Body Segment Dimensions of Indonesian Male Army

M. Iqbal¹, R. Salam², I. Hasanuddin¹ and A. B. Hassan³

¹ Department of Mechanical and Industrial Engineering, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia
² Aceh Regional Police, Banda Aceh, Indonesia
³ Electrical, Electronic and Automation Section, Universiti Kuala Lumpur Malaysian Spanish Institute (UniKL – MSI), Kulim High Technology Park, 09000, Kulim, Kedah, Malaysia.

E-mail: mohd.iqbal@unsyiah.ac.id

Abstract. The paper discusses the size of six body segments of the Indonesian Male Army, i.e. stature, leg length, chest depth, chest width, spine length and shoulder high. The particular body segments were believed as the most important body part that related to the strength and load handling capability of humans as reported by researchers. Two hundred and sixty-eight (268) male soldiers have participated as the subjects of this research. The size of the body segments and the body weight were measured by using measuring tape, Martin type anthropometer and digital body weighing scale. The result was analysed to observe the significance of the data as well as to determine the mean, standard deviation, 5th percentile and 95th percentile of the data. The comparison of the mean stature with Indonesian male students and male army of other countries was discussed in the paper. In future research, the result of this study will be used to predict the load handling capability of the Indonesian male army using the biomechanics method.

1. Introduction

Matching of supply, job task, work procedure, tool, and equipment to anthropometry has been an important measure in ergonomic. Ergonomic consideration has taken an important place in the design of tasks and facilities in industries in order to fix the nature of the human body in term of size, posture [1], load [2] and movement [3]. The continuous improvement could be easily found in many types of hand tools that become more comfortable to users over the years. The ergonomic improvement could be found in the end product as well, such as vehicles, computers and furniture. The user could enjoy a better driver seat of their cars compared to the same product of the previous years. As a result, better ergonomic design leads to a better health level of users, fewer defects of the product or service, and higher productivity.

The size of body segment, body area and body weight have been studied for decades for the purpose of safety and comfort of humans. Body size was used as a reference for the design of the products such as hand tools, machines, buildings, vehicles, furniture, clothes, etc. [4, 5, 6]. It has been a challenge for the manufacturer since it becomes a consideration of the customer’s decision. The manufacturer should improve the ergonomics of their products in order to win the market competition.

The body weight was used as a reference for the load received by the products such as chairs, vehicles, shoes, etc. The body weight of users will be very much considered during the design stage of the product, i.e. in material selection and mechanical design development. With the help of computer design software, even the dynamic load of the product could be predicted by using the body weight data of users.

Research of anthropometry was needed to be conducted to all human races since different races have different body sizes [7, 8, 9]. That was the reason why all countries should support anthropometry research on their people. The data could be used to fit the people of that particular race to their daily used products. As humans grow, the different body sizes would be found in a different group of ages.
Harton [10] reported that the stature of the human body increased by the increase of the age from 6-9 years old to 10-12 years old. In the older age, the stature did not increase, but the volume and the weight of the body increased significantly. However, the elderly subjects lost some volume of their body size, as well as their body weight. As the food quality and the wealth of living improves, the anthropometry of population changes after some period of time. Tomkinson et al. [11] reported that there were substantial changes (typically increases) in the body dimensions of male Australian Army personnel over the period 1977-2012. Therefore the anthropometry data need to be updated periodically.

Some groups of the profession require special body sizes, such as fashion models, flight attendance, pilot and soldiers. Fashion model and flight attendance require high stature and slim body size for beauty and attractive appearance, while soldiers require special body stature and size for strength, stamina and capability to carry the load. Bauer and Freivalds [12] and Brackley and Stevenson [13] studied the load-carrying capability by using a biomechanics approach based on anthropometry measure. They discussed six body segments that significantly affected the load-carrying capability, i.e. stature, leg length, chest depth, chest width, spine length, and shoulder height. The workers should not carry the load over their capability because it could cause injuries, generate mental stress and burnout syndrome and decrease the working performance, as reported by Erwan et al. [14] and Hasanuddin et al. [15].

This study aims to investigate the anthropometry of the Indonesian army. The research focuses on the six body segments as investigated earlier [12, 13]. The result could be used as a reference to predict the strength, stamina and load-carrying capability, as well as the size of military products, i.e. clothes, tools and weapons. In addition, the result of the investigation was compared to the anthropometry data of Indonesian university students to identify the influence of occupation in anthropometry data. We also compared the anthropometry data of the Indonesian male army with the male army of other countries to learn the influence of race in anthropometry data of military persons.

2. Methodology

There were 40 body segments commonly considered as anthropometric body measurement as shown in Fig.1. Each of the body segments was measured either during the standing or sitting position. However, this study did not focus on the anthropometry measurement of the army. The study observes the size of body segment that reflect the performance of the army in term of strength and capability to handle the load.

Two hundred and sixty-eight Indonesian male army soldiers (mean age = 27.6 years, SD = 6.93 years) from Kodam Iskandar Muda (Indonesian Army in Aceh States Unit) participated in the study. The soldiers were recruited from the Infantry Battalion 112/ Raider Banda Aceh. No soldiers from other districts were involved in the study. Even though anthropometrics difference existed among different ethnicities in Indonesia [7], the subjects of this study did not represent only a particular ethnic since the Indonesia Military Management distributes the soldiers proportionally to all state units in Indonesia. In other words, the subjects of the study reflected national soldiers rather than Aceh (ethnic) soldiers only.

The survey was conducted at the indoor activity building of Infantry Battalion 112/ Raider Banda Aceh. The size of the body segment and the body weight were measured by using a measuring tape, Martin type anthropometer, and digital body weighing scale. The measurement and data recording process were taken by research assistants that have been well trained by senior and experienced researchers. The topics of the training include the measurement procedure, how to handle the equipment, how to deal with the subject’s confidentiality, how to handle the complaint, and how to record the data. The measurement process of body segment was shown in Figure 2.
During the exercise and real duty, a soldier carries a backpack with a standard weight and size. The soldier must be able to carry the backpack during a long journey and within a long duration of time. Most studies found that an acceptable weight limit of a subject should be between 10% and 15% of their body weight [12, 13]. However, an acceptable weight limit did not only depend on body weight but the size of body segments as well.

A study conducted by Kroemer [16] showed that individual differences such as body dimensions should be considered to determine the safe limit for the load to be carried. The study was followed by Ismaila and Owaba [17] that used the spinal shrinkage principles to determine the maximum weight of a load that a worker should lift to be safe.

**Figure 1.** Anthropometric body measurement

**Figure 2.** The measurement of body segments
Further study by Ismaila [18] used a strain energy-based model in terms of the size of body segments, Young Modulus of Elasticity of articular cartilage and maximum permissible spinal shrinkage to predict the capability of the subject to carry the load in the backpack during both standing and moving. The study aimed to determine the safe backpack mass limit based on the consideration of the subject's anthropometric characteristics.

Based on the above literature and methods, only six body segments were observed in this study. The particular body segments have been proven as the most important body part to represent the strength and load handling capability of the subjects [18,19]. They were stature, leg length, chest depth, chest width, spine length, and shoulder height. All of the six body segments were measured during a standing position, as shown in Fig 2.

3. Result and Discussions

The sizes of the six body segments of all 268 subjects were recorded and further analyzed. The mean and standard deviation (SD) of each body segment dimension were calculated using a simple average and sample standard deviation equations [20]. The value of the 5th percentile and 95th percentile were calculated based on a normal statistical distribution. The result of the data collection and calculation are shown in Table 1.

As shown in Table 1, the average stature of the Indonesian male army was 1690.9 mm, with 90 percent of stature between 1650 mm and 1760 mm and the SD of 39.5 mm or 2.45% of the average stature. Comparison between the stature of the Indonesian male army and the stature of Indonesian male university students shows different values. As reported by [8, 10], the average stature of Indonesian male students was 1670.1 mm, and its SD was 53.1 mm or 3.18% of its average stature. It means that the Indonesian male army was taller than Indonesian male students. On the other hand, the deviation (the difference between the shortest and the highest) of the Indonesian male army's stature was smaller compared to the deviation of Indonesian male students' stature.

Sutalaksana and Widyanti [21] reported the influence of occupational when comparing the anthropometry data of Indonesian students and traditional Indonesian workers. They concluded that the students come from better socioeconomic status compared to the traditional workers, and this is associated with better nutrition, better child care, and better medical and social services, which result in bigger anthropometry size. However, the factor contributing to the differences above does not apply to the difference between the Indonesian male army and Indonesian male students. The difference was because of a minimum stature and a narrow gap limit of minimum and maximum stature that must be fulfilled by army candidates when they apply to be a trainee at Indonesian Military School. Whereas, there are no criteria of body stature for any candidate of university students.

| No | Body segments, weight, and age of the subjects | Mean | Standard Deviation | 5th Percentile | 95th Percentile |
|----|-----------------------------------------------|------|--------------------|---------------|----------------|
| 1  | Stature                                       | 1690.9 | 39.5               | 1650          | 1760           |
| 2  | Leg length                                    | 1027.1 | 117.4              | 940           | 1450           |
| 3  | Chest depth                                   | 224.0  | 36.1               | 140           | 300            |
| 4  | Chest width                                   | 231.6  | 31.5               | 190           | 320            |
| 5  | Spine length                                  | 523.8  | 45.8               | 470           | 620            |
| 6  | Shoulder high                                 | 1454.7 | 44.2               | 1380          | 1520           |
| 7  | Body weight (kg)                              | 70.28  | 7.59               | 58            | 86             |
| 8  | Age (Year)                                    | 27.6   | 6.93               | 20            | 42             |
The comparison between the stature of the Indonesia army and three other countries (Brazil, United States (US) and Australia) is shown in Figure 3. The stature of the army of Brazil, US and Australia was 1755, 1756 and 1747 mm respectively [1]. Fig 3 shows that the Indonesian army was shorter than the army from the other three countries. The US army is the tallest, where the Brazilian is in the second place.

Tomkinson et al. [1] also reported that the body size of the Australian army had been changed in time. There has been a significant change in 12 anthropometry measures of the Australian army between 1977 and 2010-2012. Actually, time increases in body size have been reported for people of all ages over the past couple of centuries. It is believed that the increases in body size to be due to nutrition and access to health care, improvements in environmental conditions, leading to the reduction of growth-inhibiting factors.

The body stature of the Australian army in 1977 was 1747 mm. It was 38 mm shorter than their stature in 2010-2012. However, it was still 56 mm higher than the Indonesian army of the present year (2018) discussed in this paper. There is no reference found that could be used to compare the situation of Brazil, US, and Australian army to the Indonesian army. Further research is required to find out whether the difference in body size among the military reflects their strength and capability.

The body stature did not really represent the performance of a soldier. A taller soldier has a heavier body weight, so they require more metabolic energy during the activity such as walking, running and handling the load. Usually, the metabolic energy and stamina of a subject are not significantly linear with their body weight and stature [4]. Furthermore, the army of Indonesia, Brazil, US and Australia came from different races. It has been proven that different races have different anthropometry size [8,10]. However, the anthropometry data of the army from Indonesia’s neighbour countries, such as Malaysia, Thailand, Singapore, the Philippines and Brunei Darussalam, are not available in the literature. Therefore, the comparison to the same race cannot be properly discussed in this paper.

4. Conclusions

The result of the observation of six body segments of the Indonesian male army has been presented and discussed in the paper. The comparison of the average stature between the Indonesian male army and Indonesian male students showed that the Indonesian male army was taller than Indonesian male students. However, the Indonesian male army has a narrower deviation of stature. Comparison of the stature of the Indonesian male army to the other three countries' male army showed that the US male
army was the tallest, followed by Brazil, Australia, and Indonesia. The result of the study can be used in future study to predict the load handling capability of the Indonesian male army using the biomechanics method.

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