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# EDITORIAL PREFACE

This is the first issue of volume two of International Journal of Ergonomics (IJEG). The Journal is published bi-monthly, with papers being peer reviewed to high international standards. The International Journal of Ergonomics is not limited to a specific aspect of Ergonomics but it is devoted to the publication of high quality papers on all division of engineering in general. IJEG intends to disseminate knowledge in the various disciplines of the Computer Science field from theoretical, practical and analytical research to physical implications and theoretical or quantitative discussion intended for academic and industrial progress. In order to position IJEG as one of the good journal on Computer Sciences, a group of highly valuable scholars are serving on the editorial board. The International Editorial Board ensures that significant developments in Ergonomics from around the world are reflected in the Journal. Some important topics covers by journal are architectures, middleware, tools designs, Experiments, Evaluation, etc.

The initial efforts helped to shape the editorial policy and to sharpen the focus of the journal. Starting with volume 2, 2012, IJEG appears in more focused issues. Besides normal publications, IJEG intend to organized special issues on more focused topics. Each special issue will have a designated editor (editors) – either member of the editorial board or another recognized specialist in the respective field.

The coverage of the journal includes all new theoretical and experimental findings in the fields of engineering which enhance the knowledge of scientist, industrials, researchers and all those persons who are coupled with engineering field. IJEG objective is to publish articles that are not only technically proficient but also contains information and ideas of fresh interest for International readership. IJEG aims to handle submissions courteously and promptly. IJEG objectives are to promote and extend the use of all methods in the principal disciplines of Computing.

IJEG editors understand that how much it is important for authors and researchers to have their work published with a minimum delay after submission of their papers. They also strongly believe that the direct communication between the editors and authors are important for the welfare, quality and wellbeing of the Journal and its readers. Therefore, all activities from paper submission to paper publication are controlled through electronic systems that include electronic submission, editorial panel and review system that ensures rapid decision with least delays in the publication processes.

To build its international reputation, we are disseminating the publication information through Google Books, Google Scholar, Directory of Open Access Journals (DOAJ), Open J Gate, ScientificCommons, Docstoc and many more. Our International Editors are working on establishing ISI listing and a good impact factor for IJEG. We would like to remind you that the success of our journal depends directly on the number of quality articles submitted for review. Accordingly, we would like to request your participation by submitting quality manuscripts for review and encouraging your colleagues to submit quality manuscripts for review. One of the great benefits we can provide to our prospective authors is the mentoring nature of our review process. IJEG provides authors with high quality, helpful reviews that are shaped to assist authors in improving their manuscripts.

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# Computer Assisted System for Enhancing the Application of Ergonomics in Manufacturing Systems

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## Abstract

The current paper focuses on the need and a plan for the development of a Computer Assisted Interactive and Intelligent Ergonomics System which, through a user friendly consulting mode presents the guidelines and formalized procedures for the application of ergonomics knowledge and data in manufacturing organizations. The system is expected to allow a production engineer or supervisor or even a worker with minimal ergonomics knowledge, to understand, analyze and find solutions to problems related to industrial ergonomics. A survey which is conducted in this regard is also described in this paper and through the outcome of the survey it is shown that the poor acceptance and application of ergonomics is due to lack of exposure to ergonomics knowledge and non-availability of ergonomics knowledge in a suitable form for its application in manufacturing systems.

**Key words:** Ergonomics, Computer Aided Systems, Anthropometric Data and Work Place Design

## 1. INTRODUCTION

Ergonomics is a science focused on the study of the 'fit' between people and their work, and decreased fatigue and discomfort through product and work place design. It is the study of people while they use equipment in specific environments to perform certain tasks. Ergonomics aims to make sure that tasks, equipment, information and the environment suit each worker. Ergonomics seeks to minimize adverse effects of the environment upon people and thus to enable each person to maximize his or her contribution to a given job. [1]

Failure to realize the significance of ergonomic principles / knowledge and data and apply for the design of their work systems and products may have serious repercussions, on not only for individuals, but whole organizations. In the literatures there are reports which indicate that many well-known accidents might have been prevented if ergonomics had been considered in designing the jobs and the work systems within which people worked.

However, the available literature reveals that there is still a low level of acceptance and limited application of ergonomics in the manufacturing industries. It is recognized that ergonomic expertise has not been adequately utilized in industrial planning practices in manufacturing organizations and significance of application of ergonomics principles for day to day operations / activities is yet to be recognized in developing countries.

Hence, there is an urgent need for implementation of ergonomics knowledge in the design of workplace, work environment and decision-making as well as in the design and use of products, machines, equipment and production systems. For this to happen in the modern enterprises ergonomics and safety considerations need to be integrated into the design, analysis, and implementation phases of the system.

The poor acceptance and application of ergonomics is due to lack of knowledge and training in ergonomics. With this idea the authors have started a long term research activity to identify strategies for the application of ergonomics standards and / principles in the manufacturing organizations. As a part of this research activity, the current paper reports the plan for development of the computer assisted software package and its applicability in manufacturing industries. The possibilities of development and application of expert systems for industrial ergonomics are examined and discussed in this paper and then the details of developing a computer assisted system for ergonomics are presented.

## 2. SIGNIFICANCE OF ERGONOMICS

As highlighted above, Ergonomics can be defined simply as the study of work and more specifically, as the science of designing the job to fit the worker, rather than physically forcing the worker's body to fit the job. Adapting tasks, work stations, tools, and equipment to fit the worker can help reduce physical stress on a worker's body and eliminate many potentially serious, disabling work related musculoskeletal disorders (MSDs).[2]. It draws on a number of scientific disciplines, including physiology, biomechanics, psychology, anthropometry, industrial hygiene, and kinesiology. If work tasks and equipment do not include ergonomic principles in their design, workers may have exposure to undue physical stress, strain, and overexertion, including vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting. Recognizing ergonomic risk factors in the workplace is an essential first step in correcting hazards and improving worker protection [2].

Ergonomists, industrial engineers, occupational safety and health professionals, and other trained individuals believe that reducing physical stress in the workplace could eliminate up to half of the serious injuries each year. Employers can learn to anticipate what might go wrong and alter tools and the work environment to make tasks safer for their workers.

The application of ergonomic principles in the workplace can result in the following [2, 3]:

- Lower injury rates as MSD incidences go down
- Increased productivity by making jobs easier and more comfortable for workers
- Improvement in product quality and productivity
- Reduced absences because workers will be less likely to take time off to recover from muscle soreness, fatigue, and MSD-related problems
- Reduced turnover as new hires are more likely to find an ergonomically designed job within their physical capacity
- Lower workers' compensation claims due to improved health and safety of workers
- Increased worker comfort and Reduced worker fatigue
- Improved morale of workers
- compliance with government regulations
- job satisfaction and lower lost time at work

The above discussions can be summarized as that, when ergonomics is applied to working places and products it is necessary to take into consideration the people who are using them and when products fit the user, the result can be more comfort, higher productivity, and less stress. Ergonomics can be an integral part of design, manufacturing, and use. Knowledge about how the study of anthropometry, posture, repetitive motion, and workspace design affects the user is critical to a better understanding of ergonomics as they relate to end-user needs. [4]

To assess the fit between a person and his work, ergonomists have to consider many aspects. These include [1]:

- the job being done and the demands on the worker
- the equipment used (its size, shape, and how appropriate it is for the task)
- the information used (how it is presented, accessed, and changed)
- the physical environment (temperature, humidity, lighting, noise, vibration) and
- the social environment (such as teamwork and supportive management)
- all the physical aspects of a person, such as:
    - body size and shape
    - fitness and strength
    - posture
    - the senses, especially vision, hearing and touch, and
    - the stresses and strains on muscles, joints, nerves.

By assessing these aspects of workers, their jobs, equipment, and working environment and the interaction between them, ergonomists are able to design safe, effective and productive work systems. Ergonomics can also reduce the potential for ill health at work, such as MSDs, aches and pains of the wrists, elbow, shoulders and back. It also considers the layout of controls and equipment and suggests that these should be positioned in relation to how they are used. Those used most often should be placed within the easy reach of the worker without the need for stooping, stretching or hunching.

## 3. SURVEY ABOUT THE LEVEL OF APPLICATION OF ERGONOMICS

As a part of the proposed research work which has been outlined above, a survey was carried out to know about the level of awareness and understanding about the ergonomics principles in manufacturing organizations, the need of these principles and identify the issues or problems related to the application of ergonomics. The parent organization of corresponding author is a 50 year old educational institute which has a large alumni database which indicates that the alumni are occupying top key positions in reputed manufacturing organization of south as well as western parts of India. Through these alumni contacts this survey has been conducted. Personal / telephonic discussions, communication through e-mail and postal approaches are used.

A sample of 1200 people was selected and each member is communicated with the purpose of survey and survey form. From this group 806 sent their responses of which 650 are found to be useful for our work.

The data collected from all the respondents was compiled, organized and arranged systematically using statistical methods. Different inference methods were used for drawing conclusions about the awareness and level of application of ergonomics in manufacturing industries. However the overall detail of the survey is beyond the scope of this paper, hence, the details of the analysis of survey is not presented here.

Several hypotheses were formulated and tested with the survey data. A sample of hypotheses that are formulated for this survey is:

In the manufacturing sector majority of the organizations, to be specific more than 60% of the organizations are aware about the significance of ergonomics knowledge and data.

The major cause of lesser application of ergonomics principles in manufacturing organization is non-availability of ergonomics knowledge in a well defined form and also proper guidelines for its application

For the enhancement of ergonomics application to manufacturing organizations more than 75 % of the organizations prefer to employ a user friendly interactive computer assisted system which permits a user to obtain information with little ergonomics knowledge

On the basis of survey results the major issues related to the implementation of a strategy for the application of ergonomic knowledge and data in the manufacturing systems are identified. These issues are described in the following section i.e. section 4

The following is the survey sheet which contains the queries used for the survey:

## Survey Sheet for Awareness of Ergonomics Principles & Data and Application to Manufacturing Industries

**Name of the Correspondent :**

**Designation :**

**Name of Organization :**

| | |
|---|---|
| **01. Are you aware of ergonomics principles and their application to manufacturing organizations? YES / NO (write Y or N)**<br>**If the reply is ' No ' GO TO 'Important Note Prior to Query number 7'**<br>**If the reply is ' Yes ' GO TO Next Query** | |
| **02. Whether the ergonomics knowledge and data are employed in your organization? YES / NO (Write Y or N)**<br>**If the reply is 'No' GO TO Query no 07**<br>**If the reply is 'Yes' Proceed to next query** | |
| **03. In which of the following areas ergonomics principles and data are being used.**<br>**(Reply by entering 'Yes' for used and 'No' for not used)** | |
| • **Work place design** | |
| • **Product design** | |
| • **Working environments** | |
| • **Process / job design** | |
| • **Material handling** | |
| • **Work schedule determination** | |
| • **Training and Development** | |
| • **Selection of employees** | |
| • **Assignment of jobs to employees** | |
| **04. Does your organization have Anthropometric database? YES / NO (Write Yes or No)** | |
| **05. Does your organization have any other database related to ergonomic knowledge? YES / NO (Write Yes or No)** | |

| | |
|---|---|
| **06. In your view which of the following benefits are being achieved by your organization by the application of ergonomics principles and knowledge**<br>**Enter '√' for Benefit and ' X ' no benefit** | |
| • **Improvement in productivity** | |
| • **Better quality** | |
| • **Good and safe working environment** | |
| • **Reduction in workers complaints** | |
| • **Reduction in worker turn over** | |
| • **Meeting the challenges of global competition** | |

## Important Note Prior to Query no 7

## Kindly Go through the following information and after considerable thinking reply to the following queries

**Ergonomics is defined as the design of the workplace, equipment, machine, tool, product, environment, and system, taking into consideration the human's physical, physiological, biomechanical, and psychological capabilities, and optimizing the effectiveness and productivity of work systems while assuring the safety, health, and wellbeing of the workers [6].**

**Ergonomics is also referred as Human Factors Engineering which deals with the application of information about human behavior, capabilities and limitations to the design of systems, machines, tools, tasks / jobs, environments, etc. for productive, safe and effective human use [1]**

| | |
|---|---|
| **07. In which of the following areas you would recommend the application of ergonomics .**<br>**( Reply by entering '√' for recommending and ' X 'for not recommending)** | |
| • **Work place design** | |
| • **Product design** | |
| • **Working environments** | |
| • **Process / job design** | |
| • **Material handling** | |
| • **Work schedule determination** | |
| • **Training and Development** | |
| • **Selection of employees** | |
| • **Assignment of jobs to employees** | |

| | |
|---|---|
| **08. In your view which of following reasons are responsible for lack of use of ergonomics in manufacturing activities.**<br>**( Rank them from 1 to 5 on the basis of their priority)** | |
| • **Not aware about ergonomics** | |
| • **Necessary information is not available** | |
| • **Information is available but not in user friendly form** | |
| • **Information available and is understood but not able to apply to the design of work systems and products.** | |
| • **There are reservations / uncertainties / doubts about the significance or usefulness of ergonomics** | |
| **09. Suggest the suitable means of providing exposure to ergonomics**<br>**( Rank them from 1 to 5 on the basis of their priority)** | |
| • **Through training** | |
| • **Through quality circle activities** | |
| • **Through a user friendly system which provides ready information about the ergonomics knowledge and data, guidelines , formalized procedures through an interactive session.** | |
| • **Through Consultants** | |
| • **Through Awareness programs** | |
| • **By recruiting new employee who possesses the necessary expertise about the ergonomics and assigning the responsibility of introducing the elements of ergonomics in the design of working system to these new employees.** | |

An example from the results of survey conducted, in which 650 responded the questionnaire, for query number 1, about the awareness of ergonomics principles and their application to manufacturing organizations, 400 respondents answered they are aware of ergonomics principles and their application to manufacturing organizations.

For query number 8, 430 respondents mentioned that ergonomics information is available and understood but it is difficult to apply, as it is not in a user friendly form and have certain doubts/reservations about it, and this was considered as one of the reasons responsible for lack of use of ergonomics in manufacturing activities.

For query number 9, asking the respondents to suggest the suitable means of providing exposure to ergonomics and applying ergonomics in their organizations, 395 respondents

believed that a user friendly system which provides ready information about the ergonomics principles, guidelines and formalized procedures through an interactive means as the possible way to apply the ergonomic principles and data without specific ergonomics knowledge by the engineers, supervisors and even the workers. However the overall detail of the survey is beyond the scope of this paper, hence, the details of the analysis of survey is not presented here.

## 4. ISSUES RELATED TO THE APPLICATION OF ERGONOMICS

As mentioned above a detailed analysis has been carried out on the basis of survey responses with the help of statistical inference methods. The details of analysis are not presented in this paper as it does not fit into the objective of this paper, however some of the major out comes of this survey which are relevant to this paper are listed below.

- The application of ergonomic expertise including anthropometric and working environment related data, in manufacturing industries in not to the level of expectations.

- The overall opinion in manufacturing industries leads to the conclusion that the significance of ergonomics knowledge is acknowledged and it is agreed that there is an urgent need for implementation of ergonomics knowledge in design of manufacturing systems and related decision-making processes.

- Most of the organizations do not possess the expertise necessary for applying ergonomic principles to the design of industrial workplaces and products and even if it is available they are finding it difficult to use it for manufacturing activities in the existing form. Further proper guidelines and procedures required for the application of ergonomic knowledge and data are not available

- There is a need for compiling the ergonomics knowledge and data, representing systematically in a user friendly and acceptable form and make it available to manufacturing organizations in the form of well defined systems

- Information technology and computers are currently playing a very important role in the automation and improvement of almost all manufacturing activities and therefore, it is advisable to extend their application to the management and representation of huge amount of ergonomic information for its implementation.

- The availability of a user friendly intelligent computer assisted system which supports the application of ergonomics information for the day to day activities is the need of the hour for manufacturing industries to overcome the gap between experts and users of industrial ergonomic knowledge and data.

## 5. A REVIEW ON COMPUTER ASSISTED SYSTEMS FOR ERGONOMICS

As pointed out in the previous section, the efficient and expected level of application of ergonomics principles for manufacturing organization and its fruitful results are possible only when, the computer-assisted systems are realized which can be used by any one (even with a little knowledge of ergonomics) in an interacting or consulting mode, in which guidelines, necessary data and solutions are presented through a question/answer dialogue between the user and the system.[5]. In this direction attempts are being made to apply computer-assisted systems of which some are in the form of expert systems to support problem-solving and decision-making activities related to industrial ergonomics. A sample of works reported in the literature about the application of computer for the realization of ergonomics systems is presented below.

Shikdar et al [6] have developed a computer software package which can be used as a self-assessment tool to evaluate ergonomic improvement potential of production systems by engineers, managers and safety professionals. It is reported that production managers of

manufacturing industries with no prior knowledge of ergonomics were able to identify ergonomic deficiencies successfully (81%) in the shop floors as a result of the application of the ergonomic assessment tool. This enabled them to formulate intervention strategies to improve ergonomic conditions in their industries. The software package is user friendly, self-explanatory and provides relevant information, data and guidelines.

Jeffrey et al [7] have described an interactive Ergonomics CAD system (ErgoCAD) developed to allow human factors designers to determine the appropriate dimensions of an industrial workstation for a given population. ErgoCAD is a means by which individuals, not necessarily familiar with ergonomic principles, can interact with CAD software thereby designing an ergonomic workstation

The main fact that is highlighted here is, the human factors engineer relies upon the successful integration of anthropometric data bases with ergonomic design principles when designing the human-machine interface.

Chen et al [8] have reported a work on the development of an interactive computer-assisted Ergonomics Analysis System (EASY). The system consists of three major components a) the Ergonomics Information Analysis System (EIAS) for evaluation of tasks by the worker, b) the Physical Work Stress Index (PWSI) used by the supervisor or the ergonomist for further investigation of problem situations, and c) the Dynamic Lifting Analysis System (DLAS) for manual material handling tasks. Extensive use of menus for database entry/editing and analysis provides an efficient and friendly interface design.

The expert system proposed by DeGreve and Ayoub [9] only provides work station designs based on anthropometric data. It gives critical dimensions of interest to the user in designing the work station as well as other anthropometric information of interest for further work with the work station. This system does not address standard times, performance on a given task or the body posture while at the work station, nor will it, for example, address biomechanical and physiological stress while performing the activity. Laring [10] et al has presented a tool that helps to meet the needs of concurrent engineering: a Knowledge Based System (KBS) that supports the design of a workplace, by a production engineer, in a CAD environment. The production engineer is asked to specify three structures: the products and parts of products, a plan for the work process and the layout of the workplace. The KBS subsequently performs an ergonomic analysis and presents an assessment to the production engineer, who then decides if any changes in any one of the three structures are necessary.

Moty and Khalil [5] have presented a work to demonstrate the use of personal micro-computers to individualize the design of the sitting workplace. Engineering static and functional anthropometry as well as ergonomic design principles is implemented. This work presents a computer model for individualizing the design of the regular sitting workplace. The model considers the human characteristics such as dimensions, capabilities and limitations as emphasized by ergonomics and motion study principle in the design of tools and equipment. The computer algorithm combines inputted static and functional anthropometric data with principles of body mechanics and energy saving techniques to produce an optimal sitting workplace design.

Asawarungsaengkul et al [12] have proposed a decision support system for designing effective noise hazard prevention (NHP) strategies which consists of four modules: (a) database, (b) input, (c) algorithms, and (d) solution. The user can choose among single-, two-, and three-approach solution procedures. Heuristic and genetic algorithms are used to determine appropriate noise controls (NCs). From the given noise condition and NC budget, NHP recommends a minimum-cost NHP strategy that prevents any worker's daily noise exposure from exceeding the permissible level. If the budget is insufficient, NHP is able to search for a feasible noise hazard strategy that requires a minimum NC budget.

Chen and Yeung [13] reported a work to discuss the effect of nurse shift job on circadian rhythm, work stress, and some important ergonomics criteria and also review and compare different nurse

shift scheduling methodologies via the criteria of flexibility, consideration of nurse preference, and consideration of ergonomics principles. A hybrid expert system, entitled NURSE-HELP, is developed to facilitate the nurse scheduling process with an emphasis on considering ergonomics criteria. The evaluation of the system is done by comparing 18 sets of four-week schedules generated by the head nurses manually and by NURSE-HELP. The quality of the schedules is measured by the following four criteria: minimum staff level not satisfied, day off request not granted, backward rotation, and maximum consecutive work periods on the night shift. The results show that NURSE-HELP is superior to the head nurses in preparing schedules, both in terms of time and quality.

Azadeh et al [14] have presented a study is to design a fuzzy expert system for performance assessment of health, safety, environment (HSE) and ergonomics system factors in a gas refinery. The work proposed is expected to lead to a robust control system for continuous assessment and improvement of HSE and ergonomics performance. The importance of this study stems from the current lack of formal integrated methodologies for interpreting and evaluating performance data for HSE and ergonomics. Three important reasons to use fuzzy expert systems are (1) reduction of human error, (2) creation of expert knowledge and (3) interpretation of large amount of vague data. To achieve the objective of this study, standard indicators and technical tolerances for assessment of HSE and ergonomics factors are identified. Then, data is collected for all indicators and consequently, for each indicator four conditions are defined as ‘‘acceptance”, ‘‘low deviation”, ‘‘mid deviation” and ‘‘high deviation”. A membership function is defined for each fuzzy condition.

The above literature review reveals that computer assisted expert systems have been developed for a single ergonomic factor or few ergonomics factors are taken into consideration with respect to a specific problem such as, for designing a workstation or workplace or noise control or for scheduling of manpower etc.
But a computer assisted system that covers the total ergonomics aspects of workplace design, work environment, posture evaluation, giving ergonomic knowledge and training etc. which can be used as a self-assessment tool to evaluate ergonomic improvement potential of production systems by engineers, managers and supervisors and safety professionals is the need of the hour.

The current work highlights the need for compiling the ergonomics knowledge and data, representing systematically in a user friendly and acceptable form and make it available to manufacturing organizations in the form of well defined user friendly intelligent computer assisted system, which supports the application of ergonomics information for the day to day activities for manufacturing industries to overcome the gap between experts and users of industrial ergonomic knowledge and data.

## 6. FEATURES OF PROPOSED COMPUTER ASSISTED SYSTEM

Identifying and Understanding the need of the manufacturing organizations, a user friendly Computer Assisted Interactive and Intelligent Industrial Ergonomics System (CAIIIES) has been developed. For this the ergonomics standards, knowledge and data has been collected from various sources, classified, compiled and arranged systematically. The following are the features and functions of the proposed system.

1. The system presents an overview of Ergonomics, its principles, data and also how benefits are derived by applying the principles of ergonomics and ergonomics data for the design of workplace and product. In this regard the knowledge of the human body necessary for this purpose is outlined. In particular it describes following concepts precisely;
    - Explains the concepts of anthropometric data and describes how measurements of human characteristics can be used for the design of workplace, working environment and product

- Analyzes properties and effect of illumination, noise and temperature and explains how proper illumination and control of noise and temperature leads to a safer and better workplace by reducing worker fatigue.
- Explains feasible ways to recognize proper sitting positions and to design seating arrangements to minimize stress to the human body and maximize comfort.
- Highlights the significance and the benefits of proper selection and strategic arrangement of controls and displays for the machining operations.

2. It allows the user to select the Guidelines for the following activities for a specific working situation and also permit to perform these activities
   - to identify and analyze the problems related to ergonomics,
   - assess the level of application of ergonomics
   - apply ergonomics principles and data
3. It provides well defined procedures and demonstrates how working systems can be designed that matches with the characteristics and capabilities of available work force and how to increase employee motivation through better working conditions leading to safety, health, comfort and productivity. Specifically procedures are made available to perform the following tasks
   - to enter anthropometric data of a user population and then obtain the output in the form suggested values for the design of workplace and product
   - Suggestions for illumination, noise and temperature for a given working system.
   - Posture analysis through the various available ergonomic evaluation tools, checklists, questionnaires etc.
   - Suggested values for proper sitting positions within a given set of working conditions.
   - Selection and strategic arrangement of controls and displays for a specific machining operation.
4. It serves as a user manual for applying ergonomics knowledge and data for manufacturing organization. Even a user with a little ergonomics knowledge can use this as a starting point from which expertise can be received to find ergonomic solutions to design of work systems.

## 7. CONCLUSION

An understanding of ergonomics while designing a workplace can improve day to day routine works in a manufacturing organization and at the same time enhance work quality and productivity, by eliminating the risks of MSDs, aches, pain and stresses at work. However, the expected level of application of ergonomics in manufacturing systems is yet to be achieved, since the complete information about ergonomics standards and data is not available. An extensive survey which was carried out as a part of the proposed work revealed the need of ergonomics related information and data, and also significant issues related to application of ergonomics in manufacturing organizations. The survey also leads to the identification of a strategy to develop a computer assisted system for ergonomics which is proposed in the current paper. The proposed system is expected to enhance the level of application of ergonomics knowledge and data in manufacturing systems, and results in safe and healthy working conditions and also increase in quality of work and productivity.

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**Abstract**

A Cross sectional survey design was used to conduct a study, on a sample of ninety students taken from a population of both part time Postgraduate and final year graduate students of Majan College. Non Probability convenience sampling technique was used to select the samples from the population. The exclusive criteria were students with IT major. The questionnaire consists of queries regarding the health effects of computers, ergonomic postures and the precautionary measures to be taken while using the computer. The knowledge level of the students was assessed using a predesigned questionnaire. The subjects were then exposed to a Self Instruction Module (SIM).The SIM included a power point presentation with multimedia clippings of demonstration of exercises regarding ergonomics of computer use. It was mainly related to the precautionary measures and the correct postures to be maintained to reduce health issues caused by use of computer.

The results of the survey showed that the mean of the knowledge score = 7.37 and the standard deviation = 3.37. This proved the need for educating the students on the heath tips and ergonomic postures related to prolonged computer use.

The investigators felt that a practical application of this SIM would create health awareness among them and thus improving the quality of work as well as studying environment.

A similar study can be recommended on students and also employees of other organizations to educate them with the ergonomic guidelines used to prevent health related problems due to extensive use of computer .

**Keywords:** Self Instruction Module, Computer Ergonomics.

## 1. INTRODUCTION

Total worldwide computers in-use was 1.67B units in 2011 and is projected to reach 2.55B in 2016.[26] It had taken 27 years to reach 1 billion computers in use and market researchers say it will take only 5 years to reach the next billion.[2].Due to the expanding use of computers among adolescents , concerns have been expressed about their health effects. These health effects may be due to excessive fatigue, eye strain/irritation ,blurred vision, headaches, muscle pain, neck pain, arm and shoulder pain. Musculoskeletal disorders is a primary health concern related to the use of computer. They commonly affect the upper limbs like neck ,shoulders ,arms, hands/wrists, back and lower limbs like knees and hips. This may result in pain, discomfort or numbness and tingling sensations throughout the upper and lower limbs. These effects have a close association with poor body posture and static load on the muscles of the shoulders and neck. Reports of studies have suggested clearly the likelihood of pupils or staff suffering health problems linked to computer use is related to the amount of time spent using them and also lack of knowledge

related to computer ergonomics.[16] There is evidence that these health problems can be reduced through ergonomic approach and education. According to dictionary.com, "Erg-go-nomic is the applied science of equipment design intended to maximize productivity by reducing operator fatigue and discomfort". The students of today use computers for library references, contacting friends by chatting on web, submission of assignments and games during free time. There are students who are working as well as studying. They make use of VDT(Visual Display Unit) not only during their work but also for their studies. Frequent requirement of completion of work before deadlines both in college as well as work place has been the main reasons to spend long hours in front of the computer. As computer and internet use become increasingly widespread, large percentages of the population will enjoy the potential benefits and get exposed to health risks. The important question is whether there is a need for a self instruction module (SIM) on "Healthy tips associated to computer use" to improve the level of knowledge of the subjects.

## 2. RELEVANCE OF THE PROBLEM

Today's adolescents and children are the first generation to have the privilege to have an access to information communication technology. Increasing popularity of computers have caused concerns on computer related health complaints. As computer technology is becoming an integral part of the education curriculum, careful considerations need to be given regarding the ergonomic design of computer workstations matching with the anthropometric factors of growing children. There is scientific evidence that the computers can adversely affect different anatomical sites of the human body. Both the educators and the students need to be aware of the importance of correct working postures and appropriate work-rest ratios in using computers.[14] Since it is observed that most of the part time students are employed, they spend long period of time in front of the computers both for their studies as well as their work. The need of meeting the deadline, overshadows the thought of discomforts during computer usage. We are only at the tip of the iceberg .An ounce of prevention is worthy of a pound of cure in order to avoid the pain, aches and disorders that millions of people suffer as a result of "Computer Burnout" Hence it is very important that health and safety issues need to be addressed. Even though this is a silent global epidemic, the truth is that it is not being acknowledged. Most companies blindly follow ergonomics recommended by American or European countries, ignoring that the body stature are different across the world. Studies done by Dawood Slaiman Al-Faris regarding the development of Anthropometric data for Omani male population of age group 18 – 60 indicate that the Omani male population in statistical terms are shorter 8 cm compared to many European Industrial or Manufacturing nations. Moreover review of literature reveals that most of the studies on computer users are done in developed countries, very few are done in Oman. Therefore the present study was an attempt to fulfill this gap by making an investigation in this area in Omani context.

## 3. FIELDS OF APPLICATION OF THE PROPOSED RESEARCH RESULTS

The study results will help many students as well as employees of various fields to create an awareness of the basic principles of compute ergonomics, which may help in reducing the risk of computer related health disorders, thus improving the performance and creating a healthy atmosphere in their work as well as academic field.

## 4. REVIEW OF LITERATURE AND OTHER EXISTING INFORMATION

Adetuter Ijose(2009) shares her insight into the health issues faced by computer users everywhere having being casualty of serious life threatening complications of computer usage. [23] According to her, for decades people have been ignoring the seriousness of health effects of computer use fearing that this would reduce the use of computers. Thus causing effect on technological advancement. Increased risk of forearm pain was associated with the use of a mouse device for more than 30 hours a week and a keyboard more than 15 hours a week.[19] A study reported that people who work with computer have shown an increased output of 20 to 25% due to ergonomic improvement in workstation layout. [15] The computer workers who received screen alerts to take breaks were 13% more accurate in their work than those who did not as

reported by Hegde (2001). [5] According to Shikdar and Al-Kindi(2007)[14] , 90% of the employees used computers more than 4 hrs a day, 45% of the employees adopted bent and unsupported back postures and the major problems reported were eyestrain (58%), shoulder pain (45%), back pain (43%), arm pain (35%), wrist pain (30%), and neck pain (30%).Sheady (1999) reported that 50-90% of computer users experienced the symptoms of computer Vision Syndrome.[13] Chaffin and Anderson (1991) considered that the seat alone is insufficient for stabilization and the use of the legs , feet and back in contact with other surfaces, as well as muscular forces are necessary to produce equilibrium.[24] New York State United Teachers developed a health and safety fact sheet to decrease computer-related health hazards and measures that can be taken to reduce or eliminate, the chance of suffering from pain, discomfort or a disabling condition due to extensive computer use.[10] A participatory approach was used to create computer ergonomics workshop for college students for solving computer workstation ergonomic problems and adopting healthy computing behaviors. The results of the study justify formal controlled trials of this intervention in university students, who will become tomorrow's workers.[12] Millions of people are suffering silently without even identifying the source of their problem. Thus on the basis of comprehensive literature review, it can be concluded that computer is a marvelous tool and the only solution to the information need. However, using it for a long time has raised many health related issues like overuse syndrome, repetitive strain injuries and commutative trauma disorder. There is a need for students who are employed to be more ergonomically conscious. They have a greater risk of developing health problems in their study as well as work place. Therefore it is advisable for video terminal users to make full use of it in order to get the best from it and avoid potential health problems.

## 5. STATEMENT OF OBJECTIVES

i. To what extent the subjects were aware of (level of knowledge) of the potential risks associated with computers use.

ii. To associate the knowledge of the subjects and the selected demographic variables.

iii. What were the strategies adopted to deal with health issues with computer use.

## 6. VARIABLES

a. Gender.
b. In-service training given to staff on computer ergonomics.
c. Years of experience.
d. Number of hours spent on a computer per day.

7. STATEMENT OF RESEARCH HYPOTHESIS

$H_1$: There is adequate level of knowledge among the respondents.
$H_2$ : There is an significant association between level of knowledge and the selected demographic variables.

8. RESEARCH METHODOLOGY

*A. Summary of Methodology*

The study was conducted to:

i. Determine the level of knowledge of the part time students of Majan college regarding computer ergonomics
ii. Develop a structured information module on computer ergonomics.

Based on the availability of the samples, we take the

| | |
|---|---|
| Sample Size | : 90 |
| Sampling Technique | : Convenience Sampling |
| Setting | : Majan College |

Exclusive Criteria : Students information technology as a major subject

*B. Selection of Research Strategies*

A survey design was adopted for the study.

i. Description of the tool

The study was carried out by using a structured knowledge questionnaire and the planned teaching programme. The questionnaire consisting of two parts. Tool-1 consists of demographic proforma and Tool-2 consisting of 21 questions related to knowledge, knowledge of practice on computer ergonomics and the most likely health hazards related to long term usage of computer. Each respondent was asked whether they had any information related to these issues, the period elapsed since they began operating with the computer and the time they spent on computers on daily basis. They were also asked if they were involved in little or extensive usage of computers and if they had any knowledge about breaks taken in between, wrist and arm positions while typing, maintaining user monitor distance, positioning of eyes against computer screen, changing body positions while working on computers, chairs with wheel supported legs, sitting postures. Precautionary measures to be taken related to health hazards were among the aspects of interest to the researchers.

The SIM was a power point presentation which consisted of demonstrations and multimedia clippings related to health hazards and ergonomic behaviors. It helped in motivating the staff to follow the ergonomic positions while using the computers, and practice some exercises during their breaks.

Validity

The content validity of the tool was done by experts from the department of Ergonomics, Ophthalmologist and Computer Science. The modifications and suggestions were incorporated in the final presentation of the tool.

Reliability

The reliability of the questionnaire, determined by split half technique was 90%.

Ethical Consideration

1. Permission was obtained from the Dean of Majan College.
2. The students were briefed on:
   - i. The knowledge questionnaire.
   - ii. Purpose of the study.
   - iii. Selection criteria for subjects.
   - iv. Self instruction module.

*Short Description of Self instruction module(SIM)*

A SIM on ergonomic behaviors was given to the students. The SIM was a power point presentation educating the users on the possible health risks associated with computer use and some respective precautionary measures against it could definitely make a difference and result in “Healthy Computing”.

*Description of Data Collection*

*Recruitment of samples*: The investigator selects subjects who work on the computer other than IT staff. The target was 100% coverage of the students satisfying the inclusive criteria. But due to various reasons the target sample could not be reached. The questionnaire was administered to 158 subjects. 90 respondents returned the completely filled questionnaire. Their knowledge was assessed by the structured knowledge questionnaire.

*Analysis and Findings*

A graphical representation of the samples on the basis of the demographic variables.

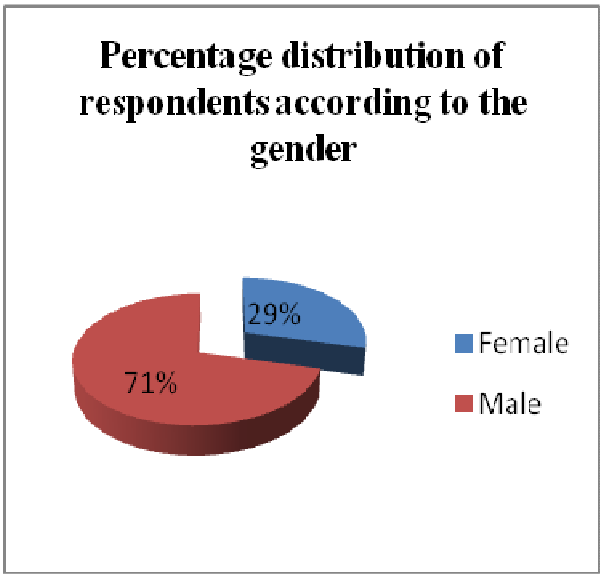


**FIGURE 1**

Among the respondents (71%) were males and (29%) were females.

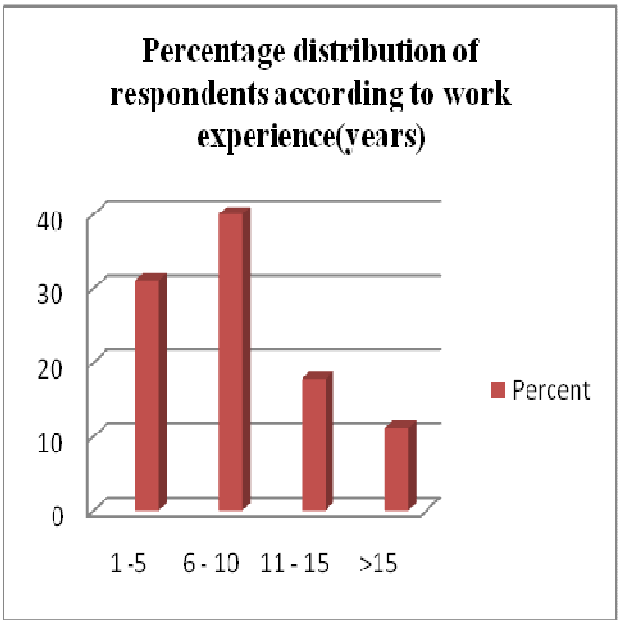


**FIGURE 2**

In the "Figure2", 40% of the respondents had 6 to 10 years of work experience, 31% had less than 5 years, 18% had between 11 to 15 years of experience. Whereas 11% of the respondents had more than 15 years of work experience.

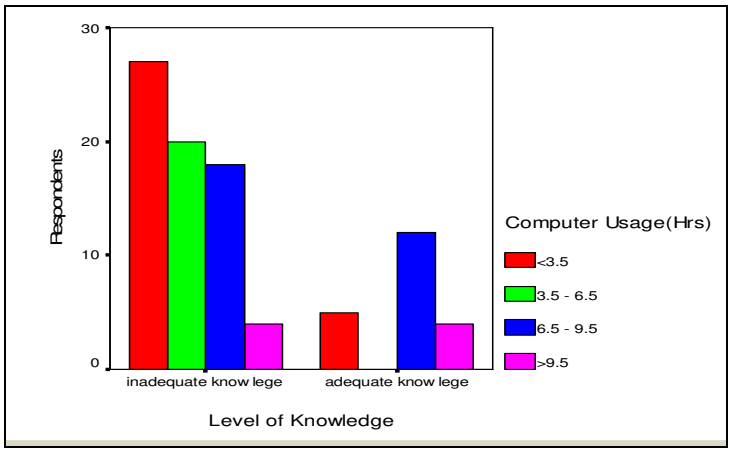


**FIGURE 3:** Distribution of respondents level of knowledge on the basis of computer usage

The bar chart in "Figure3" shows that all the subjects spending 3.5 to 6.5 hours on the computer on a daily basis have no adequate knowledge. Many studies have reported that people working on the computer for 3.5 hours a day are exposed to health disorders due to lack of knowledge of safe ergonomic behaviors. Although computer is used in classroom or homes or in the work place, where people can spend all day working on a computer, this study documents the inadequate level of knowledge among most of the respondents.

The total score of each respondent was calculated and their level of knowledge was interpreted as follows:

a. Inadequate knowledge $(\bar{x} - 1\sigma)$ < Total score < $\bar{x}$

b. Adequate knowledge $\bar{x} \leq$ Total score < $(\bar{x} + 1\sigma)$

The results of the survey motivated the investigators to initiate certain strategies to improve the knowledge of the respondents.

*Short Description of Analysis and Interpretation of Results*
Data processing was be aided by Statistical Package of Social Sciences software.

*Statistical Analysis*: Analysis of data was done by descriptive and inferential statistics.
Descriptive statistics of frequency and percentages were used to summarize the sample characteristics.

The increased number of computer users in Oman indicated to the researchers that there is a need to conduct this study. They decided to identify the need for an intervention in the knowledge of the visual display terminal users regarding ergonomic behaviors and precautionary measures

related to health. A self instruction module would be an effective approach to increase the level of knowledge of the students of Majan College, who are working on the computers for more than 3.5 hours a day.

| Level of Knowledge | Knowledge scores | |
|---|---|---|
| | Frequency | % |
| Inadequate | 69 | 76.7 |
| Adequate | 21 | 23.3 |

**TABLE I:** Knowledge scores %-Percentage

TABLE I indicates that the number of students with adequate knowledge were 76.7% and with inadequate knowledge were 21%.These observations indicate that maximum students do not have knowledge of the ergonomic principles and the health effects caused due to incorrect ergonomic behaviors'.

The level of knowledge clearly indicates a need to educate the students on the basic ergonomic issues related to the computer which supports our comprehensive literature review

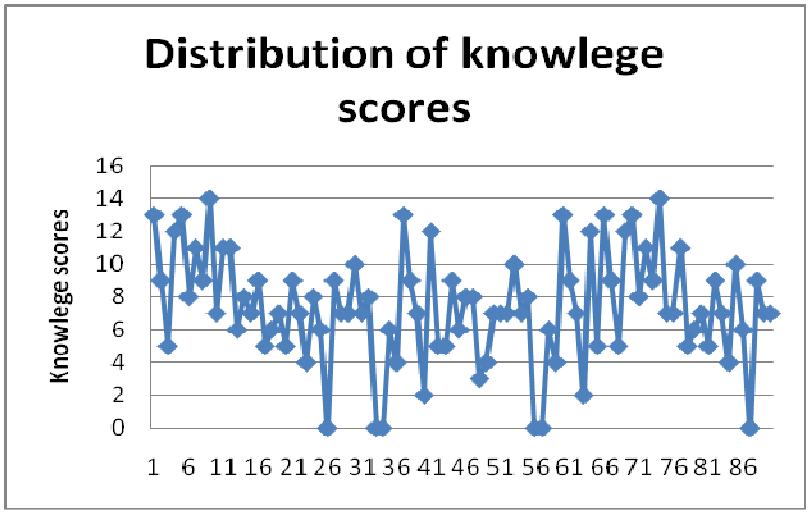


**FIGURE 4:** Graphical representation of the knowledge scores of the respondents

Figure 4 gives you an indication that many respondents do not have required information although most of them used computers in their work place and colleges. This was due to lack of professional development and discussion of these issues by them. Hence the researchers felt that the SIM would be an effective measure to improve the knowledge among the subjects.

| Statistics | Notation | Knowledge Score |
|---|---|---|
| Samples | $n$ | 90 |
| Median | $M$ | 7 |
| Mean , Standard deviation | $\overline{X},\sigma$ | 7.37 , 3.37 |
| Mode | $Z$ | 7 |
| Minimum | Min | 0 |
| Maximum | Max | 14 |
| Quartiles | $Q_1$<br>$Q_2$<br>$Q_3$ | 5<br>7<br>9 |

**TABLE II:** Statistics of Knowledge Scores.

The TABLE II shows the mean, median, mode, minimum, maximum and the quartiles of the knowledge scores.

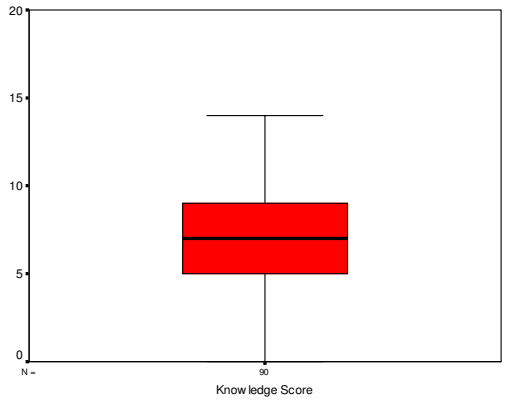


**FIGURE 5:** Box plot for knowledge scores

The box plot in "Figure 5" indicates maximum, upper quartile, median, lower quartile and minimum of the knowledge scores.

| | Level of Knowledge | |
|---|---|---|
| Exposure to computer use | Inadequate knowledge | Adequate knowledge |
| <3.5 | 27 | 5 |
| 3.5 - 6.5 | 20 | 0 |
| 6.5 - 9.5 | 18 | 12 |
| >9.5 | 4 | 4 |

**TABLE III**

The TABLE III shows that zero percent of students who work for 3.5 to 6.5 hours a day don't have enough knowledge about ergonomic issues related to computer use. According to Shikdar and Al Kindi (2007), people who work on the computer for more than 4 hours a day had inadequate knowledge of ergonomic positions that are to be maintained while working on the computer and this resulted in many countries to make interventions like conducting workshops/seminars and introducing health safety fact sheets to increase the knowledge of computer users and have succeeded to a certain extent to reduce the health risks associated with the computer use.

Chi Square test shows a significant association between the level of knowledge and frequency of computer use at $p<0.001$.

It was also observed in the study that most of the subjects did not have any formal training on ergonomic principles on computer use. They received only pieces of information from their friends, as email alerts, advertisements etc.

## 8. CONCLUSION

The study documents the lack of understanding of the health risks as well as the inability of the subjects to come up with strategies to deal with them. The results of the research supports literature reviews.[9]-[16] that there is a need to educate the people by conducting computer workshops/seminars on safety issues related to health due to extensive computer use. Health and Safety Fact sheet, related to health hazards of computer use is a publication of New York State United Teachers (NYSUT) has conveyed that they have set up various regional training centers for ergonomic training. Thus the researchers felt the need to send the self instruction module (SIM) to the students to educate them about the health issues, preventive measures and ergonomic behaviors related to prolonged computer use.

Having information about ergonomic issues is the first step towards minimizing computer health risks. In this study, it was observed that most of the subjects were ignorant of the ergonomic behaviors. Even though they had some information about the health issues related to prolonged computer use, they may not have tried to disseminate or discuss these issues with their peers. Neither have they tried to put these ergonomic principles into practice. Very few studies have been done on intervention of knowledge on this subject. The application of the SIM will create health awareness among the adult and the young generation of computer users in Oman. The SIM and presentations in different academic institutions and organizations would definitely motivate the students to get acquainted to the ergonomic behaviors and precautionary measures to develop a healthy computing environment. Computer users themselves should take the initiative of having an in-depth understanding of the self instruction module and practice in their college and work environment. This study is continuation of research conducted by S. Devesh and N.AL-Bimani (2011) [28]

## 9. RECOMMENDATIONS

a) Similar study can be conducted using a control group.
b) Explore strategies for colleges and organizations where intensive computer use is unavoidable in their study and work culture.
c) Similar study can be conducted on students and other firms to improve their knowledge on "Computer ergonomics".
d) Many organizations can train their employees by conducting workshops/ in-service educational programmes on ergonomics and health issues related to extensive computer use.

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