

Anthropometry as an Ergonomic Design Factor in an Open Plan Selected Computer Operator Work Station: Cyber Cafés Perspectives

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Abstract

The aim of this research is to study selected cyber cafe workstations to establish the current practices with reference to the use of anthropometry. Also to re-design the work station, if necessary, in order to improve productivity, health safety and comfort of the operators in the work station.

Optimising the anthropometric data for computer work station design can be a complex task because of the number of design parameters that must be put into consideration. This problem has recently been made much easier to solve as a result of the development of some design principles like design for extreme, design for average sizes and design for adjustable range. Because of the nature of the selected workstations, design for adjustable range principle is used. Anthropometric dimensions of the operators were used to design chair and table which can accommodate 5% - 95% of the operators.

The work stations were examined and analysed under the combination of different anthropometric parameters. The analysis of the results indicates some deficiencies in the design of the workstation based on the design parameters and standard values from the literatures. Based on the analysis of these results the operators and their clients may likely be exposed to fatigue, work stress and other related diseases.

For demonstration of the application of the adjustable range design approach, a computer operator work station (Open Plan Cyber café) has been re-designed as a real case. It is hoped that the new design will contribute to improvement in productivity, health safety and comfort of the operators in the workstation. In the proposed adjustable range design approach, I suggest to every organisation operating with the workstation. Before any decision on making or buying equipments and tools, industrial engineers are to be consulted depending on the design factor, for proper guidance.

Anthropometric dimensions of the workers should also be considered for any workstation that requires chair and table design.

Many works that were done on anthropometry as a design factor for computer operator work station were done on simple system, where design for extreme and average are always reasonable. The research work was done on multiple complex systems like cyber cafe, where many people of different sizes and shapes were considered. In view of these, design for adjustable range is most economical and ergonomic appropriate.

Key words: Ergonomic, Workstation, Anthropometric data, design for extreme, design for average sizes and design for adjustable range.

Word count: 360

1.0 INTRODUCTION

An ergonomic design computer workstation environment should eliminate static or awkward posture, repetitive motion of the worker, poor access or inadequate clearance and excessive reach to work areas. This is achieved, when an organization successfully matches the work processes with the individual who performs the tasks. Computers have almost totally replaced typing machine, and facilitated intensive research activities of various sorts through their screens using key board and mouse [1]. Therefore, continuous and repetitive nature of computer application, normally involving long hours of work for on the job usage or for leisure, engaging mostly one hand (and about three middle fingers of the right hand in the case of using mouse) [12] in most hanging situation, and sewing the eyes to hieroglyphs on the improperly positioned screen are bound to inflict multitude of very complicated injuries, mostly of persisting kind, to the user [[1]. Epidemiological studies have concentrated on identifying the primary risk associated with the wrong design of computer workstation in Nigeria [7]. Researchers have identified three main categories; cardiovascular diseases,

2.0 LITERATURE REVIEW

Anthropometric Measurements and Percentile Humans

Anthropometry is the science that measures the range of the body sizes in a population [13]. When designing products it is important to remember that people come in many sizes and shapes. Anthropometric data varies considerably between regional populations [13]. For example, Scandinavian population tend to be taller, while Asian and Italian population tend to be shorter [13].

Anthropometric dimensions for each population are ranked by sizes and described

gastrointestinal illness, and musculoskeletal problems [7]. The most prevalent health problems in Nigeria are musculoskeletal, relating to neck and back pain [7]. Studies have found that frequent user of about 80.5% have experienced some degree of back pain, compared with 50% of non – user. The incidence of reported low back pain is 20% higher for user than non – user as a results of poor design and not putting Anthropometry into consideration.

Optimising the anthropometric data for computer work station design can be a complex task because of the number of design parameters that must be put into consideration. This problem has recently been made much easier to solve as a result of the development of some design principles like design for extreme, design for average sizes and design for adjustable range. Using these designs, one can conveniently predict the safety in term of comfort and thus increasing the performance level of workers in a particular computer work station.

The research aimed at study cyber café selected work station to establish the current practice with reference to the use of Anthropometry. To re-design the work station, if necessary, in order to improve the productivity, health safety and comfort of the operators in the workstation

as percentiles [13]. It is common practices to design for the 5th percentile female to the 95th percentile male. The 5th % female value for a particular dimension e.g. sitting height usually represents the smallest measurement for design in a population. Conversely, the 95th % male value may represent the largest dimension for which one is designing. The 5th % to 95th % range accommodates approximately 90% of the population. To design for a larger portion of the population, one might use the range from the 1st % female to the 99th % male.

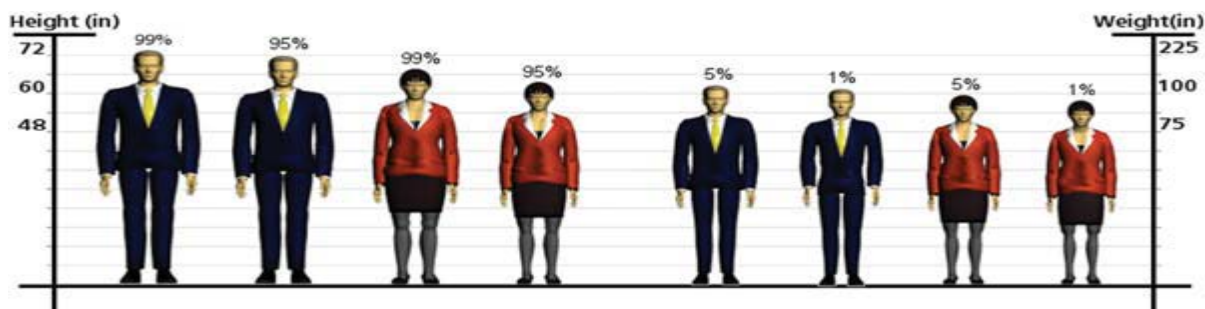


Figure 1 Comparison of Percentiles Males and Females
 Source: [6] [8] [9]

Computer Desk Design

Applying practical interview, and remembering the tilt angle that draft person used to provide for themselves of their drawing boards, one can propose a totally different angle for the screen in respect to the desk surface, and a stepped desk, which can include useful components that lack in most present design. Good designs certainly eliminate or, at least alleviate the use-inflicted problems to a great extent. New conceptual look and redesign of certain items, such as the seat, mouse, keyboard, etc. using advantages of developments in the science of

mechatronics is a vital necessity before too late [1].

In order to alleviate hand, wrist, arm and back strains, it has been approved by the computer users to locate the mouse and keyboard at a lower height than the desk, main surface. This lower desk surface is considered continuous lengthwise, in the design, to provide enough free space for some of the peripheral to move about. Considering the anthropometric standard, the design also facilitates serial arrangement of desk [3], which are suitable for most of the work environment as generally practiced now.

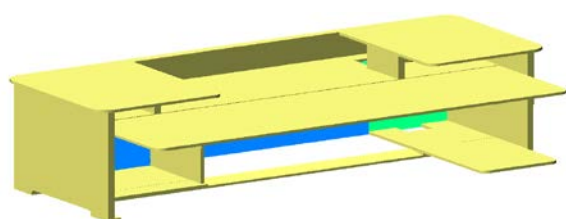


Figure 2 Continuous step desk designs
 Source: [1]

The height of the desk step provides just enough room for some compartmentalization purposes. These compartments, though limited in size, facilitate design of lockers for the user, space for writing paper, CDs, etc. the best location of the tower for right-hand users, which is an established practice now, is underneath the desk at the right hand.

Some people are casual users of computers. However, at work situations most of the computer users include those who would be busy at it the whole working hours continuously, day in and day out. It can be argued that continuous use of present design computer facilities, which suffer major design errors, would certainly be bound to inflict injuries of persistent degree to the enormous population of users who are on the increase. As we emphasized earlier, unless the whole system of the hardware and the software is revised on the basis of the principles of engineering design backed up by certain law regulations, the problem will insist. Present PC terminals, keyboards, mice, desks and seats are the major components, which, on the opinion of the present authors, require serious design revisions.

It is now an established fact that, repetitive use of computers constituting of monitor, mouse, keyboard, desk, and seat can fatally ruin the health of user eyes, wrist, and cause various musculoskeletal changes and general fatigue of mind and other organs.

We have also considered a continuous lower level on the desk design to facilitate a free-to-move or positional adjustability of the keyboard and mouse to be located at a lower level than the screen and peripheries. The step on the desk also provides compartmental facilities to cater for the user private belongings and filing purposes.

Ergonomic Chair Design

Computer chair is the most important part of computer work station [11]. The chair has to fit user and suit the tasks that is been done. One style of chair may not suit every worker. For example, the average chair is designed in some instances to fit the average male and may not suit other users.

A chair is only ergonomic if it can be adjusted to fit the user [11]. The following features are part of a good computer chair [11]:

- I. 5 – Caster Swivel base
- II. Arm rest
- III. Height adjustable seat pan
- IV. Tilt adjustable back rest
- V. Ability to make adjustments easily while sitting in the chair
- VI. Firm padding covered with non slip, breathable fabric

The special features include [11]:

Seat Pan: the seat pan should be the type with rounded front edge, wide and deep enough to fit the user Comfortability, and with adjustable in angle.

Back rest: the back rest contains padding for the low back area that is curved to fit the shape of the back of the user. It must be of adjustable height and angle with locking mechanism, wide and high enough to fit the

back of the user. It should be noted that, when seated, the back tends to lose some of its natural curvature [13]. An effective lumbar support of a chair is designed to help maintain the natural curvature of the spine when sitting. It is important to provide appropriate support for the spine so that there is no discomfort or pain.



Figure 3. Chair with Lumbar support
Source: [11]

The arm rest should be designed in such a way to eliminate interference with the work surface and will provide height and width adjustability.

The chair height is designed in a way that allows the feet of the user to rest comfortably on the floor and even pressure is felt from the seat pan both on the back of the seat (buttock region) and under the thighs (near the knees). To cater for the chair range of motion, the seat and back rest should allow for varied seated postures. This can be accomplished by allowing a rearward tilt of the back. A minimum of 10° rearward tilt (between 90° and 115°) is preferable [13]. The only guidelines for seat tilt measurement is to ensure the torso-to thigh angle is not less than

90°, and that the seat angle is between 0- 4° rearward tilt [13].

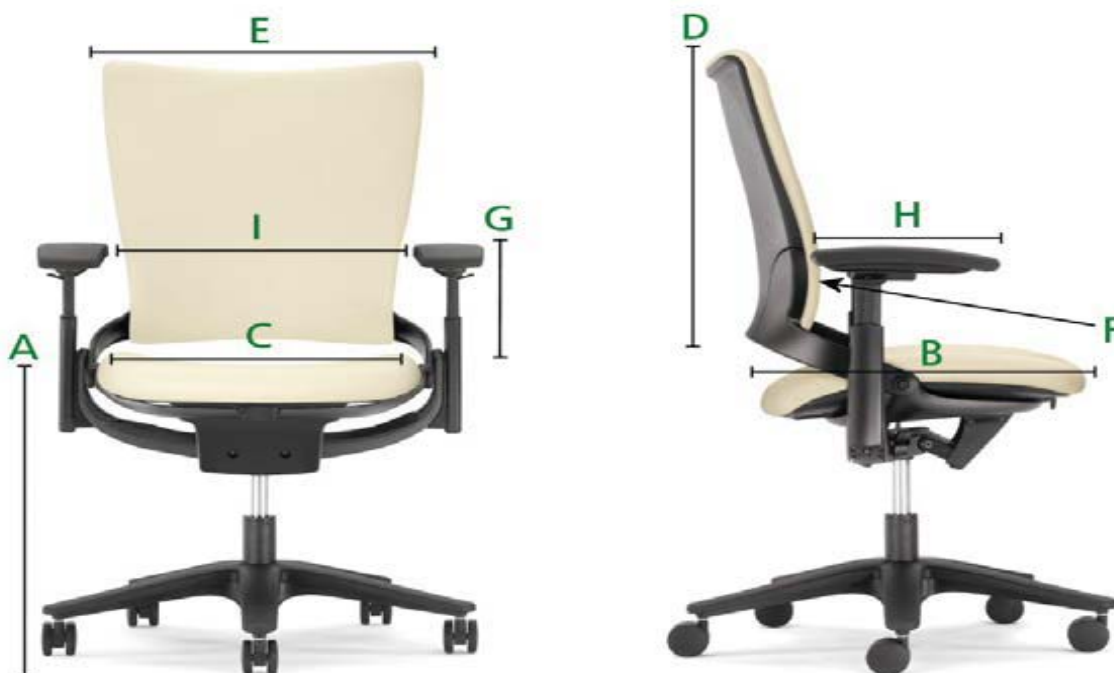


Figure 4. Measurements from BIFMA guidelines used for Ergonomic Chair

Source: [4]

Table 1 Specific BIFMA Chair design guideline Measurements (all dimensions in inch)

Source: [4]

		measurement	BIFMA Guideline (inch)	All Steel Sum Chair (inch)
Seat Height	A	Popliteal Height + Shoe allowance	15.0 - 19.9	15.0 – 22.25
Seat Depth	B	Buttock- Popliteal length- Clearance allowance	No deeper than 16.9 (fixed), 16.9 include (adjustable)	15.0 – 18.0
Seat Width	C	Hip breadth, Sitting + Clothing allowance	No less than 18.0	18.0
Back rest Height	D	None	At least 12.2	24.0
Back rest Width	E	Waist breadth	14.2	16.0
Back rest Lumbar	F	None	Most prominent point 5.9 – 9.8 from seat pan, in and out1	Infinite through height of back
Arm rest Height	G	Elbow rest Height	6.9 – 10.8 7.9 – 9.8	7.0 – 11.0
Arm rest Length	H	None	None	10.5
Distance between Arm rest	I	Hip breath, Sitting + Clothing allowance	18 (fixed) 18 (adjustable)	16.5 – 19.0

3.0 METHODOLOGY

Field Experiment

A random sample of thirty respondents was selected from two different cyber cafes in equal proportions. The study was divided into two phases. A survey was conducted using questionnaire and observation method, focusing on the anthropometric dimensions of the respondents. These were done to identify the level of ergonomic awareness and the level of implementation of ergonomic programmes in the design of the computer work station. The second phase of the study was the ergonomic re-design of the computer work station using data from the anthropometric dimensions of the respondents and the standard parameter from the literature.

Anthropometric Dimensions for Desk and Chair Design

The data was collected under the following body dimensions:

1. Sitting Height: with the subject sitting erect, distance from sit to vertex of the hair pressed down.
2. Shoulder Width: the distance from the edge of one shoulder to the next in the sitting position.
3. Hip Width (Seat Width): distance between the outer part of the right and left hips in a seated position.
4. Elbow Rest Height (Arm rest Height): with subject sitting erect, distance from seat to bottom of elbow.
5. Knee Height (Seat Height): distance from the knee to the sole in sitting position.

6. Buttock-Knee Length (Seat Depth): distance from the back of the buttocks to the foremost point of the patellar.
7. Thigh Clearance: with subject sitting, distance between the right and left thigh.
8. Eye Height: with subject sitting erect, distance from the seat to the eye level.
9. Lower Arm-Hand Length (Arm rest Length): in sitting position, distance from the elbow to the mid finger tip.
10. Back rest Lumber: distance between the lower back rest curvature to the tip of the seat pan.
11. Back rest Height: distance between the topmost edge and bottom edge of the back rest.
12. Back rest Width: distance between the top most right side to the top most left side of the back rest.
13. Distance between the Arms rests: in sitting position, hip width with clothing allowance.

Selection of statistic and Error Rate

The primary statistical procedure used was one - way analysis of variance (ANOVA) [2]. The general linear model in SPSS 16.0 was used for analysing data. The SPSS 16.0 Software program includes an additional column labelled sig. for significance [10]. Several assumptions were made for the one - way ANOVA statistical procedures in the study. (a) Samples were randomly collected from the population and randomly assigned to group (b) There was homogeneity of variance (c) the error rate selected was 0.05 type 1 error.

4.0 RESULTS

Result of Survey on Desk and Table Design

The results of the survey are presented in tables 2 and 3

Table 2: Response on ergonomic awareness and implementation

Part	Profile	Category	Frequency	Percentage
	Gender	Male	16	53.33

		Female	14	46.67
	Age Limit	50 year above	4	13.33
		40-50yrs	5	16.67
		30-40yrs	9	30.00
		20-30yrs	10	33.33
		Below 20	2	6.67
	Weight	30-45kg	5	16.67
		45-70kg	15	50.00
		Above 70kg	10	33.33
	Height	Below 1.5m	6	20.00
		1.5-1.7m	17	56.67
		1.7m above	7	23.33
	Job Responsibility	Computer Operator	30	100.00
Daily Working Hour on the Computer	How Often does the user work on the machine	Always	20	66.67
		Sometimes	9	30.00
Rarely		1	3.33	
Not at all		0	0.00	
	Duration per day	6-8hrs	8	26.67
		3-6hr	15	50.00
		Below 3hrs	7	23.33
	Did you experience pain during and after work	Always	6	20.00
		Sometimes	13	43.33
		Rarely	6	20.00
		Not at all	5	16.67
	Which of the working position is more comfortable	Sitting	30	100.00
		Standing	0	0.00
		Alternating standing and sitting	0	0.00
	Did you feel pain in any of these parts	Spinal cord	12	15.79
		Thigh	7	9.21
		Legs	2	2.63
		Hips	3	3.95
		Fingers	0	0.00
		Hand muscles	7	9.21
		Leg muscles	3	3.95
		Feet	0	0.00
		Buttocks	14	18.42
		Shoulders	10	13.16
		Neck region	13	17.11
		Elbow forearm	3	3.95
		wrist	2	2.63
Identification of	How often did	Always	6	20.00

knowledge and Ergonomic Awareness	you experience fatigue at work	Sometimes	11	36.67
		Rarely	8	26.67
		Not at all	5	16.67
	In which of the body part do you feel much pain	Leg muscle	4	12.12
		Neck region	11	33.33
		Buttocks	5	15.15
		Spinal cord	8	24.24
		Hand muscles	3	9.10
		Hips	0	0
		fingers	2	6.10
Level of implementation	Can you evaluate the existing design of the workstation	Strong conformed	5	16.67
		Slightly conformed	9	30.00
		Moderately conformed	7	23.33
		Conformed	7	23.33
		Not conformed	2	6.67
	How can you rate your productivity and efficiency with existing design at work	Excellent	6	20.00
		Average	12	40.00
		Good	10	33.33
		Poor	2	6.67

Table 3: Mean Values and Standard deviations of the Male Anthropometric Dimensions

specification	SH	SW	HW	ERH	KH	BKL	TC	EH	LAHL
Mean Value	32.8	19.3	19.3	7.3	17.9	23.2	6.7	29.5	12.1
Range	30-36.4	16.8-21.6	16.4-22.8	6-9.2	17-19	19.6-25.2	6.4-10.8	27.6-31.2	11-14.4
STD	3.68	3.13	3.87	2.53	2.83	3.41	3.21	2.76	2.35

Table 4: Mean Values and Standard deviations of the Female Anthropometric Dimensions

specification	SH	SW	HW	ERH	KH	BKL	TC	EH	LAHL
Mean Value	30.0	19.3	19.1	7.1	17.4	23.3	6.5	29.3	12.1
Range	28-34.4	17.6-20.8	16.4-22.8	5.2-8.8	17 -19	20-27.2	6-9.2	27.6-31.2	10.8-13.2
STD	3.96	2.93	3.89	2.72	2.64	3.68	2.66	2.83	3.00

Results Analysis

Analysis on Ergonomic Awareness and Implementation

The survey exercise was 100% response; all the questionnaires given out were attended to. The majority of the respondents were male, which was 53.33% while the female was 46.67%. The age limit of most of the respondents fell in between 20 – 30 years

with a percentage of 33.33%, followed by the age limit between 30 – 40years with a percentage of 30%. Age 40 – 50 years limit was 16.67%, 50 years and above was 13.33% and 20% of the respondents were below 20 years. Most of the respondents were 56.67% and 50% in height and weight respectively. The extremely tall respondents of above 1.7meters were 23.33%, followed by those

respondents below 1.5 meters with 20% quota. All the respondents were frequent computer user, so 100% computer operators were recorded.

In the area of daily working hour of the respondents, the highest number of the respondents uses computer between 3 – 6 hours per day with 50% quota, while the least users were below 3 hours per day. Full working hour respondents fell in between the two, with 26.67%. Almost half of the respondents experiences pain sometimes during and after work with 43.33%. ‘Always’ and ‘rarely’ pain experience user were both 20%, 16.67% of the respondents neither experience pain during nor after work. All the respondents preferred sitting position while at work on computer. The respondents’ experiences pain mostly on the buttock, neck region, spinal cord and shoulder with 18.42%, 17.11%, 15.79% and 13.16% respectively. The thigh and hand muscles both shared the same level of 9.2%, while hips, leg muscles and elbow/forearm were 3.95%. The respondents rarely experience pain on the legs

and wrist with 2.63%. None of the respondent experience pain on the finger.

In the ergonomic awareness part of the result from the questionnaire, 36.67% of the respondent sometimes experiences fatigue at work, mostly at the neck region with 33.33%, while 26.67% rarely experience fatigue. 20% always experience, and 16.67% never experience at all. The percentage of respondents that also experienced fatigue causing pain on the spinal cord, buttocks, leg muscles and hand muscles were 24.24%, 15.15%, 12.12% and 9.10% respectively.

The level of implementation of ergonomic in the existing design was evaluated by the respondents using likert scale. 23% of the respondents agreed to moderately conformed, 30% agreed to slightly conformed, 16.67% consented to strongly conformed, while only 6.67% chose not conformed. The respondents rated their productivity and efficiency on the existing design. 40% consented to be good, 33.33% consented to be average performance, 20% believed to be excellent, and only 6.67% agreed to not conform.

Analysis of the Anthropometric Dimensions for the Respondents (Desk/Chair Design)

Table 5. Comparison of Existing Design with Ergonomic Design Standards

Chair/Desk Specification	Specification Dimensions of existing design	Dreyfuss Standard Values	Woodson Standard Values
Seat Height	Popliteal height + Shoe allowance = 12.5	14.5 – 19.0	15 - 18
Seat Depth	Buttock-Popliteal length – Clearance allowance = 14	16	16
Seat width	Buttock-Popliteal length – Clearance allowance = 16	16 - 22	19
Seat Angle	Fixed	0 – 4⁰ rearward (fix)	0 - 5⁰
Back rest Lumber	None	7.0 – 11.5 in/out 0.6 – 0.8	7.0 – 10.0

Back rest Height	At least 12.5; over 25 For upper body support	At least 13; over 25 for upper body support, 36 for head support	At least 8; 34 for head support
Movement of seat and Back rest	Fixed	90⁰ - 105⁰	90⁰ - 105⁰
Arm rest Height	None	7.5 – 10; 8.5 (fixed)	12
Arm rest Length	None	10 – 12 forward of seat reference point	12
Shoulder width	14.5	19.3	19.9
Distance between Arm rest	None	19 minimum	19
Hip width	14	14.3	14
Buttock – kneel length	20.2	22.2	25.2
Thigh clearance	None	5.4	6.9
Eye Height	24.3	29.3	33.5
Sitting Height	18.0	33.4	38.0

The comparative analysis of the anthropometric dimensions of the respondent, existing design of the computer workstation and standards from the literature shows that the existing computer workstation is poorly designed. The anthropometric dimensions of users in the workstation were not considered in the design of computer desk and chair.

To design the workstation to attain Standard ergonomic level of implementation as described in the literatures, the principle of Anthropometry must be considered.

The re- designed workstation is presented in the tables below

The computations of parameters of re- designed work stations are summarized in Table 6 and 7

Table 6: Results of the Re- designed Work stations

Chair /Desk Design Parameters	Woodson Design Standards				Anthropometric Measurements Mean Values		Re- Design Workstation
	Female 5%	Female 95%	Male 5%	Male 95%	Female Mean Value	Male Mean Value	
Seat Height (KH)	17.9	21.5	19.3	23.4	17.4	17.9	17.9 – 23.4
Seat Width (BKL)	20.4	24.6	21.3	25.2	23.3	23.2	20.4 – 25.2
Seat pan Angle	0 - 5 ⁰		0 - 5 ⁰		N/A	N/A	0 - 5 ⁰
Back rest Lumber	7.0	11.0	7.0	10.0	9.2	8.8	7.0 – 11.0
Back rest Height	At least 8, 34 for head support				N/A	N/A	At least 8, 34 for head support
Seat Width	19.0	19.0	19.0	19.0	19.1	19.3	19.0
Back rest Width	16.0	16.0	16.0	16.0	N/A	N/A	16.0
Movement of	90 ⁰ - 105 ⁰				N/A	N/A	90 ⁰ - 105 ⁰

the Seat and Back rest							
Arm rest Height	7.1	11	7.4	11.6	7.1	7.3	7.1 – 11.6
Arm rest Length	12.0	12.0	12.0	12.0	12.1	12.1	12.0
Distance between the Arm rests	Hip Width plus Sitting Clothing Allowance = 19 Minimum				N/A	N/A	19 Minimum
Shoulder Width	12.3	19.3	13.7	19.9	19.3	19.3	12.3 – 19.9
Hip Width	19.0	19.0	19.0	19.0	19.1	19.3	19.0
Buttock-Kneel length	20.4	24.6	21.3	25.2	23.3	23.2	20.4 – 25.2
Thigh clearance	4.1	6.9	4.3	6.9	6.5	6.7	4.1 – 6.9
Eye Height	27.4	31.0	28.7	31.3	29.3	29.5	27.4 – 31.3
Sitting Height	30.9	33.4	33.2	38.0	30.0	32.8	30.9 – 38.0

Table 7. Anthropometric Measurement and Areas of Practical Application

Anthropometric measurement	Area of practical application
Height	Height of panel wall
Weight	Weight limit for sitting
Sitting Height	Over head clearance and sitting panel height
Sitting eye height	Height of top of monitor and the tilt angle of the monitor
Thigh clearance	Clearance between the thighs and bottom of work surface
Sitting hip width	Seat width
Sitting Popliteal height	Seat height
Sitting knee height	Knee clearance under work surface
Waist depth	Clearance between back rest and work surface edge
Buttock- to - Popliteal	Seat length
Buttock -to -knee	Knee clearance
Shoulder width	Seat and arm rest widths
Elbow rest height/ Arm rest length	Arm rest, keyboard and work surface height
Back rest height and breath	Back rest and support

Statistical Analysis of the Anthropometric Dimensions

Table 8 Descriptive Statistics for the Dependent Variables

Descriptives

Anthropometric Dimensions

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum

Male Anthro	9	53.5978	17.86191	5.95397	39.8679	67.3277	19.31	82.10
Female Anthro	9	49.1722	20.31322	6.77107	33.5581	64.7863	17.71	75.10
Total	18	51.3850	18.69497	4.40645	42.0882	60.6818	17.71	82.10

The Maximum and Minimum mean values anthropometric dimensions for male and female respondents are (82.10, 19.31) and (75.10, 17.71)

respectively. The standard deviations for both male and female anthropometric dimensions are 17.86 and 20.31 respectively.

Table 9 Test between and within samples for Anthropometric dimension (ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	88.135	1	88.135	.241	.630
Within Groups	5853.399	16	365.837		
Total	5941.533	17			

Using the one – way ANOVA [2] based on the SPSS 16.0, [10] the test of the between and within samples were run for anthropometric dimension as shown in table 4.6B. The samples are statistically significant at $F(1, 16) = 0.241$ and level of significance 0.63 respectively. Using a test of significance reference table, the F- critical value

was 6.3 at 1 degree of freedom and alpha equals 0.05 which was the 95% confidence level. The F-observed value for the anthropometric dimension with degree of freedom of 1 was less than F critical value. Based on analysis F statistical value, the samples were insignificant at the 95% confidence level.

5. CONCLUSIONS

1. There is low level of ergonomic programme implementation in the computer operator work station.
2. The operators suffer work stresses like fatigue and pains during and after prolonged usage of the work station.
3. There is negative impact on the productivity of the operators of the work station
4. The work station is not user friendly.

The following recommendations will I suggest to every organisation operating with the workstation:

1. Before any decision on making or buying equipments and tools, industrial engineers are to be consulted depending on the design factor, for proper guidance.
2. Anthropometric dimensions of the workers should also be considered for any workstation that requires chair and table design.

5.2 Recommendations

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