International Journal of Science Engineering and Advance Technology

Ergonomic Evaluation of Workstations in an IT Industry

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Abstract:

In the Information Technology (IT) industry an individual spends most of time in front of their computers working for more than 7 to 8 hours per day. This continuous sitting in the same postures has been the reason for many musculoskeletal disorders (MSDs) and repetitive strain injuries (RSIs). The paper focuses on the finding the different body parts that suffer strain and discomfort. A questionnaire was designed to evaluate the different parts of the body suffering from pain and to evaluate the different aspects of the five workstation elements considered. The questionnaire was subjected to a Reliability test to measure the consistency of the questions and their responses. From the data collected it was found that the chair was the element that caused most discomfort. The major body parts that the employees had pain frequently were the neck, shoulder, upper back and lower back. The reliability test conducted showed that all the questions in the questionnaire were consistent and reliable. High correlation was found between the body parts affected and aspects of the chair.

1. INTRODUCTION

Ergonomics is a systematic approach to study the relationship between the individuals, their tools and the work environment [1]. Ergonomics seeks to make a better match between workers' physical capabilities and their work environment and activities that can be accomplished through better design and operation of tools, workstations, equipment and controls [2]. One of the easiest way to address risk factors associated with RSIs is improper workstation configuration including the use of an appropriate pointing device and keyboard[3]. It examines the issue of repetitive strain injuries in the workplace and offers guidance on instituting an effective ergonomic program that reduces the incidence and cost of work-related RSIs. [4]. There is a practical guide for interpreting ergonomic guidelines and the anthropometric data that can be used to create a user friendly, ergonomically correct computer work environment[5].

2 Data Collection and Analysis

The questionnaire was distributed to all the employees of an IT company, who met the target group specifications, and from them 78 responses were received. The questionnaire was distributed through the company's internal servers and responses were collected ONLINE. The data collected is summarized below. The frequency of occurrence of pain in the different body parts assessed as shown in table 2.1.

Table 2.1 Frequency of Pain in different Body Parts out of 78

Sl No	Body Part	Responded Rarely	Responded Sometimes	Responded Often	Responded Always
1.	Head	4	64	10	0
2.	Eyes	26	48	4	0
3.	Neck	14	38	26	0
4.	Shoulders	14	32	32	0
5.	Elbows	36	38	4	0
6.	Wrists	40	28	10	0
7.	Fingers	54	24	0	0
8.	Arms	36	36	6	0
9.	Upper Back	24	24	30	0
10.	Lower Back	22	26	28	1

11.	Buttocks	62	14	2	0
12.	Thighs	72	6	0	0
13.	Knees	62	12	4	0
14.	Ankles	70	6	2	0
15.	Feet	68	6	4	0

The following tables shows the average score of different aspects of the workstation that were given by the respondents. The average score is out of 5 where 1 is Very Poor, 2 is Poor, 3 is Average, 4 is Good and 5 is Excellent.

Table 2.2 Average scores of aspects of Chair out of 78

Sl No.	**Factors to be evaluated**	**No of Very Poor/ Poor Responses**	**Average Score**
1.	Backrest Height	22	2.86
2.	Seat Height	34	2.64
3.	Seat Pan Comfort	24	2.94
4.	Arm Support	20	2.87
5.	Seat Edge Contour Comfort	18	2.92
6.	Backrest Cushion Comfort	40	2.58
7.	Foot Placement	2	3.25
8.	Armrest Height	12	2.94
9.	Position of Chair Controls	10	3.05
10.	Mid/Upper Back Support at Recline	34	2.58
11.	Lumbar Support	40	2.51

Table 2.3 Average scores of aspects of Table out of 78

Sl No.	Factors to be evaluated	No of Very Poor/ Poor Responses	Average Score
1.	Table Height	3	3.38
2.	Smoothness of Work surface	3	3.35
3.	Availability of Space	6	3.30
4.	Clearance of Leg space	2	3.46
5.	Storage above the Table	13	2.84
6.	Storage in drawers	5	3.82
7.	Overall Comfort	2	3.33

Table 2.4 Average scores of aspects of Monitor out of 78

Sl No	**Factors to be evaluated**	**No of Very Poor/ Poor Responses**	**Average Score**
1.	Viewing Height	2	3.41
2.	Viewing Distance	0	3.46
3.	Clarity of Display	2	3.51
4.	Monitor Tilt	6	3.33
5.	Screen Size	20	3.15
6.	Lighting of the Room	2	3.51
7.	Effect of glare	8	3.30
8.	Space occupied by monitor	2	3.48

Table 2.5 Average scores of aspects of Keyboard out of 78

Sl No	Factors to be evaluated	No of Very Poor/ Poor Responses	Average Score
1.	Distance from the Keyboard	0	3.41
2.	Angle of Tilt of Keyboard	4	3.38
3.	Height of the Keyboard	4	3.48
4.	Flexibility of Position	4	3.53
5.	Responsiveness of Keys	14	3.33
6.	Distance between Keys	6	3.38
7.	Palmrest on Keyboard Platform	4	3.53
8.	Alignment with Monitor	10	3.53
9.	Stability of Keyboard platform	4	3.43

Table 2.6 Average scores of aspects of Mouse out of 78

Sl No	Factors to be evaluated	No of Very Poor/ Poor Responses	Average Score
1.	Ease of Reach	4	3.69
2.	Ease of Movement	4	3.66
3.	Responsiveness	6	3.64
4.	Distance from Keyboard	4	3.64
5.	Ease of Fit in the Palm	8	3.66
6.	Wrist Position	6	3.56
7.	Stability of Mouse Platform	4	3.61
8.	Length of Mouse Wire	6	3.61
9.	Size of Mouse Buttons	6	3.64

The total scores were calculated for each of the 5 elements of the workstation per respondents. The average of these scores are shown below in Table 4.7 converted to a percentage scale.

Table 2.7 Average Score for Workstation Elements

Sl No	Workstation Element	Average Score (%)
1.	Chair	56.66
2.	Table	65.64
3.	Monitor	67.98
4.	Keyboard	68.56
5.	Mouse	72.76
	Total Workstation Average	**65.73**

2.1 Statistical Analysis

Using the Statistical Quality Control software tool Minitabs 16, 2 basic tests where done on the data collected:

- Reliability Test
- Correlation Analysis

2.1.1 Reliability Test

The Internal Consistency Reliability Test was conducted on the responses of the questionnaire to measure the consistency among the questions and their responses combined to form a single scale. This helps in establishing the reliability and consistency of the factors measured. The Cronbach coefficient alpha, which is the coefficient of reliability, for each of the aspects measured are shown in Table 4.8.

Table 4.8 (i) Cronbach Alpha Coefficients Calculated

Sl No.	Aspect of the Workstation	Cronbach's Alpha value
1.	Backrest Height	0.953292
2.	Seat Height	0.952626
3.	Seat Pan Comfort	0.952692
4.	Arm Support	0.953168
5.	Seat Edge Contour Comfort	0.953195
6.	Backrest Cushion Comfort	0.954074
7.	Foot Placement	0.954365
8.	Armrest Height	0.953043
9.	Position of Chair Controls	0.952722
10.	Mid/Upper Back Support at Recline	0.953492
11.	Lumbar Support	0.952734
12.	Overall comfort	0.952517
13.	Table Height	0.952478
14.	Smoothness of Work surface	0.952415
15.	Availability of Space	0.954317
16.	Clearance of Leg space	0.952831
17.	Storage above the Table	0.952634
18.	Storage in drawers	0.953117
19.	Overall Comfort	0.952396
20.	Viewing Height	0.952715
21.	Viewing Distance	0.952623
22.	Clarity of Display	0.952702

Table 4.8 (ii) Cronbach Alpha Coefficients Calculated

Sl No.	Aspect of the Workstation	Cronbach's Alpha value
1.	Monitor Tilt	0.953781
2.	Screen Size	0.952810
3.	Lighting of the Room	0.952494
4.	Effect of glare	0.951800
5.	Space occupied by monitor	0.952376
6.	Distance from the Keyboard	0.952253
7.	Angle of Tilt of Keyboard	0.951853
8.	Height of the Keyboard	0.952332
9.	Flexibility of Position	0.951061
10.	Responsiveness of Keys	0.951833
11.	Distance between Keys	0.951258
12.	Palmrest on Keyboard Platform	0.951117
13.	Alignment with Monitor	0.951220
14.	Stability of Keyboard platform	0.952462
15.	Ease of Reach	0.951346
16.	Ease of Movement	0.951281
17.	Responsiveness	0.931462
18.	Distance from Keyboard	0.951121
19.	Ease of Fit in the Palm	0.951269
20.	Wrist Position	0.951455
21.	Stability of Mouse Platform	0.950969
22.	Length of Mouse Wire	0.951276
23.	Size of Mouse Buttons	0.951296

2.1.2 Correlation Analysis

A Correlation Analysis was conducted to establish a relationship between the 4 major body parts that were found to be affected frequently; and the different workstation aspects that were assessed. The body parts considered were Neck, Shoulder, Upper Back and Lower Back.

3. Results

On analysis of the data collected through the questionnaire, it was found that the four major body parts that suffered frequent pain (refer fig 3.1) were: Neck, Shoulder, Upper Back, Lower Back.

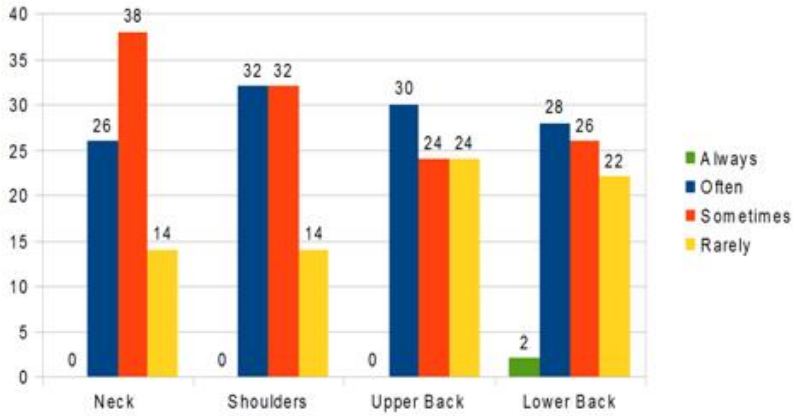

Figure 3.1 Major body parts affected

The chair was found to have the lowest score among the five elements (Figure 3.2) and was therefore selected for further analysis.

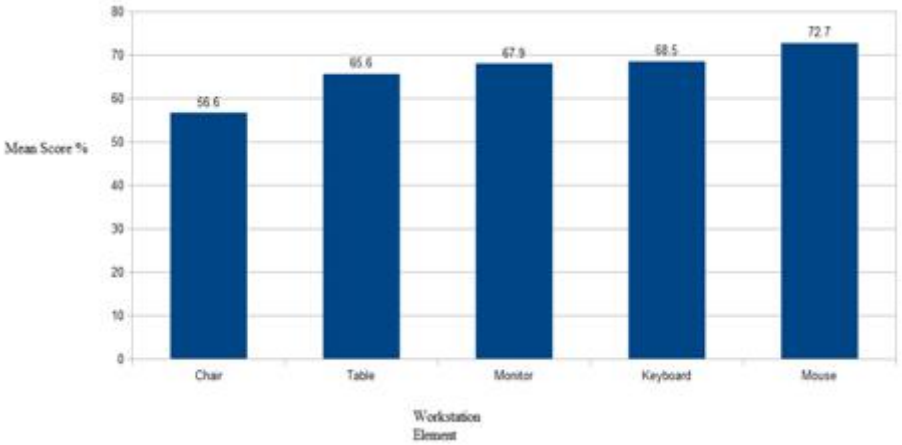

Fig 3.2 Average Scores of Workstation Elements

3.1 Reliability and Correlation

The Reliability Test conducted on the questionnaire gave an average Cronbach's alpha coefficient of 0.9533. The Cronbach's alpha values for each parameter is given in Table 4.8. Since there is no parameter with Cronbach's alpha coefficient less than 0.7, all the questions can be considered to be reliable. The Correlation analysis was conducted to identify which of the workstation aspects measured have a direct dependence on the four major body parts considered (Neck, Shoulder, Upper Back, Lower Back) . The parameters that show highest correlation is given in Table 5.1.

Table 5.1 Correlation Analysis Results

Sl No	**Body Part**	**Workstation aspect (correlation coefficient)**
1.	Neck	Seat Height (0.748) Viewing Height (0.637)
2.	Shoulders	Backrest Height (0.729) Seat Height (0.846) Mid/Upper Back Support (0.615)
3.	Upper Back	Backrest Height (0.775) Seat Height (0.781) Mid/Upper Back Support (0.755)
4.	Lower Back	Lumbar Support (0.665) Backrest Cushion(0.609)

It is noted from the results of the correlation analysis that a high correlation is found between the major body parts affected and some of the aspects measured in the Chair. Specifically: Seat Height, Backrest Height, Mid/Upper Back Support, Lumbar Support, Backrest Cushioning

3.2 Chair Evaluation and Improvements Suggested

The evaluation of the seat showed that the following aspects require improvement: The range of *seat height adjustment* is less than the standard and should have extended upto 610mm. The *seat pan depth* should be less than the buttock-popliteal length, but in the current chair it is found to exceed the limit by 22mm. The *backrest* of the chair falls short of the required *height* by 30mm and added to the lack of neck support, are two major causes for the frequent neck pain suffered by the employees. The *backrest* of the chair is covered by a net instead of a *cushion* which provides inadequate support for the back. Using a chair with a solid, contoured backrest can be more comfortable for the shoulders and upper back. The material of the backrest as well as its design does not provide enough lumbar support. Using a chair with an increased flexibility is also suggested to improve the support given to upper and lower back regions.

Table 5.2 Chair Design Parameters- Standard and Measured

Sl No	**Design Parameters**	**Standard Value(mm)**	**Measured Value(mm)**
1.	Seat Height	380 - 610	393-520
2.	Seat Pan Depth	384	406
3.	Seat Cushioning	38-50	50
4.	Seat Width	489	508
5.	Armrest Height	203-254	200
6.	Armrest Width	436	490
7.	Backrest	634	609
8.	Seat-Backrest Angle	100-110 degrees	96 degrees

Table 5.2 shows the chair design parameters standard and measured value for the new design of a chair.

4. CONCLUSION

The ergonomic evaluation conducted in an IT industry showed that employees evaluated suffered frequent discomfort in their **neck, shoulders, upper back** and **lower back**. Evaluation of the workstation showed that the major element that was not ergonomic was the **chair**. Hence, the chair was further evaluated and improvements were found. Correlation analysis showed that the major factors causing discomfort were Seat Height, Backrest Height, Mid/Upper Back Support, Lumbar Support, Back rest Cushioning. The following improvements were found to be necessary; Increase range of seating height adjustment by 90mm, Add Neck Support, Increase the height of backrest by 30mm, Use of solid contoured cushioning for backrest using polyurethane foam, Use of chair with seat-backrest angle between 100-110 degrees, Decrease depth of seat pan by 20mm, Provide Lumbar Support using polyurethane foam cushion.

Acknowledgement: This paper is based on the study by a 2014 batch of final year students of department of Industrial Engineering & Management, R V College of Engineering, Bangalore. The authors thank Mr. Govind Ashokkumar, Mr. Mohak, Mr. Kavitha S, Mr. Mahesh V for their effort in the study.

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