

ERGONOMIC DESIGN OF VDT WORKPLACE FOR INDIAN SOFTWARE PROFESSIONALS

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Abstract— It is very common to find readymade chairs and tables being used 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 etc. 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 excessive strains are placed on a particular group of muscles, and discomfort level is increased. The objective of this paper is to propose an ergonomically designed a Recommended Chair and Work Surface dimensions for VDT Tasks for Indian Software Professionals appropriate chair and table dimensions with respect to the Indian anthropometric data have been recommended and presented.

Key words— Ergonomics, VDT workplace, Visual Problem, anthropometric etc

I. INTRODUCTION

The word ergonomic has been derived from the Greek word, ergon, meaning work, and nomos, meaning law or usage. The literature suggests that the word “Ergonomics” was first independently used in 1949 by a British Scientist, K.R.H. Murrell [1]. During the past one decade, research in ergonomics has led to increased interest in the technology of work and furniture design based on biomechanics of the human body. These researches have been focused on the development of new principles for the design of chairs and desks in the workplace [2]. Anthropometry is a research area in ergonomics dealing with the measurement of human body dimensions and certain physical characteristics. Anthropometric data can be used to specify the physical dimensions of workspaces, workstations, and equipment as well as for the product design. Presently, the importance of safety and ergonomics in the design and manufacture of consumer products has grown significantly [3,4]. The latest technology has 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 decisions during designing of machines, equipments, products and systems strain with care [5]. Visual and musculoskeletal discomfort, particularly in the neck and shoulders and arms, back pains, tennis elbow, carpal tunnel syndrome swelling in car. are occupational health concerns for people who work with computers [6]. 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[7]. 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 [8]. Anthropometry has been considered as

the very basic core of ergonomics in an attempt to resolve the dilemma of “fitting people to machines”[9].

II. EXPERIMENTAL

A. Measured Dimensions

A total of twelve anthropometric dimensions have been measured in the age group of 20-50 years in this study. These are: stature, shoulder breadth, chest depth, sitting height, sitting eye height, sitting shoulder height, popliteal height, sitting knee height, forearm length, sitting elbow height, thigh clearance, and head length as shown in Figure 1. These twelve anthropometric dimensions are measured because they are directly related to the design of chair and table for VDT users in this study. Four dimensions were collected in the standing position & the remaining eight dimensions were taken remained seated. All anthropometric data collected is based on Indian standards[10].

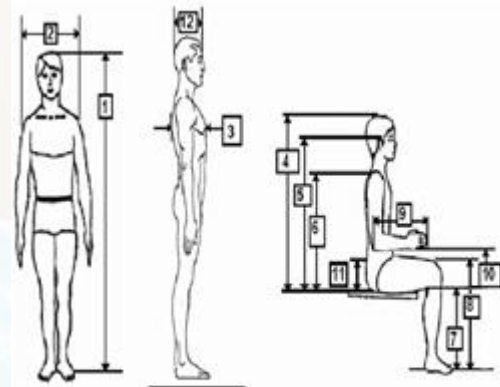


Figure 1. Twelve Measured Anthropometric Dimensions

- | | |
|---------------------------|-------------------------|
| 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 |

B. Data Acquisition.

In this study, 12 anthropometric dimensions have been recorded. Tables 1 and 2 and figure 1 show the average, standard deviation, 5th percentile and 95th percentile of anthropometric dimensions collected for Indian male & female population. From Table1 and Table2, there are several major differences in terms of the 12 dimensional values. The value for stature, sitting height and sitting eye height are higher for males compared to female Indian subjects. These values are

acceptable because normally men are taller than women. Meanwhile, the value for thigh clearance of females is larger compared to males. This data shows that female have larger thigh clearance than men which can be explained by the fact that a female pelvis bone is slightly wider than men due to biological reasons. The females pelvis is therefore more widely separated causing a widening of the hips with respect to the male [11].

in a distribution over a bell curve. If you draw the bell, and mark the 5th and 95th percentile spots, those marks separate the bulk of the curve from its edges. The calculations for the 5th and 95th percentile are carried out using normal distribution. The examples of calculation for stature are as follows:

Mean= μ
Standard Deviation= α

5th percentile,
= $\mu - 1.65\alpha$
= $1645 - (1.65 \times 75)$
= 1521.25mm

95th percentile,
= $\mu + 1.65\alpha$
= $1645 + (1.65 \times 75)$
= 1768.75mm

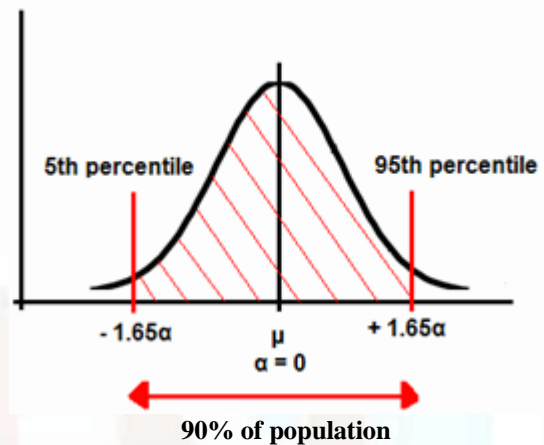


Figure 2. Normal Distribution graph (percentiles used in this study)

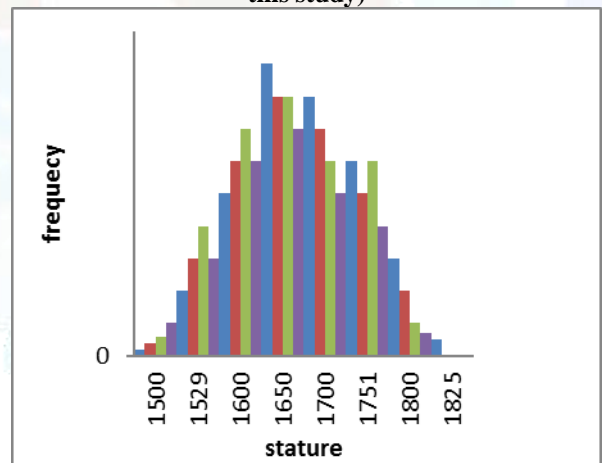


Figure 3. Normal distribution graphs with histogram for stature of male Indian subjects between 20-50 years age group

For example, the highest standard deviation value for stature of male Indian subject is 75. It can be seen from Figure 3, that the distribution is quite normal. Therefore, it can be summarized that the stature of 90 percent of the male Indian subjects lies between 1521.25mm and 1768.75mm.

The sixth dimension in Table 1 is the sitting shoulder height, it shows average value of 549mm with a standard

Dimensions	Average	Std.Deviation	5 th Percentile	95 th Percentile
Stature	1645	75	1521.25	1768.75
Shoulder breadth	430	34	373.9	486.1
Chest depth	217.40	47.89	138.38	296.41
Sitting height	837	45	762.75	911.25
Sitting eye height	738	39	673.6	802.3
Sitting shoulder height	549	37	487.9	610.05
Popliteal height	426	28	379.8	472.2
Sitting knee height	520	30	470.5	569.5
Forearm hand length	468.14	40.96	400.55	535.72
Sitting elbow height	219.78	47.09	142.07	297.48
Thigh clearance	556	43	485.05	626.9
Head length	207.70	27.87	161.71	253.69

Table 1. Anthropometric Data for Male Indian Subjects, all units are in mm between age group of 20-50 years

Dimensions	Average	Std. Deviation	5 th Percentile	95 th Percentile
Stature	1506	68	1393.8	1618.2
Shoulder breadth	376	37	314.9	437.05
Chest depth	214.39	43.02	143.40	285.38
Sitting height	775	39	710.6	839.3
Sitting eye height	657	45	582.7	731.2
Sitting shoulder height	507	30	457.5	556.5
Popliteal height	399	39	334.6	463.3
Sitting knee height	483	28	436.8	529.2
Forearm hand length	422.36	35.40	363.95	480.76
Sitting elbow height	225	55.76	132.99	317.01
Thigh clearance	527	40	461	593
Head length	198.44	33.98	142.37	254.51

Table 2. Anthropometric Data for Female Indian Subjects, all units are in mm between age group of 20-50 years

From Table 1, it can be seen that the average stature for Indian male subject is 1645mm, while the standard deviation is 75mm. Standard deviation value is directly proportional to the difference between each data and the mean value. The 5th and 95th percentiles are the lines that set of the "edges of the curve"

deviation of 37mm, the 5th percentile value is 484mm and the 95th percentile value is 608mm. This data could be used to determine the tools or equipment height on the table that matches with the anthropometric dimensions of the workers who 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 4 shows the normal distribution graph of sitting shoulder height for male Indian subjects collected in this study. The distribution seems to be quite normal.

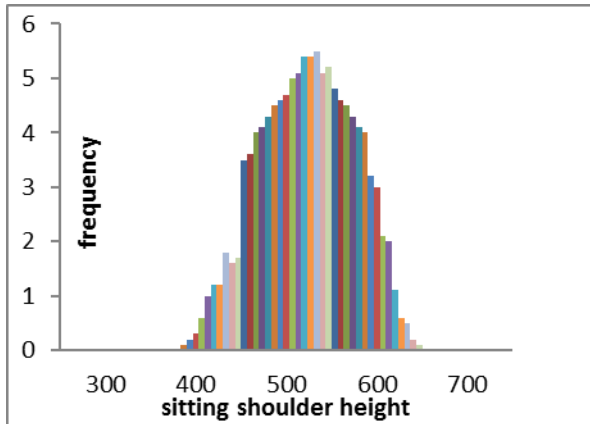


Figure 4. Normal distribution graphs for sitting shoulder height of male Indian subjects between 20-50 years age group

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 Indian subjects. Besides the overall data analysis, the anthropometric data for male and female categories for reference as shown in Table 1 and Table 2 respectively.

III. GENERAL REQUIREMENTS FOR CHAIR DESIGN

With reference to the data in Table 1 and Table 2, the adjustable seat height of the chair can be adjusted from 334.6mm – 472.2mm. This data was taken from 5th percentile of female citizen popliteal height and 95th 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 132.99mm to 297.48mm, which is parallel to the floor, or held with the hand higher than the elbow. These ranges were taken from the 5th percentile of females sitting elbow height and 95th percentile of males sitting elbow height. This is done to ensure that the wrist can be placed 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 operator's 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 between 507mm to 549mm from the chair seat (taken from the average of male and female sitting shoulder height) or forward and backward

from 90 degrees to 120 degrees perpendicular to the ground as shown in Figure 5.

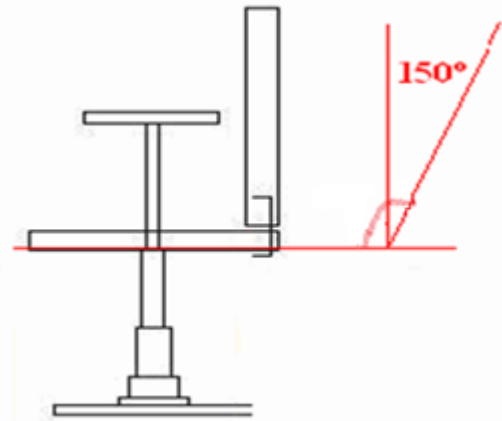


Figure 5. Chair with adjustable backrest

The operator 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 a reclining position to relieve the strain on muscles required for sitting up straight. Figure 6 shows the detailed drawing of chair design with recommended dimensions.

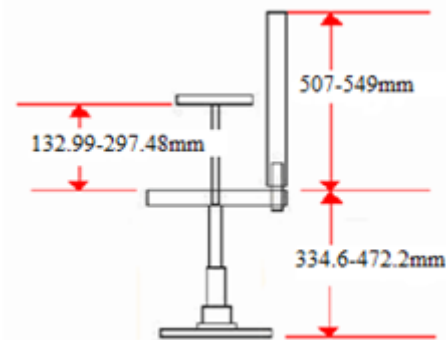


Figure 6: Proposed chair dimension

IV. GENERAL REQUIREMENTS OF TABLE DESIGN

The table is also an 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. The dimensions of the VDT tables should provide adequate clearance for the operator's 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 of 99°. While most operators prefer to lean back 104°- 113° with trunk inclination of 110°- 110° (only 10% preferred upright trunk posture) with arms slightly raised and elbow angles slightly opened.

- Placement of keyboard is adjusted to 620 mm lower than the sum of average popliteal height and sitting elbow height for male that is 645.78 mm & for female is 624. This is to provide the worker with more relaxed movements during typing, reading, or etc.
- The calculation of desk height (D) has been carried out using Gouvali and Boudolus equation [12] as shown below.

For males:

- $E + [(P + 2) \cos 30^\circ] \leq D \leq [(P+2) \cos 5^\circ] + (Ex0.8517) + (Sx0.1483)$
- $297.48 + [(472.2+2)0.866] \leq D \leq [(472.2+2)0.996] + (297.48x0.8517) + (610.05x0.1483)$
- $708.12 \leq D \leq 816$

For female:

- $E + [(P + 2) \cos 30^\circ] \leq D \leq [(P+2) \cos 5^\circ] + (Ex0.8517) + (Sx0.1483)$
- $317.01 + [(463.3+2)0.866] \leq D \leq [(463.3+2)0.996] + (317.01x0.8517) + (556.5x0.1483)$
- $719.9 \leq D \leq 815.8$

Where: E = Sitting elbow height = 317.01mm
P = Popliteal Height = 463.3mm
S = Sitting Shoulder Height = 556.5mm

The value for the sitting elbow height, popliteal height and sitting shoulder height are taken from the 95th percentile calculation of Indian subjects. Therefore, from calculation the desk height is recommended to be adjustable from 720mm to 816mm. Figure 7 shows the detailed drawing of proposed table dimension.

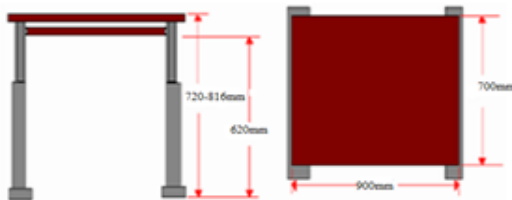


Figure 7. Proposed table dimension

Figure 8. Both the chair and the table dimensions suggested for Indian VDT users incorporating the anthropometric data collected and used.

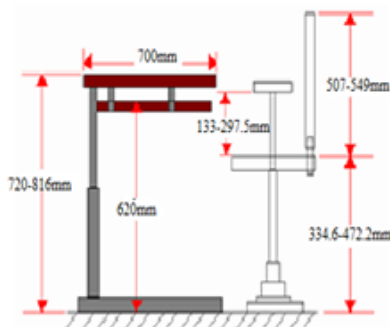


Figure 8: Table and chair dimension for VDT user (Table top is 900mm x 700mm)

V. CONCLUSIONS AND GENERAL RECOMMENDATIONS

The anthropometric data measurement for Indian subjects collected in this study could assist designers and engineers to design ergonomically, product and workstations. The anthropometric data collected in this study shows that 90% stature values for Indians lies between 1521.25mm and 1768.75mm. Normal distribution graph for thigh clearance value of male and female subjects shows that females thighs are larger than males. This study had focused on the suitability of chair and table used for VDT workstation according to the anthropometric data collected from Indian subjects. 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 Indian citizens. For office workers, they spend most of the working time sitting in front of the monitor (i.e. 8 hours). Thus 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 enhance workers performance and productivity.

Our own observations and work of some other investigators [13, 14, 15] on VDT workstation design tend to suggest the following general guidelines for the preferred settings of VDT workstations in offices. It has been generally observed that there is some departure from the ideal (erect) ergonomic posture

A. Screen setting

Comfortable screen distance of 710- 930 mm, a letter size of 3.4mm height and a visual angle of 0- 15°.

B. Postures

Most operators preferred postures they adopt when during a car. Lean back (104 – 113°) posture; elbow angle slightly open (99°).

C. Furniture

Key-board height (floor to home row) 700-850, screen centre above floor 900-1150, screen inclination to horizontal 88-105, key – board home row to table edge 100-260, screen distance from table edge 500- 750.

D. VDT workstation should have

Easily adjustable height and eye-to-screen distance. The distance between the front table edge to backwall should not be less than 600mm at knee level and at least 800 mm at the level of the feet.

E. Design of key-boards

Front height should not be less than 20mm and home row above the desktop equals 30mm with an inclination of 5-15. Distance between key centres 17-19 mm, force to operate keys 0.4 to 0.8 N key displacement 3-5 mm. keyboard to be moveable as per need. Tactile feedback (feeling of acceptance) and support for arms. Recently there is a development of split keyboard based on ergonomic principles. The two halves have an opening angle of 25° to avoid sideways twisting of the hands and are provided with lateral slopes of 10 to reduce the extent of inward rotation of the forearms and wrists [15]

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