A New Quality Rating system for the Computer Workstation arrangements of the Information Technology Industries: A Six Sigma Model Approach

Arun Vijay S.[1] and Sekar.P.C.[2]
[1]KG Hospital and Post Graduate Medical Institute, 18, Arts College Road, Coimbatore-641018, INDIA
[2]Department of Management Studies, Madurai Kamaraj University, Madurai, INDIA

Abstract

Objective: To study existing Computer Workstation arrangements prevailing in the Information Technology (IT) Industries in India and to provide an employee driven Quantitative Data-driven Quality rating system for the Computer workstation arrangements in the Indian IT setup. Study design: A descriptive study design was adopted to capture the existing Computer workstation arrangements as rated by the IT employees belonging to the Information Technology Industries in India. Materials and Methods: IT Professionals (N=120) belonging to the Programming and Software developmental division of the Information technology Industries located at two metropolitan cities in India were formed the population of this study. A Self-administered questionnaire was used to capture employee's opinion on the computer workstation arrangements. A Six-Sigma Analytical tool using Poisson principle was employed to capture the level of Satisfaction of the employees about the various features of Computer Station arrangements. Results: The non-conformance rate per respondent (DPU) was calculated to find out the chance for the person to be totally satisfied with the existing computer workstation arrangements and the corresponding PPM (Parts per million defectives) was also determined using the Normal distribution table. The outcome of this study provided a Sigma rating for each component of the computer workstation and accordingly, a Six Level Quality rating system for the Human-Computer interface was developed. Conclusion: This study provided a Quantitative data-driven Quality rating system for the computer workstation arrangements prevailing in the Indian IT Set up. The study provided warning sign to the Policy planners and the Facility managers of Indian IT setup to take appropriate steps to provide better Physical working environment for the employees.

Keywords: Information technology professionals, information technology industries, computer workstation, six-sigma and quality ratings.

Introduction

The work related Musculoskeletal Health Problems are widely reported by the IT Professionals working in the Information Technology Industries in India[1]. Musculoskeletal disorders are work-related when the work environment and performance of work are significant contributors to their development or exacerbation, but are not the sole determinant of causation. Thus, a disorder is work related when work procedures, equipment, or environment contribute significantly to the cause of the disorder[2]. The Critical factors of Health in IT Professionals consisting of Physical Atmosphere including Working Conditions, Health consciousness and Knowledge of employees in handling Computer peripheral, importance of Health and Safety training on Ergonomics, Job design and Health care initiatives taken by the top management[3]. The other factors contributing to the occurrence of computer related problems are workstation environment, degree of mobilization and levels of constrained posture, awareness levels and practices of workers regarding computer ergonomics[4]. Accordingly, the Health related Ergonomic Knowledge of the employees is considered as a modifying factor for the occurrence of Work related Health problems among the IT Professionals. Previous

studies supported this notion that an intensive ergonomic approach and education on workstation changes and musculoskeletal disorders among the Video display Unit (VDT) workers demonstrated a less musculoskeletal discomfort in the participants who attended the Ergonomic Educational Program[5,6]. Another large-scale field intervention study also supported the effectiveness of ergonomic training program which indicated a significant increase in overall ergonomic knowledge and lower musculoskeletal risk in the invention group than the control group[7]. Ironically, most Indian computer users are unaware of safe computing techniques and any of them use the computer incorrectly for more than one hour daily, are at risk of health hazards. The most productive and hardworking employees are the most likely to get injured[8]. Thus, all the findings of the previous study concluded that the Health related Ergonomic Knowledge as an important factor for the Occurrence of Health Problems in the IT professionals. Moreover, it is found that the research studies focusing on capturing the perception of IT employees' knowledge about the ideal computer workstation arrangements and the optimal posture while working on computer is much limited in the Literature.

Another important point of consideration is the design of Computer Workstations prevailing in the Indian IT setup. In spite of the existence of various international standards for the ideal computer workstation setup, the implementation of such standards in the Information Technology industries are often limited in the developing countries like India due to space and Financial constraints. Most Indian Information Technology Companies are not giving sufficient importance to ergonomics while choosing chairs, seating and lighting arrangements, with many companies not even following the industrial standard of designing workstations which require a minimum of 50-60 square feet per individual. This present scenario indicates that most IT Companies are still to adopt health as a key issue; however industrial experts believe that this scenario will change in near future and the health factor will become a major concern for the Information technology Industries[9].

It is interesting to note that the nature of Computer work itself expose the employees to make significant changes to their Body positions so as to operate the Computers. Ideally, Computer work is characterized by low force exertions and static postures that are sustained for long durations[10]. The hands and forearms perform small dynamic contractions during keyboard work while the arm, neck and shoulder muscles are statically activated to maintain head and hand positions. Furthermore, the arrangements of Computer workstation might impose the operators to bend his or her neck forward or elevate the arms and shoulders while working on Computers that can exacerbate the postural loading on neck and shoulder muscles. Thus, the elevated shoulder postures, unsupported loads, prolonged static contractions, and task duration have been identified as computer-related risk factors for neck and shoulder problems[11-13]. In terms of computer hardware, the placement of the Monitor and Keyboard are the primary determinants of upper extremity posture while performing computer work. Head and neck positions are constrained by the visual demands and location of the Monitor. Arm position is largely driven by the location of the Keyboard and Mouse (if used). Thus, Working Posture is one of the most frequently cited risk factors for musculoskeletal disorders (Armstrong, 1986). Proper posture is considered to be a state of musculoskeletal balance that involves a minimal amount of stress or strain to the body[14]. Contrary to this, any deviation from normal alignment (i.e. postural abnormality) imposes imbalance and abnormal strain on the musculoskeletal system[15].

Moreover, the design of the Keyboard is one of the factors contributing to the incidence of Musculoskeletal disorders among computer operators[16]. Standard typewriter keyboards and most contemporary keyboards conform to the QWERTY keyboard layout, referring to the letter-number-symbol sequence of the keys. The top row of alpha keys in this layout begins on the left with the letters QWERTY. This layout was designed to distribute keystrokes over the entire keyboard and thereby prevent jamming of keys as typists' keyboard skills and speed increased. In addition, the typewriter requires inputting interruptions for paper replacement and correction of errors. Finally, many typists were trained on technique and appropriate use of the typewriter. The standard Computer keyboard still conforms to the QWERTY layout. However, the advanced technologies of computers can handle unlimited inputting speed. From a biomechanical perspective, this presents a dilemma in that faster typing and inputting speeds are supported technologically by the system but not physically by key layout. This technology has also eliminated the opportunity for work interruptions and changes of posture related to paper changes and error corrections. In addition, the keys of the computer keyboard are closer to the work surface, making the work surface more accessible to the wrist and forearms for support. The result is a greater propensity for awkward and sustained postures during computer keyboard use. In addition to that, the presence of hard copy will also affect posture and movements of the upper extremities, depending on how hard copy is integrated into the task.

Low level static exertions (LLEs) have been identified as a risk factor for repetitive motion injuries[17] and it is quite common in many work situations, specifically prevalent in computer-based work. Even motions that appear to be dynamic usually have an underlying static component[18]. During low load static exertions, the load rarely, if ever, decreases to zero, so the muscle is unable to relax completely[18]. Much of the load on the shoulder and neck can be classified as low-level static exertions. Further, recent research indicated that regardless of force levels, continuous contraction would cause fatigue if sustained over long period of time[17]. This indicates that the IT Professionals working continually in front of the computers may prone for Low Level static exertions and subsequently exposed to Musculo-skeletal health Problems. Thus, in order to provide a Healthy work place, the understanding of the all Physical work environmental issues from the employees' perspective is very important. To the first of its kind project in Indian IT set up, this study was conducted to capture the opinion of the employees about the existing workstation arrangements prevailing in the Information Technology Industries in India. Moreover, it attempted to provide a Quality rating system for the Physical Work environment of the Information technology industries using a quantitative data driven Six-sigma Methods.

Material and Methods

Study Design: A descriptive study design was adopted to capture the existing Computer workstation arrangements as rated by the IT employees belonging to the Information Technology industries in India.

Subjects: The Information Technology Professionals (N=120) belonging to the Programming and Software developmental division of selected private Information Technology Industries located at two metropolitan cities (Coimbatore and Bangalore) in India formed the population of this study. Two corporate Information Technology Industries were covered with 60

samples were recruited from each industry using criterion sampling methods. The criterion for including the samples in to this study includes: Age (i.e. 25-40 years), duration of working hours (at least 4 hours a day or 20 hours per week); and those who are working only in day shifts. Throughout the study period, care was taken to protect anonymity of the Participants' Personal details.

Methodology: A Self-administered Questionnaire tool was developed by adopting standard guidelines provided by the Human Factors and Ergonomics society and Cornell University Ergonomics Web. This Questionnaire was designed by keeping in view of the nature of the IT industrial work and its work-related risk factors contributing to major Health outcomes. The Questionnaire consists of two parts: Part-1 is concerned with Demographical Information of the subjects and the Part-2 concerned with Questions related to the various components of Computer workstation arrangements with Likert scale response options (i.e. 1-Strongly disagree, 2-disagree, 3-Neutral, 4-Agree and 5-Strongly agree). Ten Computer Workstation Components were covered in the Questionnaire tool viz. the employees opinion about Computer workstation layout, Desk space, Key Board arrangements , Mouse locations, Positioning of Monitor, Contrast and brightness of the Monitor, Indoor Environmental parameters, Computer chairs and its provisions, arrangements of desktop accessories, and Knowledge of the employees about the ideal working posture and Computer workstation setup. Questionnaires were distributed to 120 participants with 60 samples were recruited from each Industry using Criterion Sampling methods. 115 completed questionnaires were returned along with signed Informed Concern form. The response rate was measured as 96%.

Results and Discussion

Data Analysis and Interpretation of Findings: A Six-Sigma Analytical tool using Poisson principle was employed to capture the level of Satisfaction of the employees about the various features of Computer Station arrangements. The *non-conformance rate per respondent (DPU)* was calculated to find out the chance for the person to be totally satisfied with the existing computer workstation arrangements and the corresponding PPM (Parts per million defectives) was also determined using the Normal distribution table. The outcome of this study provided a Sigma rating for each component of the computer workstation and accordingly, a six level Quality rating system for the Human-Computer interface was developed.

The table-1 depicts the demographic characteristics of the samples included in this study. It is inferred that 65% of them are men and 35% of them are females constituting the ratio of 2:1 for Men and Women. Further, the mean age of the participants below 28 years thus constituted the younger age group of work force. All the samples are working in the IT set up for the duration of 4 Plus years.

The table-2 provided Six-level rating system for the Computer Workstation arrangements prevailing in the Indian IT setup. This rating is based on the Six-sigma score calculated from the opinion of the participating employees about the computer workstation arrangements using Poisson distribution model. A Six point Quality rating and its corresponding sigma value ranges were given in table-2. The Higher score indicates better Quality rating provided by the employees about the Computer workstation Arrangements and vice versa.

Table-1
Demographic Characteristics of the Samples included in this study

S. No.	Gender	N, (%)	Mean Age	Working Hours	Working Experiences (in years)
1.	Men	75, (65)	27.5 Years	8.30 Hours	4.5 years
2.	Women	40,(35)	25.5 Years	8.10 Hours	4 years

Table-2
Quality rating of Human Computer interface with respect to the Occupational Health Status of the IT Employees

Quality Rating	Rating Range Descriptions	Description of Computer Workstation Arrangements provided in the Organization
6	Above 5 and up to 6	Excellent Healthy World class Environment
5	Above 4 and up to 5	Benchmarked competing Healthy Environment
4	Above 3 and up to 4	Adjustable Workstation arrangements with medium necessary provisions to carry out the work task with minor risks
3	Above 2 and up to 3	Inadequate Workstation Arrangements just sufficient to carry out the work tasks with moderate risks
2	Above 1 and up to 2	Highly Compromised Workstation arrangements that have the possibility of developing Occupational Health problems after some years
1	Less than or equal to 1	Totally inappropriate for both Employer and Employees with a potential to develop Occupational Health Problems

Table-3
Quality-rating of Human-Computer Interface as observed by the participating Information Technology Employees

Computer Workstation Components	No. of respondents	No of Questions	Opportunities	Defects (Non Conformance)	DPMO*	DPU**	Chance for a person to be totally Satisfied	Non-Conformance per respondent (probability)	PPM*** for complete satisfaction	Quality rating (sigma rating)
Sufficiency of Workstation Layout	115	1	115	35	304348	0.30	0.74150	0.25850	2,58,500	2.01
Desk Space is large enough and at appropriate height to Operate.	115	1	115	29	252174	0.25	0.77940	0.22060	2,20,600	2.17
Size of Keyboard Tray and appropriate placement of Key Board (at right height)	115	2	230	65	282609	0.28	0.75643	0.24357	2,43,570	2.08
Location and Free movement of Mouse is conductive to perform work comfortably.	115	1	115	39	339130	0.34	0.71251	0.28749	2,87,490	1.91
Positioning of Monitor at appropriate Height and at right distance for use.	115	1	115	41	356522	0.36	0.69844	0.30156	3,01,560	1.87
The Clarity of text, Contrast and Brightness of the Computer Monitor is Good	115	1	115	33	286957	0.27	0.76401	0.23599	2,35,990	2.06
The Indoor Environmental parameters are conductive to work comfortably (i.e. Room temperature, Humidity background noise and Quality of lighting)	115	1	115	30	260870	0.26	0.77166	0.22834	2,28,340	2.14
Sufficiency of Computer Chair for performing work efficiently (i.e. Chair height, base of chair, Arm rests, Back rest and seat cushions)	115	5	575	188	326957	0.32	0.72686	0.27314	2,73,140	1.95
Arrangements of desktop accessories for easy reach according to the frequency of use.	115	1	115	26	226087	0.23	0.79509	0.20491	2,04,910	2.25
Knowledge of Optimal working posture and ideal computer workstation set up	115	2	230	90	391304	0.39	0.67786	0.32214	3,22,140	1.78

*Defects per Million Opportunities; **DPU-Defects per Unit; PPM-Parts per Million Defectives

The table-3 illustrated the Quality rating of the Human Computer interface as observed by the participating Information technology Professionals. From the analysis, it is inferred that while analyzing employees opinion about the sufficiency of workstation layout, the existing workstation lay out is just sufficient for them to carry out the work tasks with moderate risk (σ =2.01). With respect to the location and positioning of the Monitor as well as the Mouse, the IT employees rated it as 'highly compromised' that they may develop some health problems after some years if the existing work atmosphere is continuing ($\sigma < 2$). The employees' opinion on the existing Computer Chair provisions, it was found that they are highly conceded to use it (σ=1.95). When analyzing the ergonomic knowledge of the workers, it is found that the workers face confrontation in gathering such knowledge (σ=1.78). Similarly, with respect to all the other components of the Computer workstation arrangements, the participating employees rated them that they are just sufficient to carry out their work with possibility of developing moderate Health related risks ($\sigma > 2$ and <3).

Discussion of Findings: This research article is the documentation of the Information Technology professionals' opinion on the Computer workstation arrangements including their existing ergonomic knowledge with reference to the Information Technology Industries in India. For the purpose of exploring this research problem at a broader level, a wider representation of samples had been adopted by considering the Information Technology professionals (IT) employed at two different Metropolitan cities in India. To embrace uniformity in the selection of Samples in to this study, a Criterion based sampling approach was used by the researcher. The criteria for including the samples in this study were: Age (between 25 to 35 years), Working Hours (at least 4 hours per day) and, the employees working at the specific domain of Information Technology Industry (Programming and Software development personnel). Only the younger age groups of Workers were included whose mean age was less than 27 years.

The computer workstation components included in the present study are selected on the basis of the principles stipulated by Human Factors and Ergonomic society and Cornell University Ergonomics Webpage. Accordingly, a Questionnaire tool was designed by taking into consideration of the following major components of the Computer workstation Arrangements viz. capturing the employees opinion about i. sufficiency of Computer workstation layout; ii. Location and size of Desk space; iii. Size of Key Board Tray and positioning of the Key board; iv. Location of Mouse and its free movement for performing the computer operations; Positioning of Monitor at appropriate height for the User; v. Contrast and brightness of the Computer Monitor; vi. Indoor Environmental parameters; vii. Computer Chairs and its provisions (height, Base, Arm rests, back rest and, seat cushion provisions); viii. Arrangements of Desktop accessories, and ix. Knowledge of the employees about the ideal working posture and Computer workstation setup. The

response choice for each question was given as Likert type options. Out of all the components studied, two components consisting of Height and Positioning of the Monitor and the Computer Mouse location and its free movement for operation are rated by the employees as 'Highly compromised' and there is possibility of developing Health problems after some years. Theoretically, the Monitor needs to be placed directly in front of the operators and it should be at an arm length distance from the operators[19]. Deviation from this standard can force the operator to bend his neck either up or down to view the monitor that can prone the Computer operator to develop Neck Pain[20].

Other components such as Sufficiency of Workstation layout; Size and Location of Desk space and; the size of the Key board tray and the placement of Keyboard at appropriate height were rated by the employees as "Inadequate" to carry out their work tasks. They face moderate amount of risks while carrying out their task with that particular working atmosphere. Any deficiencies noted in the components such as Workstation layout, Position of Key Board tray and the Key board, and the size of the Desk space for the assigned job will force the operators to adopt faulty posture so that they may develop Neck, Back or Upper limb symptoms according to the areas of compromise developed by the operator[21].

The Indoor environmental parameters such as Room temperature, Humidity, Back ground noise and Quality of lighting were rated by the employees as "Inadequate" and deficiencies noted in all the indoor parameters leads to several health related outcomes and in turn affect the Productivity[22].

The comfort and satisfaction of the employees on the utility of the Computer chair is addressed in this study. Employees' satisfaction on the five major dimensions of the Computer Chair is addressed which includes: Chair Height, Chair base, Arm rests; back rests, and Seat cushions. In this study, the collective response by taking into consideration of all the five dimensions of Computer Chair provided in their company is rated as "Inadequate" by the employees so as to function effectively to carry out their Job. Insufficient chair height either 'too short' or 'too long' would have an impact on the Health of the employees. If the Chair is too short, it will leads to Low back and Hip Pain whereas if it is too long, it prone the employees' leg to be hanging from the Chair and it can leads to Lower leg pain[23,24].

The employees' knowledge on the Working posture and the ideal computer workstation is the next issue explored in this study. Posture is one of the most frequently cited risk factors for musculoskeletal disorders[25]. Ideal posture is considered to be a state of musculoskeletal balance that involves a minimal amount of stress or strain to the body[14]. Any deviation from the normal alignment (i.e. postural abnormality) suggests the presence of imbalance and abnormal strain on the musculoskeletal system[15]. The results of this present study indicated that ergonomic knowledge of the employees about the Working posture is rated

as "Highly compromised" and lacking. Such findings are in conformance to the findings of previous study which indicated that the computer users were not aware of principles of safe ergonomic practices. Even those who had the knowledge were not able to carefully and entirely apply this for the prevention from health hazards[26].

Conclusion

This study concluded that the satisfaction of the IT employees about their Computer workstation arrangements is not adequate and as well as it is not at the World class Standards. With that atmosphere, if the employee prolong to work, they may prone to more severe Health problems. This study also provided a Quantitative data-driven Quality rating system for the computer workstation arrangements prevailing in the Indian IT Set up. The study provided warning sign to the Policy planners and the Facility managers of Indian IT setup to take appropriate steps to provide better physical working environment for the employees.

Acknowledgements

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