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# Recommended Chair and Work Surfaces Dimensions of VDT Tasks for Malaysian Citizens

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### Abstract

It is very common to find chairs and tables in the workplaces used for Video Display Terminal (VDT) tasks. Various problems have been associated with the use of VDTs, including visual problems, muscle aches and pains, repetitive trauma injuries such as carpal tunnel syndrome and job stress. Visual problems, muscle aches and pains are some of the common complaints reported by VDT operators. When workstations are poorly designed, the result is poor posture because strains are placed on a particular group of muscles, and discomfort level is increased. The objective of this paper is to propose an appropriate chair and table dimensions with respect to the Malaysian anthropometric data. The dimensions should be appropriate to 95% of the male and female population. This analysis was conducted using anthropometric data of 638 Malaysian consisting of 273 males and 365 females. The equipment used in this study are anthropometric chair and measuring tools comprising of Human Body Measuring Kit and Anthropometer for body dimension measurements.

**Keywords:** VDT workplaces, ergonomics, anthropometric data, Malaysian

## 1. Introduction

The word ergonomic was derived from the Greek word, ergon, meaning work, and nomos, meaning law or usage. The literature suggests that the word "Ergonomics" was independently used in 1949 by a British Scientist, K.R.H. Murrell (Kroemer, 2003).

During the past decade, research in ergonomics had led to heightened interest in the technology of work and furniture design based on biomechanics of the human body. These researches were focused on the development of new principles for the design of chairs and desks in the workplace (Parcells et al, 1999).

Bridger (1995) and Chou and Hsiao (2005) believed anthropometry is a research area in ergonomics dealing with the measurement of human body dimensions and certain physical characteristics. Anthropometric data can be used in ergonomics to specify the physical dimensions of workspaces, workstations, and equipment as well as applied to product design.

Presently, the importance of safety and ergonomic in the design and manufacture of consumer products had grown significantly. The latest technology had increased the option to broaden the ergonomic and safety features of certain consumer products. However, it will also pose new risks which are more complicated to manage. Therefore, it is important for the product designer and manufacturer to use anthropometric data and ergonomic knowledge in making decision during designing of machines, equipment, products and systems (Mattila, 1996).

Visual discomfort and musculoskeletal discomfort, particularly in the neck and shoulders, are occupational health concerns for people who work with computers (Bergqvist and Knave, 1994; Bergqvist et al, 1995; Hunting et al, 1981). In terms of ergonomics, comfort integrates a sense of well-being with health and safety; conversely, discomfort could be related to biomechanical factors involving muscular and skeletal systems (Zhang et al, 1996).

Over the last two decades, ergonomics in work environments has gained much attention from researchers, this is because ergonomics had played a very important role in preventing and controlling work-related injuries and illnesses (Piegorsh et al, 2006). According to Wang et al. (1999) anthropometry has been considered as the very basic core of ergonomics in an attempt to resolve the dilemma of "fitting people to machines".

## 2. Research Method

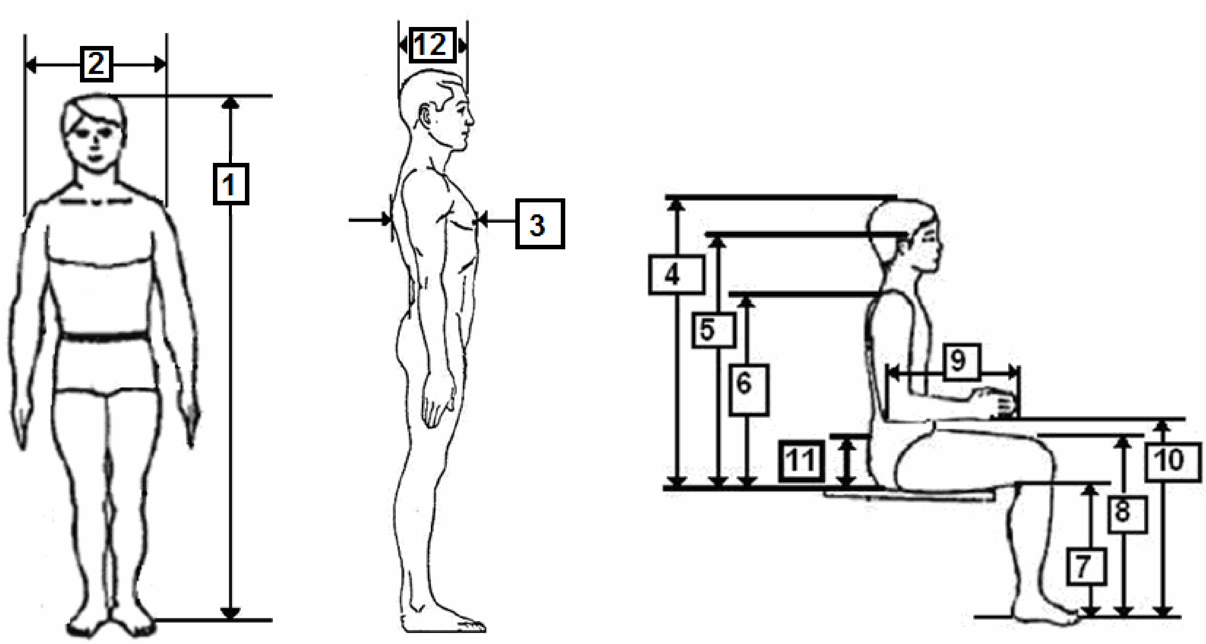
### 2.1. Participants

In this study 638 Malaysian citizen were involved including 273 males and 365 females. The participants' ages varied between 18 - 80 years old. The range of participants for collecting the anthropometric data comes from all ages to fit the $95^{th}$ percentile of Malaysian citizens. More than half of participants measured in this study are students. This is because the main location for the anthropometric measurement process was conducted at a local university and it is easier to get participants from among the students.

### 2.2. Measured Dimensions

A total of twelve anthropometric dimensions were measured in this study. All the twelve dimensions measured are: stature, shoulder breadth, chest depth, sitting height, sitting eye height, sitting shoulder height, popliteal height, sitting knee height, forearm hand length, sitting elbow height, thigh clearance, and head length as shown in Figure 1. These twelve anthropometry data are measured because they are directly related in designing chair and table for VDT user in this study. Four dimensions were collected while the participants in the standing position, the remaining eight dimensions were taken while the participants remained seated. All anthropometric data collected were based on MS ISO 7250 (2003) standard (Malaysian Standard, 2003).

**Figure 1:** Twelve Measured Anthropometric Data




### 2.3. Equipment

The equipment used in this study comprise of (i) anthropometric chair (Yanto, 2006), (ii) anthropometric measuring tools such as the Human Body Measuring Kit and Anthropometer. It is a well known fact that the use of computerized mechanism may produce more accurate results (Robinnette et al, 1999), however it lacks in terms of flexibility, mobility and very costly. On average, it took around 30 minutes to complete measurement for all the twelve dimensions.

### 2.4. Data Acquisition

The dimensions measured were recorded in a form as shown in Figure 2. The form includes some personal information such as age, sex, race, state of origin, date of birth, religion and occupation. Participants are required to fill in their personal information before the measurement process started. This form also provides spaces for the entire twelve dimensions measured. Figure 2 also shows clearly the exact location for all twelve anthropometric dimensions. This is important in ensuring the measurement process for all participants are done correctly and accurately to minimize error in data collection. Later, the data that had been collected was analyzed using Microsoft Excel to calculate the mean and standard deviation values. In addition to the mean and standard deviation, the 5$^{th}$ and 95$^{th}$

percentile values of the data were also calculated. Prior to that, a chair and table were designed to incorporate the Malaysian citizens anthropometric data collected during this study.

**Figure 2:** Anthropometric data collection form

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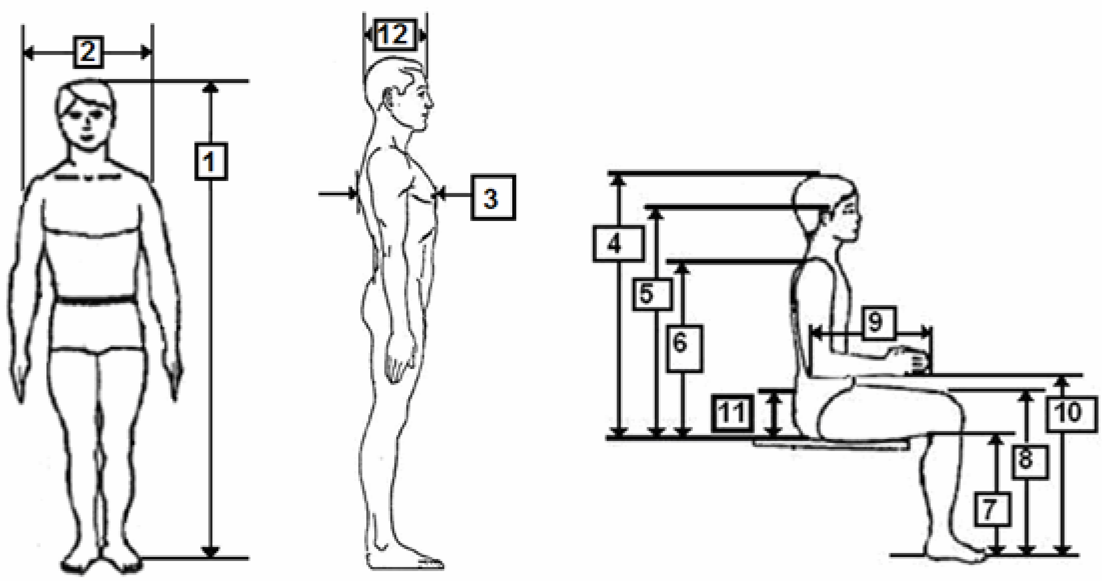
**MALAYSIAN ANTHROPOMETRICS DATA**

| | | | | | |
|---|---|---|---|---|---|
| Data No. | : | | Age | : | |
| State origin | : | | Date of birth | : | |
| Sex | : | | Religion | : | |
| Race | : | | Occupation | : | |

| ANTHROPOMETRY DATA | UNIT/mm | ANTHROPOMETRY DATA | UNIT/mm |
|---|---|---|---|
| 1. Stature | | 7. Popliteal height | |
| 2. Shoulder breadth | | 8. Sitting knee height | |
| 3. Chest depth | | 9. Forearm hand length | |
| 4. Sitting height | | 10. Sitting elbow height | |
| 5. Sitting eye height | | 11. Thigh clearance | |
| 6. Sitting shoulder height | | 12. Head length | |




## 3. The Results and Discussion

In this study, 12 anthropometric data were measured from 638 subjects. Table 1 shows the average, standard deviation, 5$^{th}$ percentile and 95$^{th}$ percentile of anthropometric dimensions collected for the 638 Malaysian males and females citizen.

**Table 1:** Anthropometric data for the overall Malaysian citizen, all units are in mm.

| No | Dimension | Average | SD | 5th Percentile | 95th Percentile |
|---|---|---|---|---|---|
| 1 | Stature | 1623.55 | 90.99 | 1473.42 | 1773.68 |
| 2 | Shoulder breadth | 459.54 | 61.53 | 358.02 | 561.06 |
| 3 | Chest depth | 215.68 | 45.16 | 141.17 | 290.19 |
| 4 | Sitting height | 820.55 | 79.20 | 689.88 | 951.23 |
| 5 | Sitting eye height | 703.44 | 82.11 | 567.95 | 838.92 |
| 6 | Sitting shoulder height | 535.37 | 70.00 | 419.87 | 650.87 |
| 7 | Popliteal height | 441.55 | 44.47 | 368.18 | 514.92 |
| 8 | Sitting knee height | 487.25 | 71.22 | 369.74 | 604.76 |
| 9 | Forearm hand length | 441.95 | 44.12 | 369.15 | 514.74 |
| 10 | Sitting elbow height | 222.76 | 52.25 | 136.55 | 308.98 |
| 11 | Thigh clearance | 192.77 | 50.35 | 109.69 | 275.84 |
| 12 | Head length | 202.40 | 31.82 | 149.90 | 254.90 |

From Table 1, it can be seen that the average sitting height for Malaysian citizen are 820.55mm, while the standard deviation is 79.20mm. Standard deviation value is directly proportional with the difference between each data and the mean value. The calculations for the 5th and 95th percentile are using normal distribution. The examples of calculation for sitting height are as below:

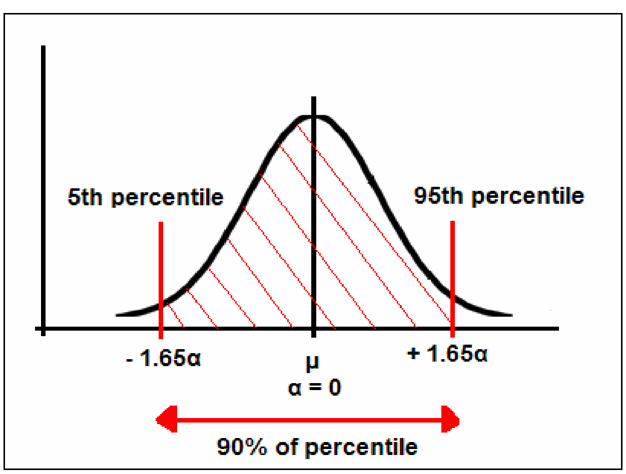
Mean= $\mu$
Standard Deviation= $\alpha$

5th percentile,
$= \mu - 1.65\alpha$
$= 820.55 - (1.65x79.20)$
$= 689.87$mm

95th percentile,
$= \mu + 1.65\alpha$
$= 820.55 + (1.65x79.20)$
$= 951.23$mm

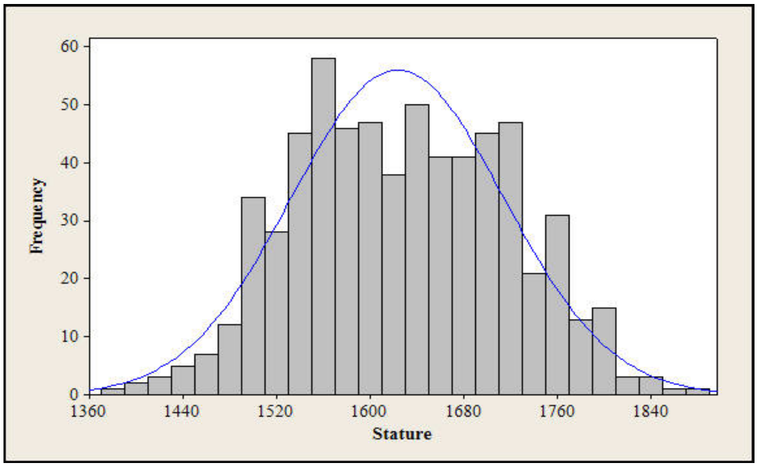
For further understanding, a basic normal distribution graph is shows in Figure 3 with clear description on the 90% of distribution.

**Figure 3:** The Normal distribution graph



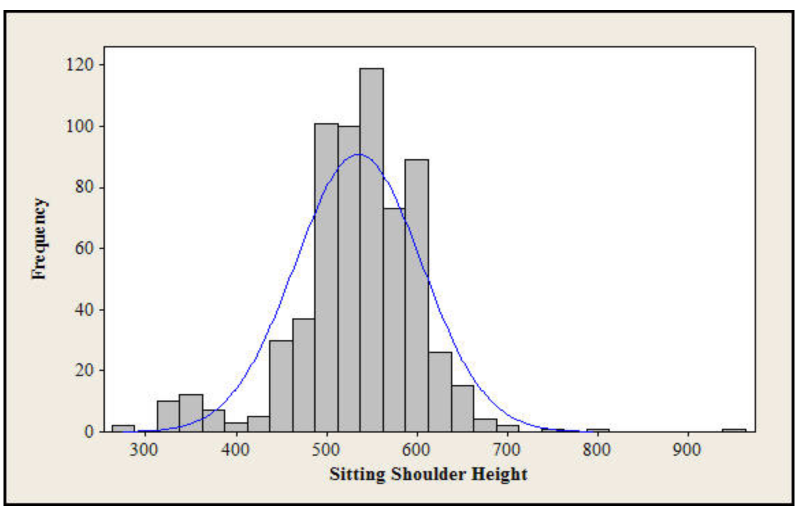
For example, the highest standard deviation value for stature is 90.99. This figure shows that variation in term of stature for Malaysian citizen is high. It can be seen in Figure 4, which shows that the distribution is quite normal. Therefore, it can be summarized that 90 percent of the Malaysian citizen heights lies between 1473.42mm and 1773.68mm.

**Figure 4:** Normal distribution graphs with histogram for stature of Malaysian citizen




The sixth dimension in Table 1 is the sitting shoulder height, it shows average value of 535.37mm, standard deviation is 70mm, the $5^{th}$ percentile value is 419.87mm and the $95^{th}$ percentile value is 650.87mm. This data could be used to determine the tool or equipment height on the table that is suitable with the workers heights which are required to perform their tasks while in the sitting position. This is to ensure that the workers do not have to raise their hands excessively. Figure 5 shows the normal distribution graph of sitting shoulder height for Malaysian citizens collected in this study. The distribution seems to be quite normal.

**Figure 5:** Normal distribution graphs for sitting shoulder height of Malaysian citizens




The value of the sitting eye height is also important and can be used to determine the proper height of a computer screen at workplace that is suitable for Malaysian citizens. Besides the overall data analysis of all the participants, the authors had also categorized the anthropometric data into male and female categories for easy reference as shown in Table 2 and Table 3.

**Table 2:** Anthropometric Data for Male Malaysian citizen, all units are in mm.

| No | Dimension | Average | SD | 5$^{th}$ Percentile | 95$^{th}$ Percentile |
|---|---|---|---|---|---|
| 1 | Stature | 1699.51 | 61.39 | 1598.22 | 1800.80 |
| 2 | Shoulder breadth | 484.70 | 57.68 | 389.53 | 579.87 |
| 3 | Chest depth | 217.40 | 47.89 | 138.38 | 296.41 |
| 4 | Sitting height | 857.95 | 59.44 | 759.87 | 956.03 |
| 5 | Sitting eye height | 738.40 | 69.50 | 623.73 | 853.07 |
| 6 | Sitting shoulder height | 561.85 | 61.27 | 460.76 | 662.95 |
| 7 | Popliteal height | 455.85 | 39.74 | 390.28 | 521.41 |
| 8 | Sitting knee height | 512.09 | 69.12 | 398.05 | 626.13 |
| 9 | Forearm hand length | 468.14 | 40.96 | 400.55 | 535.72 |
| 10 | Sitting elbow height | 219.78 | 47.09 | 142.07 | 297.48 |
| 11 | Thigh clearance | 188.11 | 44.16 | 115.25 | 260.97 |
| 12 | Head length | 207.70 | 27.87 | 161.71 | 253.69 |

**Table 3:** Anthropometric Data for Female Malaysian citizen, all units are in mm.

| No | Dimension | Average | SD | 5$^{th}$ Percentile | 95$^{th}$ Percentile |
|---|---|---|---|---|---|
| 1 | Stature | 1566.74 | 64.09 | 1460.99 | 1672.49 |
| 2 | Shoulder breadth | 440.72 | 57.53 | 345.81 | 535.64 |
| 3 | Chest depth | 214.39 | 43.02 | 143.40 | 285.38 |
| 4 | Sitting height | 792.58 | 80.64 | 659.53 | 925.64 |
| 5 | Sitting eye height | 677.28 | 81.16 | 543.37 | 811.20 |
| 6 | Sitting shoulder height | 515.56 | 69.64 | 400.65 | 630.47 |
| 7 | Popliteal height | 430.86 | 44.86 | 356.85 | 504.88 |
| 8 | Sitting knee height | 468.66 | 67.06 | 358.01 | 579.31 |
| 9 | Forearm hand length | 422.36 | 35.40 | 363.95 | 480.76 |
| 10 | Sitting elbow height | 225.00 | 55.76 | 132.99 | 317.01 |
| 11 | Thigh clearance | 196.25 | 54.32 | 106.63 | 285.88 |
| 12 | Head length | 198.44 | 33.98 | 142.37 | 254.51 |

From Table 2 and Table 3, they are several major differences in terms of the 12 dimension values. The value for stature, sitting height and sitting eye height are higher for males compared to females' Malaysian citizen. These values are acceptable because normally men are taller than women. Meanwhile, the value for thigh clearance of females is larger compared to males. Figure 6 and Figure 7 shows clearly the differences in values of thigh clearance between males and females. This data shows that female have larger thigh than men which can be explained by the fact that a female pelvis bone is slightly wider than men for reproduction purpose. Dlugos (1999) explained that the female pelvis is more widely separated causing a widening of the hips with respect to the male.

**Figure 6:** Normal distribution graphs for thigh clearance of Male Malaysian citizens

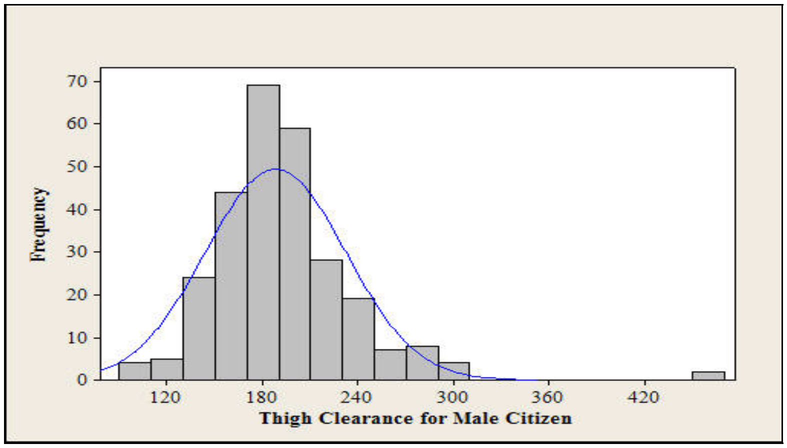
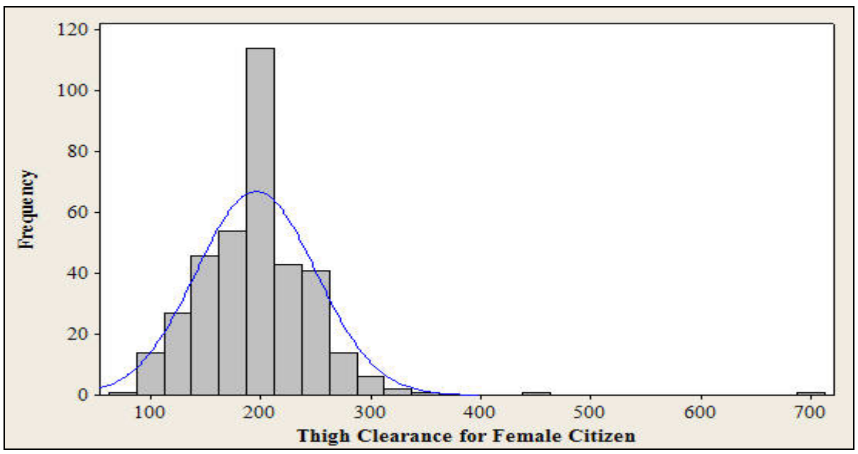



**Figure 7:** Normal distribution graphs for thigh clearance of Female Malaysian citizens



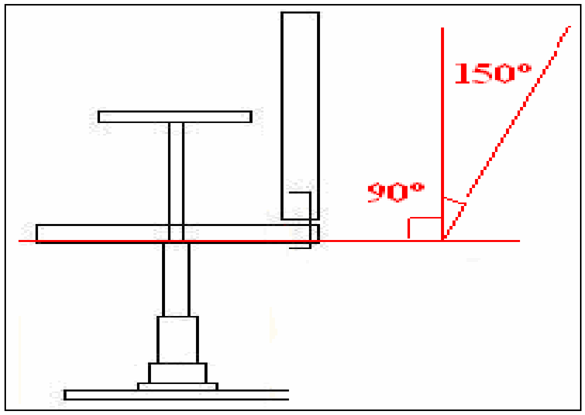

### 3.1. General requirement for chair design

With reference to the data in Table 2 and Table 3, the adjustable seat height of the chair can be adjusted from 356mm – 521mm. This data was taken from 5$^{th}$ percentile of female citizen popliteal height and 95$^{th}$ percentile of male citizen popliteal height. It allows the operators to place their feet firmly on the floor or on a footrest because hanging legs put extra loads on lower back muscles. Besides, this combination with the work surface heights, adjustable chairs height allows the operators to achieve both a suitable keyboard-to-forearm relationship and adequate leg clearance.

The armrest of chairs was also designed to be adjustable from 133mm to 297mm, which is parallel to the floor, or held with the hand higher than the elbow. These ranges were taken from the 5th percentile of female citizen sitting elbow height and 95$^{th}$ percentile of male citizen sitting elbow height. This is to ensure the wrist can be place flat on the table and in the same plane as the forearm. A flat wrist is very important in order to avoid pressure building on the median nerve which can lead to carpal tunnel syndrome (CTS).

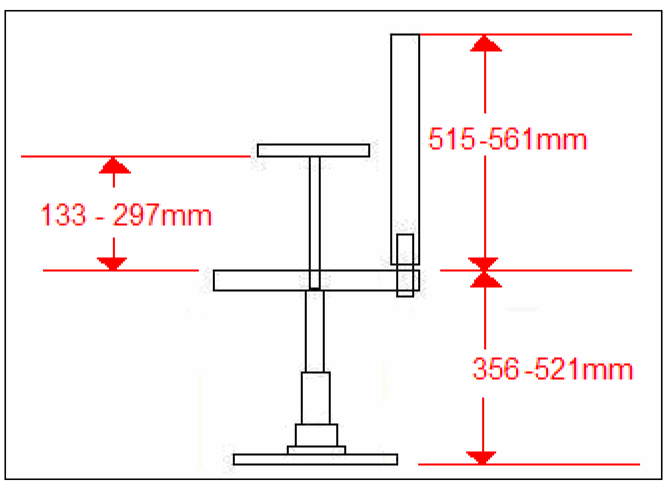
The backrest was designed with a curve shape so that the depth of the seat is capable to allow maximum contact between the operators' lumbar region and the seat back. This is to avoid pressure points on the back side of the leg above and below the knee. Besides that, the backrest can also be adjusted up and down between 515mm to 561mm from the chair seat (taken from the average of male and female citizen sitting shoulder height) or forward and backward from 90 degrees to 150 degrees perpendicular to the ground as shown in Figure 8.

**Figure 8:** Chair with adjustable backrest




The operators should be able to adjust the height and tilt of backrest without using any tools. Lumbar support helps to restore the forward curve of the spine found in a standing position. This spinal position requires the least muscles work to be maintained and the least pressure on the spinal discs is desirable for long periods of sedentary work. Middle and upper back support allows an operator to shift to a reclining position to relieve the strain muscles required for sitting up straight. Figure 9 shows the detailed drawing of chair design and its recommended dimensions.

**Figure 9:** Proposed chair dimension




### 3.2. General requirement for table design

The table is also important furniture for a VDT workstation. The main function of the table is to place the visual display terminal, such as monitor screen, LCD screen and others. Conrad (1996) had suggested the following general guidelines for designing a table and the appropriate dimensions for Malaysian citizen. The dimensions of the VDT tables should provide adequate clearance for the operators' legs and feet. The width and depth should also be able to accommodate the largest operators.

- VDT table should be provided with a keyboard support surface, which can be independently adjusted for height without the need of special tools. The keyboard height allows the operator to change the posture from upright to leaning forward or back, while at the same time maintaining an angle between the upper arm and forearm greater than 70 degrees but less than 135 degrees while maintaining the wrist in neutral position (in the same plane as forearm).

The height of display support surface should permit the center of the screen to be located between 5 and 30 degrees below the horizontal plane with respect to the eyes height. An angle of 10 to 15 degrees is recommended. If the height of the display surface is adjustable, it should have a range of adjustability at least 125 mm.

- Placement of keyboard is adjusted to 640 mm high lower than the sum of popliteal height and sitting elbow height that is 664 mm. This is to provide the worker with more relaxed movements during typing, reading, or etc.
- The table size is suggested using ordinary table size 700mm length x 900 mm wide to comply with Malaysian small anthropometric size.
- Parcells et al (1999) had suggested that desk height should be adjusted to elbow height measured from the floor, so that it would be minimum when shoulders are not flexed or abducted and maximal when shoulders are at 25° flexion and 20° abduction. The calculation of desk height (D) is taken from the equation by Gouvali & Boudolos (2006):
  $E + [(P + 2)\cos 30°] \leq D \leq [(P+2)\cos 5°] + (E0.8517) + (S0.1483)$
  $308.98 + [(514.92+2)0.866] \leq D \leq [(514.92+2)0.996] + (308.98 \times 0.8517) + (650.87 \times 0.1483)$
  $756.6 \leq D \leq 874.5$
  Which: E = Sitting elbow height = 308.98mm
  P = Popliteal Height = 514.92mm
  S = Sitting Shoulder Height = 650.87mm

The value for the sitting elbow height, popliteal height and sitting shoulder height are taken from the 95th percentile calculation of 638 Malaysian citizens. Therefore, from calculation the desk height is recommended to adjustable from 757mm to 875mm. Figure 10 shows the detailed drawing of proposed table dimension.

**Figure 10:** Proposed table dimension

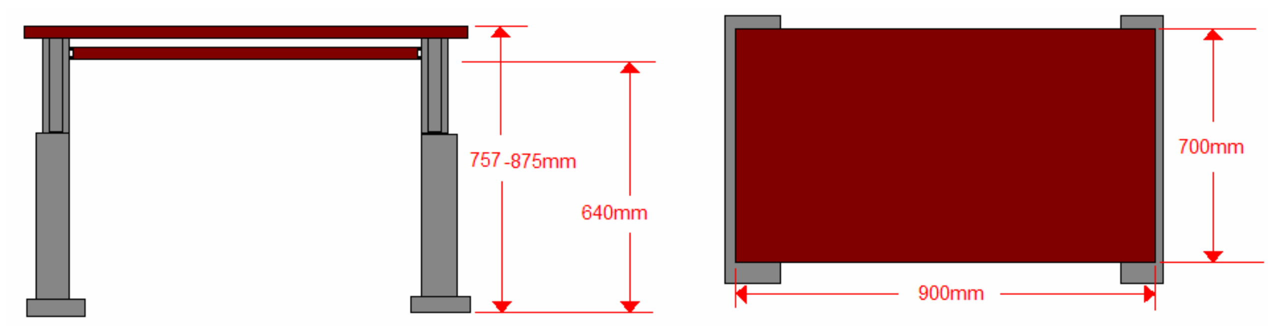



Figure 11 shows both the chair and table dimensions suggested for Malaysian citizen VDT users incorporating the anthropometric data found in this study.

**Figure 11:** Table and chair dimension for VDT user

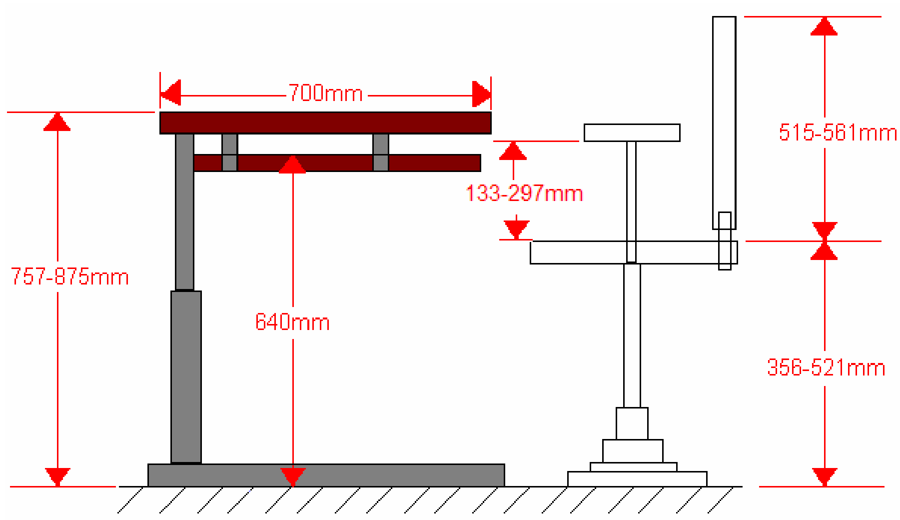
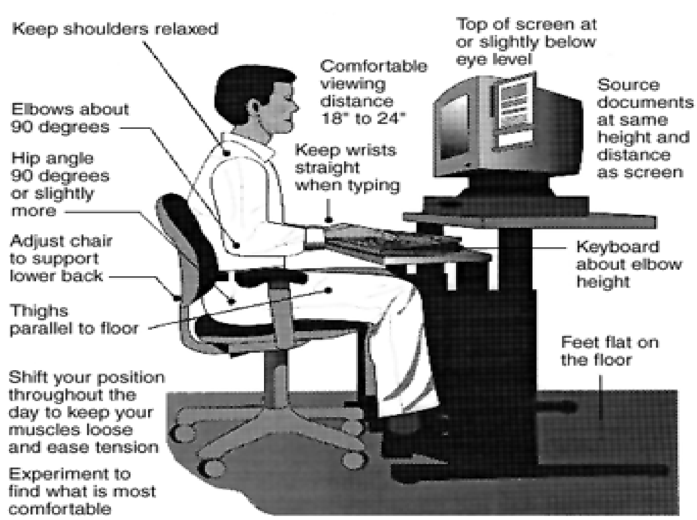



Figure 12 shows the 3-D image of VDT user's workstation. Several useful tips for comfort are highlight in Figure 12.

**Figure 12:** VDT users workstation




## 5. Summary and Concluding Remarks

The process of collecting anthropometric data is quite tedious but the authors had managed to come out with a proper data sheet of anthropometric measurement for Malaysian citizen. The anthropometric data measurement for Malaysian citizen collected in this study could assists designer and engineers to design an ergonomic product or workstation. The anthropometric data collected in this study shows that 90% stature values for Malaysian citizen lies between 1473.42mm and 1773.68mm. Normal distribution graph for thigh clearance value of male and female citizen shows that female's thigh is larger than male. This study had focused on the suitability chair and table used for VDT workstation according to the anthropometric data collected from Malaysian citizen. Chair and table are very important furniture in the VDT's workstation and they need to be designed ergonomically. This is important in order to fit at least 90% of the Malaysian citizens. For office workers, they spend most of the working time sitting in front the monitor (i.e. 8 hours), so suitable dimensions for the computer workstation are important to avoid back pain or other musculoskeletal problems. The proposed dimensions for the chair and table are expected to provide a solution for VDT user's discomfort, and able to enhanced workers performance and productivity. All these factors eventually shall translate to high organizational effectiveness, productivity, health and safety of VDT employees.

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