. Introduction

Indonesia is an agricultural country in which a large portion of the population engages in agricultural works, either as smallholder farmers, farm labourers, or workers in agro-industrial plantations. In spite of a doubling of the total population from 1970 to 2010, the proportion of the agriculture-engaged workforce decreased by half over the same period (Komatsuzaki and Syuaib, 2011). Moreover, the proportion of female and elderly farm-workers is also steeply increasing.

Various types of tools, equipment and simple machines have been commonly used to accomplish a variety of farm works, and new types of machines are sometimes introduced to improve the productivity of farm operations. Ergonomic considerations are required in this regard to attain a good match and suitability of machines to tasks to ensure safety and enhance comfort and eventually to leverage productivity.

Anthropometry is a branch of Ergonomics that considers the measurement and description of the dimensions of the human body. Anthropometric considerations in the design of tools will result in the improvement of performance and efficiency along with safety and comfort as well as prevent work-related injuries or accidents. Anthropometric dimensions vary considerably across gender, race, ethnicity and age (Pheasant, 2003). Anthropometric data of several Asia Pacific populations have been reported, such as those in China, Japan and Korea (Lin et al., 2004); the Philippines (Prado-Lu, 2007); India (Dewangan et al., 2008; Agrawal et al., 2010); Turkey (Iseria and Arslan, 2009); Malaysia (Karmegam et al., 2011); and Iran (Sadeghi et al., 2015). However, the application of anthropometry to the design of farm tools and machinery has not been implemented in practice in Indonesia due to the lack of a proper anthropometric database.

To collect anthropometric data representing the Indonesian population as a whole is quite cumbersome because the country's area is quite extensive and consists of hundreds of tribes and ethnic groups. With a focus and emphasis on the main island of Java – which is inhabited by over half of the total population as well as by over half of the agriculture-engaged population of the country (Statistics of Indonesia, 2013) – this study was conducted with the aim to obtain an anthropometric database that can be used to design, or refine the design of, tools, machines, or work systems, particularly in agriculture.

*E-mail addresses:* faizs@ipb.ac.id, mfsyuaib@yahoo.com.

http://dx.doi.org/10.1016/j.apergo.2015.05.007
0003-6870/

## 2. Methods

Anthropometric surveys were undertaken in three districts representing three separate regions on Java Island, namely, Bogor in West Java, Demak in Central Java and Ponorogo in East Java. In total 189 males and 182 females were randomly selected among the self-farming (grass-root farmers) population in the regions. The numbers of sampled-subjects were selected proportionally to the size and distribution of the population in each study area, and all of the subjects were in good health and able to stand unassisted. The procedures of data collection were explained to the subjects before starting the measurement to obtain their understanding and cooperation, thereby ensuring that the measurement accuracy could be maintained.

A portable weighing scale with an accuracy of 0.1 kg measured the body weight, and a commercial Anthropometer set (Fig. 1) and a measurement tape with accuracy of 1 mm measured the other twenty-nine basic anthropometric dimensions of the subjects. Thirteen measurements were performed with the subjects in the standing position, and the other seventeen measurements were performed with the subjects in the sitting position (Figs. 2 and 3). Subsequently, the index of RSH (relative sitting height) was calculated, and the ages of the subjects were likewise recorded. For the measurement techniques and terminologies used, please refer to the guidelines in Anthropometric Source Book (NASA, 1978).

The required number of samples was estimated according to the equation in Annex A of ISO 15535:2003 – "General requirements for establishing anthropometric databases" – for a 95% confidence interval (Hua et al., 2007):

$$n \geq (3.006\ CV/\alpha)^2 \quad (1)$$

where n is the sample size, CV is the coefficient of variation, and $\alpha$ is the percentage of relative accuracy desired. In this survey, a 5% relative accuracy was desired, and a value of CV 0.125 was used to pre-determine the sample size. Thus, the minimum number of 60 for the number of subjects taken for each sample's group in this research is acceptable; Table 1 presents the distribution and characteristics of the subjects in the regions.

A computer recorded the collected data, and a common spreadsheet software package was used to analyse them. The data set for each dimension in the sample's groups were checked to ensure that they represent a normal distribution. The values of the mean, standard deviation (SD), standard error of the mean (SEM) and coefficient of variation (CV) were computed. The 5th, 50th and 95th percentile values were calculated accordingly. The ANOVA F-test was used to compare the significant differences among the data groups of the diverse regions, while the T-test was used to compare the difference between the mean dimensions of the males and females in each data group. The significant difference was accepted if a significant outcome existed ($p < 0.05$).

## 3. Results and discussion

### 3.1. Anthropometric measures

A set of thirty anthropometric measurements were obtained, and the values of SD, SEM, CV, and the 5th, 50th and 95th percentiles of each of the measures were calculated. Tables 2 and 3 present the results of the data analyses and how they are distributed with respect to the three distinct regions of study for males and females, respectively. Generally, the SEM values of the data groups are lower than 1.0, but the values associated with body weight, arm spans and vertical reaches are in the range of 1.0–1.4. These SEM values are accepted to the 95% confidence limit and therefore indicated that the number and distribution of the samples are representative of the targeted population. Furthermore, to summarize the overall anthropometric data of the three regions, iterative statistical calculations were performed to obtain a combined distribution of the data for each region. Table 4 presents the anthropometric data that correspond to the overall population of the farmers, both male and female.

Regarding the coefficient of variation, the values of CV > 10% are associated with body weight, chest depth, sitting elbow height and grip diameter, and the values of CV < 10% are generally associated with the remaining body dimensions in the data groups. According to Pheasant (2003), the common characteristic ranges of CV (%) of the various anthropometric dimensions are: 3–4 for stature, 3–5 for body heights, 4–5 for parts of limbs, 5–9 for body breadths, 6–9 for body depths, 4–11 for dynamic reach and 10–21 for body weight. Thus, over 75% of the collected data is located in the ranges of the suggested CV. However, the CV values of some particular body dimensions, such as sitting eye height, sitting shoulder height, sitting elbow height, chest depth, arm lengths, hand breadth and grip diameter, are relatively higher. Therefore, the generalization of the sample of the population for these particular dimensions should be used more carefully.

The mean (50th percentile) body weight of males in the West (W), Central (C) and East (E) regions of Java are 54.3 kg, 57.0 kg and

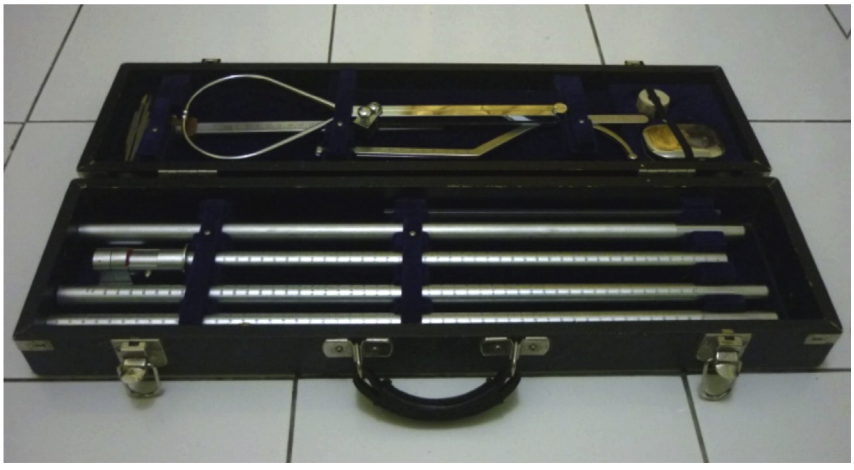

**Fig. 1.** Anthropometer set.