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The Application of Ergonomics in Recent Engineering

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***Abstract*: This paper shows the use of system ergonomics, First the impact, or perhaps a lack of impact of ergonomics in an engineering environment is considered. The methodology of system ergonomics is discussed briefly and illustrated. Several other cases are presented, which have at least two factors in common: 1) comparable system ergonomic approaches, and 2) the involvement of ergonomists until or including the implementation phase. Each case leads to some lessons learned. Practitioners evaluating work, and designing, or implementing solutions, may develop best practices. These best practices should be included in the theoretical framework of system ergonomics. Questions may be raised on whether the ergonomics community is studying the most relevant issues from an engineering point of view. The study of adoption of Ergonomics in recent engineering fields is the main aim of this paper.**

***Keywords*: Ergonomics, Musculoskeletal disorder, Industry, Workstation, Redesign, Workplace safety.**

1. Introduction

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design to optimize human well-being and overall system performance. Proper ergonomic design is necessary to prevent repetitive strain injuries and other musculoskeletal disorders, which can develop over time and can lead to long-term disability [1]. To assess the fit between a person and the used technology, human factors specialists or ergonomists consider the job (activity) being done and the demands on the user, the equipment used (its size, shape, and how appropriate it is for the task), and the information used (how it is presented, accessed, and changed). Ergonomics draws on many disciplines in its study of humans and their environments, including anthropometry, biomechanics, mechanical engineering, industrial engineering, kinesiology, physiology, cognitive psychology, industrial and organizational psychology, and space psychology.

2. Domains of specialization

Ergonomics comprise three main fields of research: physical, cognitive and organizational ergonomics. There are many specializations within these broad categories. Specializations in the field of physical ergonomics may include visual ergonomics. Specializations within the field of cognitive ergonomics may include usability, human–computer interaction, and user experience engineering.

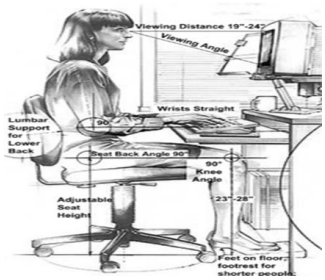

Fig. 1. The science of designing user interaction with equipment and workplaces to fit the use

A. Physical ergonomics

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1) Sub subsection

Physical ergonomics: the science of designing user interaction with equipment and workplaces to fit the user Physical ergonomics is concerned with human anatomy, and some of the anthropometric, physiological and bio mechanical characteristics as they relate to physical activity. Physical ergonomic principles have been widely used in the design of both consumer and industrial products. Risk factors such as localized mechanical pressures, force and posture in a sedentary office environment lead to injuries attributed to an occupational environment.

Physical ergonomics is important in the medical field, particularly to those diagnosed with physiological ailments or disorders such as arthritis (both chronic and temporary) or carpal tunnel syndrome. Pressure that is insignificant or imperceptible to those unaffected by these disorders may be very painful, or render a device unusable, for those who are. Many ergonomically designed products are also used or recommended to treat or prevent such disorders, and to treat pressure-related chronic pain.

B. Cognitive ergonomics

Cognitive ergonomics is concerned with mental processes,

such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. (Relevant topics include mental workload, decision-making, skilled performance, human reliability, work stress and training as these may relate to human system and Human-Computer Interaction design.) Epidemiological studies show a correlation between the time one spends sedentary and their cognitive function such as lowered mood and depression.

C. *Organizational ergonomics*

Organizational ergonomics is concerned with the optimization of socio-technical systems, including their organizational structures, policies, and processes. (Relevant topics include communication, crew resource management, work design, work systems, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work programs, virtual organizations, telework, and quality management.

3. Ergonomics policy implementation

Obstacles surrounding better ergonomic features to sedentary employees include cost, time, effort and for both companies and employees. The evidence above helps establish the importance of ergonomics in a sedentary workplace; however missing information from this problem is enforcement and policy implementation. As a modernized workplace becomes more and more technology based more jobs are becoming primarily seated, therefore leading to a need to prevent chronic injuries and pain. This is becoming easier with the amount of research around ergonomic tools saving money companies by limiting the number of days missed from work and workers comp cases. The way to ensure that corporations prioritize these health outcomes for their employees is through policy and implementation.

4. Methods

Until recently, methods used to evaluate human factors and ergonomics ranged from simple questionnaires to more complex and expensive usability labs.[6] Some of the more common human factors methods are listed below:

- *Ethnographic analysis:* Using methods derived from ethnography, this process focuses on observing the uses of technology in a practical environment. It is a qualitative and observational method that focuses on "real-world" experience and pressures, and the usage of technology or environments in the workplace. The process is best used early in the design process.
- *Focus Groups:* are another form of qualitative research in which one individual will facilitate discussion and elicit opinions about the technology or process under investigation. This can be on a one-to-one interview basis, or in a group session. Can be used to gain a large quantity of deep qualitative data. though due to the small sample size, can be subject to a higher degree of individual bias.[Can be used at any point in the design process, as it is largely dependent on the exact questions to be pursued, and the structure of the group. Can be extremely costly.
- *Iterative design:* Also known as prototyping, the iterative design process seeks to involve users at several stages of design, to correct problems as they emerge. As prototypes emerge from the design process, these are subjected to other forms of analysis as outlined in this article, and the results are then taken and incorporated into the new design. Trends among users are analyzed, and products redesigned. This can become a costly process, and needs to be done as soon as possible in the design process before designs become too concrete.
- *Meta-analysis:* A supplementary technique used to examine a wide body of already existing data or literature to derive trends or form hypotheses to aid design decisions. As part of a literature survey, a meta-analysis can be performed to discern a collective trend from individual variables.
- *Subjects-in-tandem:* Two subjects are asked to work concurrently on a series of tasks while vocalizing their analytical observations. The technique is also known as "Co-Discovery" as participants tend to feed off of each other's comments to generate a richer set of observations than is often possible with the participants separately. This is observed by the researcher, and can be used to discover usability difficulties. This process is usually recorded.
- *Surveys and questionnaires:* A commonly used technique outside of human factors as well, surveys and questionnaires have an advantage in that they can be administered to a large group of people for relatively low cost, enabling the researcher to gain a large amount of data. The validity of the data obtained is, however, always in question, as the questions must be written and interpreted correctly, and are, by definition, subjective. Those who actually respond are in effect self-selecting as well, widening the gap between the sample and the population further.
- *Task analysis:* A process with roots in activity theory, task analysis is a way of systematically describing human interaction with a system or process to understand how to match the demands of the system or process to human capabilities. The complexity of this process is generally proportional to the complexity of the task being analyzed, and so can vary in cost and time involvement. It is a qualitative and observational process. Best used early in the design process.
- *Think aloud protocol:* Also known as "concurrent verbal protocol", this is the process of asking a user to execute a series of tasks or use technology, while continuously verbalizing their thoughts so that a

researcher can gain insights as to the users' analytical process. Can be useful for finding design flaws that do not affect task performance, but may have a negative cognitive effect on the user. Also useful for utilizing experts to better understand procedural knowledge of the task in question. Less expensive than focus groups, but tends to be more specific and subjective.

- *User analysis:* This process is based around designing for the attributes of the intended user or operator, establishing the characteristics that define them, creating a persona for the user. Best done at the outset of the design process, a user analysis will attempt to predict the most common users, and the characteristics that they would be assumed to have in common. This can be problematic if the design concept does not match the actual user, or if the identified are too vague to make clear design decisions from. This process is, however, usually quite inexpensive, and commonly used.[48]
- *"Wizard of Oz":* This is a comparatively uncommon technique but has seen some use in mobile devices. Based upon the Wizard of Oz experiment, this technique involves an operator who remotely controls the operation of a device to imitate the response of an actual computer program. It has the advantage of producing a highly changeable set of reactions, but can be quite costly and difficult to undertake.
- *Methods analysis:* is the process of studying the tasks a worker completes using a step-by-step investigation. Each task in broken down into smaller steps until each motion the worker performs is described. Doing so enables you to see exactly where repetitive or straining tasks occur.
- *Time studies:* determine the time required for a worker to complete each task. Time studies are often used to analyze cyclical jobs. They are considered "event based" studies because time measurements are triggered by the occurrence of predetermined events.
- *Work sampling:* is a method in which the job is sampled at random intervals to determine the proportion of total time spent on a particular task. It provides insight into how often workers are performing tasks which might cause strain on their bodies.
- *Cognitive walkthrough*: This method is a usability inspection method in which the evaluators can apply user perspective to task scenarios to identify design problems. As applied to macro ergonomics, evaluators are able to analyze the usability of work system designs to identify how well a work system is organized and how well the workflow is integrated.

5. Weaknesses

Problems related to measures of usability include the fact that measures of learning and retention of how to use an interface are rarely employed and some studies treat measures of how users interact with interfaces as synonymous with quality-in-use, despite an unclear relation. Although field methods can be extremely useful because they are conducted in the users' natural environment, they have some major limitations to consider. The limitations include:

1. Usually take more time and resources than other methods
2. Very high effort in planning, recruiting, and executing compared with other methods
3. Much longer study periods and therefore requires much goodwill among the participants
4. Studies are longitudinal in nature, therefore, attrition can become a problem.

6. Why ergonomics important in workplace?

Ergonomics seeks to prevent such injuries by studying the relationship between the workplace and people in order to improve comfort and overall efficiency while on the job. ... Practicing good ergonomics can not only help to avoid injuries in the workplace, but can also help workers to be more efficient and productive.

Importance of Ergonomics in the Workplace It has long been understood that ergonomics offers numerous benefits, but recently a stronger emphasis has been placed on the importance of ergonomics in the workplace. The subject of ergonomics in the workplace has become so important, that it is now going to be addressed by the new OSHA standards to be released for 2010[2]. According to the Occupational Health and Safety Administration musculoskeletal injuries are on the rise. These injuries are commonly caused by a workstation that is improperly set-up. Such injuries can include carpal tunnel syndrome, tendonitis and low back pain. These injuries are now considered to be among the leading causes for disability within the modern workplace. OSHA estimates that as many as 1.8 million works related musculoskeletal disorders occur every year. These injuries result in a loss of 650,000 work days per year; more than 1/3 of the total amount of workdays that are lost on an annual basis. Ergonomics seeks to prevent such injuries by studying the relationship between the workplace and people in order to improve comfort and overall efficiency while on the job. Due to the fact that almost 70% of all work performed in the country today is done while at a seated station, many ergonomic considerations apply to work that is performed at a computer.

Adjusting your chair height so that your feet are able to rest flat on the floor and your knees are flexed at a ninety-degree angle can help to provide proper lumbar support and prevent strain. The top of a desk should be situated so that it is about two inches lower than the forearms, with the computer monitor no more than an arm's length away. The monitor should also be adjusted so as to reduce glare. Ergonomics can also be applied to the keyboard so that the upper arms are able to rest in a

relaxed position with the elbows at a ninety-degree angle and the wrists pointed forward. This will help to avoid placing strain on the wrists and hands. Practicing good ergonomics can not only help to avoid injuries in the workplace, but can also help workers to be more efficient and productive.

a) How many work days are lost each year because of musculoskeletal injuries?
   Answer: 6,50,000.
b) How much work is performed at a seated workstation across the country?
   Answer: 70%.
c) When seated, your knees should be bent at what degree?
   Answer: 90 degree.
d) You should take a 10 minute break for each_____ of work?
   Answer: one hour.

7. Applications of Ergonomics in Recent Year

A. Computer-aided ergonomics

One of the primary goals of computer-aided ergonomics is to develop software tools that allow ergonomics information to be accessed at the earliest stages of design. This case study discusses a PC-based software program that allows a designer to quantify a worker's biomechanical risk for injury based on a proposed workplace design. The program couples an established software tool for biomechanical analysis, the Three-Dimensional Static Strength Prediction Program (3DSSPP), with a widely used computer-aided design software package, AutoCAD. The use of this "3DSSPP/AutoCAD interface" in the proactive analysis of an automotive assembly task is described and the results compared with an independent assessment using observations of workers performing the same task. Both studies yield similar conclusions, suggesting that proactive use of software such as the 3DSSPP/AutoCAD interface may be a valid tool in evaluating proposed workplace designs.

B. Ergonomics and the management of musculoskeletal disorders

Prevention and Management of Musculoskeletal. Ergonomic claims include accepted disabling claims due to sprains, strains, tears, carpal tunnel syndrome, hernia and musculoskeletal diseases caused by bending, reaching, twisting, overexertion or repetitive motion. Good ergonomics can improve workplace efficiency and productivity. Ergonomics and the Management of Musculoskeletal Disorders. Reducing Musculoskeletal Disorders Through Ergonomics Managing musculoskeletal disorders Euro found Corporations have been implementing ergonomics programs for more than 30 years. Its Musculoskeletal Disorder Management and System Optimization.

C. Ergonomics in product quality and reduction in costs

Competition is an ongoing challenge confronting industrial corporations, particularly automobile manufacturing. Striving to improve product quality and productivity, automotive industries have used different quality management approaches, such as reduced variability, total quality management, and lean management, over recent years. Furthermore, incorporating proactive ergonomics such as physical and organizational ergonomics and psychosocial factors into the structure of a company is considered to be a support for productivity and quality. Several studies have shown the effects of ergonomics on better quality. Application of both quality management approaches and ergonomics in an integrated manner in the manufacturing production system is emphasized because they are similar concepts with the same objectives, that is, to improve efficiency.

D. Productivity associated with visual status

Vision is the most precious human sense. People are visually directed and depend on their eyesight every waking minute of the day. The way they use their eyes can determine how well they learn, work, and perform throughout their lifetimes. Psychologists estimate that 80% of the information people obtain from their external environment is by means of visual pattern (Manas, 1952), indicating the important role vision plays in daily activities. The way employees use their eyes in daily routines has changed dramatically [3]. More and more tasks are done at close viewing distance and employees work under a variety of workplace conditions:

1. The human visual system is not inherently designed to be used in a near-viewing posture for extended periods. The most relaxed vision is distance viewing; computer work is a visually stressful task.
2. Workplace lighting also creates visual stress and glare and can disable comfortable viewing situations. Addressing lighting issues in the office can prove beneficial for most viewing tasks. Lighting control is the most important modification that can be offered to resolve visual stress.
3. Humans are living longer and their eyes are aging. Lighting becomes more critical as employees age. Focusing ability decreases with age, so adjustments must be made in near-point viewing.
4. Providing vision care for computer employees makes economic sense. Vision programs increase work efficiency and employee comfort. Providing vision care for computer employees makes economic sense. Vision programs result in increased work efficiency and more comfortable employees. It is a win–win proposition for employers to provide eye care for computer workers.

8. Ergonomics in automobile industry

The automotive manufacturing industry is one of the biggest

players in providing ergonomic mandates for their plant employees. Many automotive manufacturing companies use existing health and safety standards, such as OSHA, to develop their own set of guidelines.

An automotive manufacturing plant, there are many tasks that require the right kind of posture or equipment to handle or transport product in order to keep employees safe and healthy.

These key tasks include:

- Bending down, picking up a box or product, lifting and placing onto another location
- Twisting when carrying boxes or product
- Pushing and pulling tasks which require transporting a large quantity of product using carts and dollies
- Turning or bending wrists when using hand tools
- Hand vibrations from using power tools
- Reaching overhead for work

Fig. 2. Ergonomics in automobile industry

Fig. 3. Ergonomics in car assembly in automobile industry

Ergonomics seeks to prevent such injuries by studying the relationship between the workplace and people in order to

9. Ergonomics in Pharmaceutical Industry

The equipment and machinery has to be suitable for the task. but it should also be suitable for the users.

Often equipment is purchased without first considering:

- How it will be operated
- Where it will be used
- Who will be using it
- The duration
- The frequency

Lack of consideration of these points can result in poor working postures leading to potential injury and discomfort. Think about the design and layout of equipment and machinery.

Fig. 4. Comfort bending posture

Fig. 5. Placing of products systematically

Fig. 6. Comfort seating arrangements

10. Important Points to Remember

- If new equipment / machinery is being purchased, it is vital that the user is considered.
- If possible, trials should be performed to ensure their suitability before purchase.
- Trialing equipment could prevent the occurrence of issues arising such as discomfort or difficulty of use later on alternative / specialist suppliers should be considered.
- Where possible, consult or consider the users and the nature of the job to gain an understanding of the requirements.
- Where there is a problem, change the way the job is done, how equipment and tools are used and how often.
- Consider how maintenance and repair work will be completed on machinery and whether this will be user friendly.

11. Conclusion

In conclusion, in past decades so as seen increased interest to develop and implement ergonomics in many field worldwide and also successfully applied. According to a recent study,1 more than 86 percent of U.S. employers with 10,000+ employees have a corporate wellness program. Despite their popularity, wellness programs are often viewed as "nice to have" rather than a strategic imperative. Recent evidence tells a different story. One high-profile example is Johnson & Johnson—its workplace wellness initiative has produced significant results:

- More than two-thirds of employees stopped smoking.
- More than half decreased their high blood pressure.
- More than half became physically active.
- Company savings of more than $250 million on health care costs in the past decade.

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