Formulation of Model to Execute the Comfortability Factor for Office Workstation

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Abstract **:Nowadays use of computer workstations are increasing as computer technology advances, as a result occupational health and safety problems are continuously increasing.The objective of research is to study and identify ergonomic deficiencies in the office chair design in the typical educational offices. Physical measurement and questionnaires were used to study 100 workstations. Major ergonomic deficiencies were in physical design and layout of workstations, postures, work practices and training. The consequences in terms of user health and other problems were significant.**

INTRODUCTION

Ergonomics is the science and technology of fitting the activities and environment to the abilities, dimensions, and needs of people to improve while enhancing comfort, health and safety. Companies have realized the importance of ergonomics because ergonomically designed products have a competitive advantage in the marketplace. A product may be simple or complex; however, its development process involves a series of events of identifying the user's needs, defining design concepts, making a prototype, testing usability, and releasing a product to the market. Iterative application of the most relevant knowledge and experience throughout this process will yield an ergonomically sound product. Ergonomists aim to provide working conditions which were well above the minimum required to ensure health and safety of the workforce. Thus, in achieving a comfortable, productive and satisfying office environment, any musculoskeletal complaints would also be minimized. To design such an environment, it was necessary to consider not only furniture and equipment, but also the job designs, lighting, noise, air quality, office landscaping and personal space. This work concentrates on furniture and equipment which both had a strong influence on postures.

HISTORY: As early as 18th century doctors noted that workers who required to maintain body positions for long periods of time developed musculoskeletal problems. Within last 20 years research has clearly established connections between certain job tasks and RSI or MSD.ergonomy caused various types of problems like Thoracic Outlet Syndrome.

Experimentation:

PARAMETERS UNDER INVESTIGATION

Anthropometric parameters:

1. Eye height
2. Eye height sitting
3. Sitting height
4. Shoulder breadth
5. Chest depth
6. Heap breadth
7. Heap breadth sitting
8. Acrimony height sitting
9. Shoulder elbow length
10. Elbow Hand length
11. Maximum horizontal reach
12. Elbow rest height
13. Buttock knee length
14. Buttock popliteal length
15. Direct thigh length
16. Knee height
17. Popliteal height
18. Elbow center to hand length
19. Elbow elbow breadth
20. Thigh clearance height
21. Knee knee breadth
22. Leg length

Chair Design Parameter:

a. Seat height
b. Seat depth
c. Seat width
d. Backrest height
e. Backrest width
f. Backrest lumbar
g. Arm rest height
h. Arm rest length
i. Distance between arm rests

Workstation Parameters:

1. Horizontal eye-to-moniter distance
2. Eye to monitercentre distance
3. Angle of elbow
4. Angle of knees
5. Shoulder to mouse distance
6. Workstation height
7. Leg minimum height clearance
8. Chair seat height
9. Seat depth

Output parameters: Comfortable level(Survey Base):

1. Backrests
2. Visibility
3. Neck
4. Shoulders
5. Eye height
6. Numbness
7. Hands
8. Lower back
9. Upper back
10. Legs

Observation Table:-

Parameters	Staff 1	Staff2	Staff3	-	-	-	-	-	Staff100
Age	24	25	26	-	-	-	-	-	36
Experience	1	6months	2	-	-	-	-	-	10
Weight	68	64	70	-	-	-	-	-	79
Eye height	157	150	155	-	-	-	-	-	134
Eye height sitting.	115	106	113	-	-	-	-	-	114
Sitting Height.	126	125	128	-	-	-	-	-	119
Shoulder Breadth.	46	45	47	-	-	-	-	-	45
Chest depth.	35	35	35	-	-	-	-	-	35
Hip breadth.	38	40	42	-	-	-	-	-	34
Hip breadth sitting.	43	45	45	-	-	-	-	-	37
Acrimony height sitting.	43	45	45	-	-	-	-	-	37
Shoulder elbow length.	30	32	30	-	-	-	-	-	35
Elbow hand length.	29	28	28	-	-	-	-	-	31
Maximum horizontal reach.	76	75	75	-	-	-	-	-	75
Elbow rest height.	60	59	60	-	-	-	-	-	71
Buttock knee length.	54	57	55	-	-	-	-	-	48
Buttock popliteal length.	43	45	43	-	-	-	-	-	39
Leg length.	86	89	89	-	-	-	-		95
Direct thigh length.	48	50	46	-	-	-	-	-	44
Knee height.	55	53	53	-	-	-	-	-	54
Popliteal height.	46	48	48	-	-	-	-	-	53
Elbow centre to hand length.	50	49	48	-	-	-	-	-	43
Elbow elbow breadth	43	43	45	-	-	-	-	-	53
Thigh clearance height.	3	4	3	-	-	-	-	-	4
Knee to knee bre-adth	46	48	46	-	-	-	-	-	42
Chair datasheet									
Parameters	chair 1	Chair2	Chair3	-	-	-	-	-	Chair100
Seat height (Popliteal height + Shoe Allowance)	46	45	47	-	-	-	-	-	50
Seat depth (Buttock – Popliteal length –clearance allowance)	40	43	43	-	-	-	-	-	49
Seat width (Hip Breadth , sitting + Clothing allowance)	50	51	46	-	-	-	-	-	46
Back rest height (none)	41	40	45	-	-	-	-	-	49
Backrest width (Waist breadth)	50	55	39	-	-	-	-	-	31
Backrest Lumbar (none)	55	72	75	-	-	-	-	-	85
Armrest height (Elbow rest height)	50	43	43	-	-	-	-	-	64
Armrest length (none)	69	65	63	-	-	-	-	-	68
Distance between armrest (Hip breadth ,sitting + Clothing allowance)	49	49	51	-	-	-	-	-	47
Workstation datasheet									

Parameters	Workstation 1	Workstation 2	Workstation 3	-	-	-	-	Workstation 100
Horizontal eye-tomonitor distance.	55	72	75	-	-	-	-	78
Eye-to-monitor center distance.	52	70	72	-	-	-	-	75
Angle of Elbow	60	75	75	-	-	-	-	79
Angle of knees	120	115	118	-	-	-	-	120
Shoulder to mouse distance	80	118	95	-	-	-	-	80
Workstation height.	56	85	70	-	-	-	-	56
Leg minimum height clearance.	76	60	76	-	-	-	-	76
Chair seat height	30	28	29	-	-	-	-	30
Seat depth	33	28	43	-	-	-	-	39

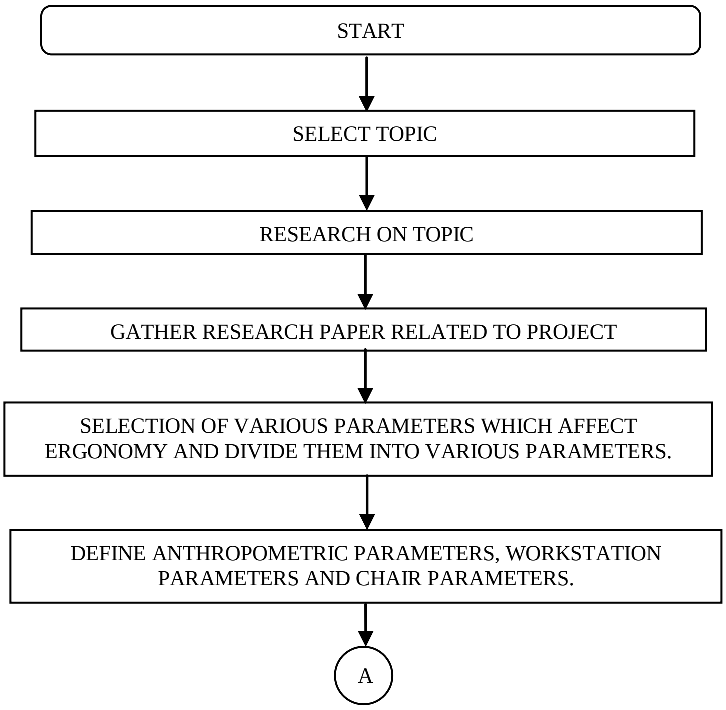
Procedure-

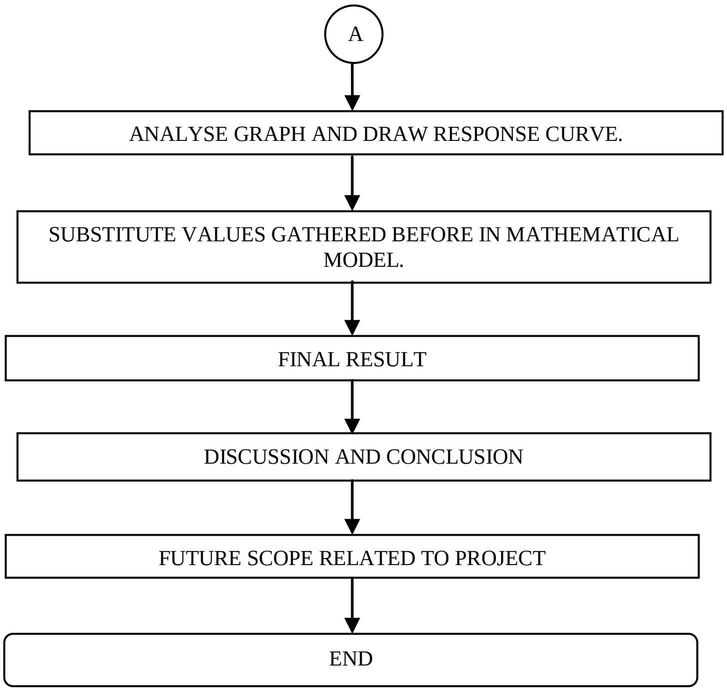
Firstly we selected the model for our project. We selected the project related to our project and then we tried to gather information on our related topic. We gathered information from various research papers searched and also from the books related to the topic.

Then we analyzed all the parameters which affect the ergonomic comfort of humans. We divided them into anthropometric parameters, chair parameters and workstation parameters. We considered them and divide them into various positions. We defined various parameters of anthropometric parameters, chair parameters and workstation parameters.

We defined workstation in our college institution. Then took the readings of various parameters with 100 different workstations. We also divided comfort zone in various parameters between rating 1 to 5, where 1 is worst condition and 5 is best condition. Then analyzed the data by plotting graph. We came on conclusion that there is vast difference in readings depending upon gender, age and size. So we needed to develop mathematical model to come on specific conclusion .Response curve was plotted depending upon the readings. Then we gave various parameters to the specific readings. By Mapping Buckingham's pi theorem to regression situation. We prepared the equation so that we can find out the paramerters.Final result was drawn from the mathematical model.

FLOWCHART (PROCSS FOLLOWED IN COMPLETING PROJECT





Model Formulation: *Following symbols are used:*

IP1: Input dimensionless pi term for human personal data
IP2: Input dimensionless pi term for Anthropometric data
IP3: Input dimensionless pi term for chair design parameters
IP4: Input dimensionless pi term for Workstation parameters
Op1: Output dimensionless pi term for chair seat
Op2: Output dimensionless pi term for chair Visibility parameters
Op3: Output dimensionless pi term for discomfort in the body

The possible relation may be linear, log linear, polynomial with n degrees. Linear with products of independent pi terms. In this manner any complicated relationship can be evaluated and further investigated for error. Mapping Buckingham's pi theorem to regression situation.

$$Op1 = K0 \times IP1^{K1} \times IP2^{K2} \times IP3^{K3} \times IP4^{K4} \qquad \text{(Eqn. 1)}$$

This dimensionless statement is easily transformed into linear relationship using log operation.

$$Log(OP1)=Log(K_0) + K1\,Log(IP1) + K2\,Log(IP2) + K3Log(IP3) + K4Log(IP4) \qquad \text{(Eqn 2)}$$

In this case we have six independent entities, ruling out the possibility of polynomial relationship i.e.

$$Y= a_0 + a_1 x + a_2 x^2 + a_3 x^3 + \text{---------} + a_n x^n \qquad \text{(Eqn. 3)}$$

The general form of Buck ham's pi theorem can be stated as

$$Op1 = K0 \times IP1^{K1} \times IP2^{K2} \times IP33^{K3} \times IP4^{K4} \qquad \text{(Eqn.4)}$$

Old K0 is not referred hereinafter for any purpose. Wherever necessary value of constant can be computed by $e^{new\ K0}$ hence equation is modified as

$$OP1 = e^{K0} \times IP1^{K1} \times IP2^{K2} \times IP33^{K3} \times IP4^{K4} \qquad \text{(Eqn. 5)}$$

Obtaining the log on both sides we get

$$Log(OP1) = K_0 + K1\,Log(IP1) + K2\,Log(IP2) + K3Log(IP3) + K4Log(IP4) \qquad \text{(Eqn. 6)}$$

This linear relationship now can be viewed as the hyper plane in five dimensional spaces. To simplify further let us replace the log terms by linear terms implies

$$Z1= K0 + K1(A) + K2(B) + K3(C) + K4(D) \qquad \text{(Eqn. 7)}$$

Where Z= Log(OP1), A= Log(IP1), B= Log(IP2), C= Log(IP3) , D=Log(IP4), This is true linear relationship between IP1------ IP4 to reveal OP1.

Applying the theories of regression analysis, the aim is to minimize the error.SayYc is the computed value of OP1 using regression equation and Ya is the value of same term obtained from experimental data with exactly same values of IP1------ IP4 then

Error (E) = Ya-Yc. (Eqn. 8)

An attempt to minimize error (E) is normally translated to minimization of E^2 conventionally in regression, using differential algebra the point of minimum can be easily obtained by stating.

$$\frac{\partial E^2}{\partial x} = 0$$

It will ensure the extreme position of error with parameter x which may mean either maximization or minimization. The second differentiation of E^2 awards the confidence whether it is maximum value or minimum value. This entire process can be reduced to finding the values of K0, K1, K2, K3, K4, K5 and K6. Once these values are known the relation between independent and dependent variables can be is completely established. Since the aim is to obtain values like K0, K1, K2, K3, K4, K5 and K6 it is obvious that square of error should be differentiated with respect to the constant of equation.

E= Yc- Ya = (K0 + K1 A + K2 B +K3 C + K4 D – Ye) Implies

E^2 = (K0 + K1 A + K2 B +K3 C + K4 D – Ye) ^{2} Differentiating with respect to K0

$$\frac{\partial E^2}{\partial Ko} = 2\,(K0 + K1\,A + K2\,B + K3\,C + K4\,D - Ye) = 0$$

$$\frac{\partial E^2}{\partial K_1} = 2\,(K0 + K1\,A + K2\,B + K3\,C + K4\,D - Ye)\,A = 0$$

$$= 2\,(K0A + K1\,A^2 + K2\,AB + K3\,AC + K4\,AD - AYe) = 0$$

$$\frac{\partial E^2}{\partial K_2} = 2\,(K0B + K1\,AB + K2\,B^2 + K3\,BC + K4\,BD - BYe) = 0$$

$$\frac{\partial E^2}{\partial K_3} = 2\,(K0C + K1\,AC + K2\,BC + K3\,C^2 + K4\,CD - CYe) = 0$$

$$\frac{\partial E^2}{\partial K_4} = 2\,(K0\,D + K1\,AD + K2\,BD + K3\,CD + K4\,D^2 - DYe) = 0$$

All equations are equated to zero and hence the constant term 2 can be dropped. In matrix form it can be written as

$$\begin{bmatrix} 1 & A & B & C & D \\ A & A^2 & AB & AC & AD \\ B & AB & B^2 & BC & BD \\ C & AC & CB & C^2 & CD \\ D & AD & BD & CD & D^2 \end{bmatrix} \begin{bmatrix} KO \\ K1 \\ K2 \\ K3 \\ K4 \end{bmatrix} - \begin{bmatrix} Ye \\ AYe \\ BYe \\ CYe \\ DYe \end{bmatrix} = \begin{bmatrix} O \\ O \\ O \\ O \\ O \end{bmatrix}$$

Replacing symbol Ye by Z and shifting it to right AND Applying summation over all experimental findings we get,

$$\begin{pmatrix} N & \sum A & \sum B & \sum C & \sum D \\ \sum A & \sum A^2 & \sum AB & \sum AC & \sum AD \\ \sum B & \sum AB & \sum B^2 & \sum BC & \sum BD \\ \sum C & \sum AC & \sum BC & \sum C^2 & \sum CD \\ \sum D & \sum AD & \sum BD & \sum DC & \sum D^2 \end{pmatrix} \times \begin{pmatrix} K0 \\ K1 \\ K2 \\ K3 \\ K4 \end{pmatrix} = \begin{pmatrix} \sum Z \\ \sum AZ \\ \sum BZ \\ \sum CZ \\ \sum DZ \end{pmatrix}$$

Using array names viz P, K and Z we get,

$[P] \times [K] = [Z]$

$[K] = [Z] \times [P]^{-1}$

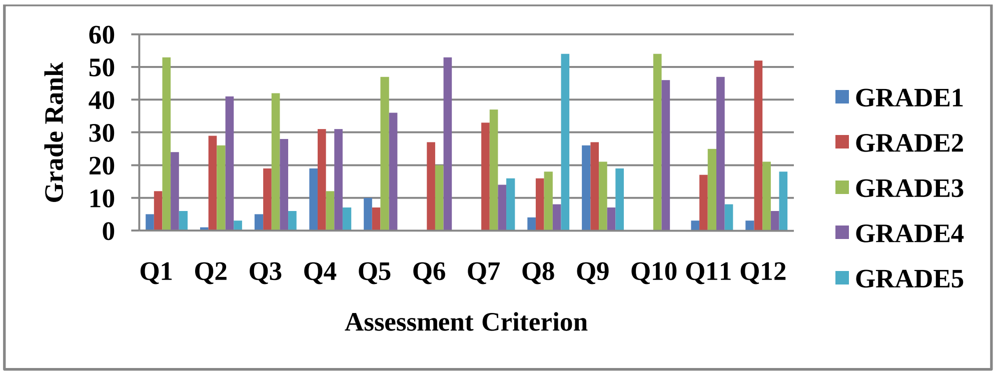
After obtaining all the summation indicated in array P and array Z the statement of the problem can be computed. After inverting array P and post multiplying with array Z we get all the required values i.e. values of K0, K1, K2, -------K4 are known after this process. The value of associated error now can be found out. Once the values of all k are known the computed value Yc can be generated.

Calculations:-

Chart On Calculations

PARAMETERS	RANKING				
Are You Comfortable with the Chair	1 Very Uncomfortable	2 Uncomfortable	3 Just Right	4 Comfortable	5 very Comfortable
Comfortable with the chair	5	12	53	24	6
Backrest Adjustment range	1	29	26	41	3
Vertical Adjustment range	5	19	42	28	6
Visibility from the chair	19	31	12	31	7
Feel about buttock after working with chair	10	7	47	36	0
Feel about hands	0	27	20	53	0
Feel about Legs	0	33	37	14	16
Feel about Upper Backs	4	16	18	8	54
Feel about Upper Backs	26	27	21	7	19
Feel about Shoulders	0	0	54	46	0
Feel about Eye Sights	3	17	25	47	8
Feel about Numbness in the Body Parts	3	52	21	6	18

(Table:Chart on Comfortability Calculation)

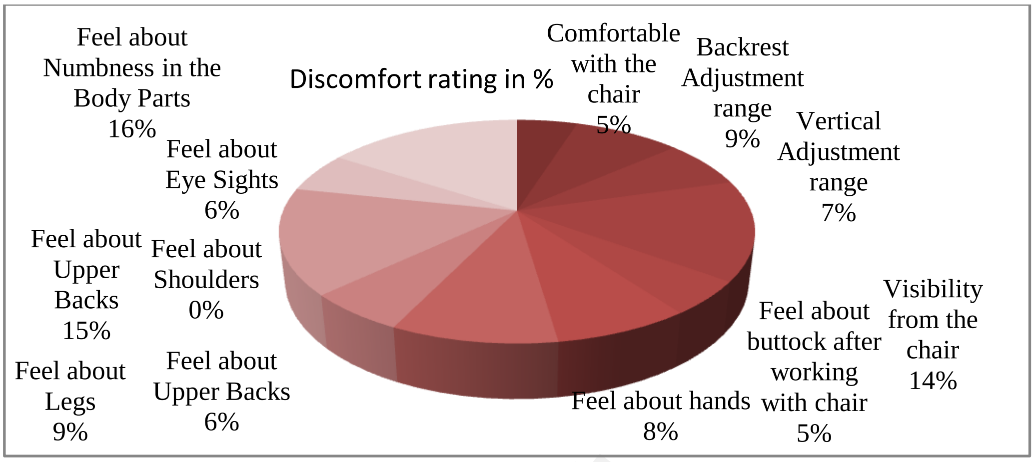


Where

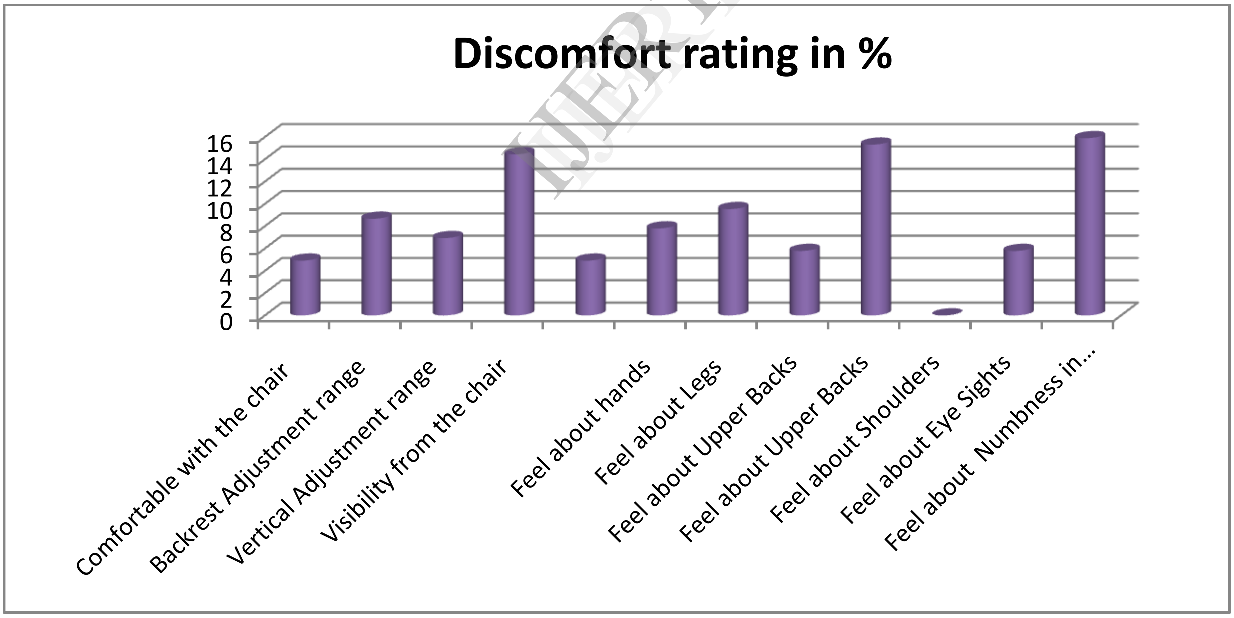
- Grade 1: Very Uncomfortable
- Grade 2: Unconformable
- Grade 3 : Just Right
- Grade 4 : Comfortable
- Grade 5 : Very Comfortable
- Q1 : Comfortable with the chair
- Q2 : Backrest Adjustment range
- Q3: Vertical Adjustment range
- Q4 : visibility from the chair
- Q5: feel about buttock after working with chair
- Q6 : Feel about hands

- Q7 : Feel about Legs
- Q8 : Feel about Upper Backs
- Q9 : Feel about Upper Backs
- Q10: Feel about Shoulders
- Q11: Feel about Eye Sights
- Q12: Feel about Numbness in Body Parts

RESULTS AND DISCUSSION:



Pie-chart diagram of discomfort rating in percentage



CONCLUSION:

From the ergonomics assessment of chairs used in different office, it could be concluded that the present's chairs were not designed as per the ergonomic standards. It was observed that the ergonomic assessment of chair was very discomfort in the that legs, upper backs, visibility and numbness.

The chair had to design by considering the following six questions

1. Is the chair comfortable to sit in for the way that you work?
2. Can you adjust the important features of the chairs?
3. Is the chair stable when you sit on it?
4. Does the chair have comfortable armrests?
5. Is the back rest high enough to provide support to the thoracic area.
6. Does the seat depth fulfilling the objectives like safety, comforts, ease of use, productivity and performance?

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