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Ergonomics and the Prevention of Musculoskeletal Strain and Back Injuries

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Abstract: ***As technology becomes more complex, so ergonomics is undoubtedly destined to play an increasingly important role in industrial production and industrial health and safety. At the workplace, ergonomics places equal emphasis upon greater system efficiency and improved health of the individual. Ergonomics must be involved in fitting the tool and machine to the worker by design, fitting the worker to the machine by selection and training, and the optimization of the ambient environment to suit the man or the adaptation of the man to tough environmental conditions. Ergonomics aims to promote efficiency, safety and comfort at work situation in industry through better relationship between man, his tools and the work environment. This paper deals about the injuries such as backaches, neck aches, and other muscular strains due to bad seating and incorrect working posture and how to prevent them by designing of workstation that will be very comfortable and convenient to work at. This paper also discusses the optimal conditions for the workers, reduction of physical workload, improvement of working postures and facilitating psycho-sensorial functions in instrument handling, and so on.***

Keywords: Back injury, Workstation design, Human factor, Productivity and Anthropometry.

I. INTRODUCTION

The word ergonomics comes from the Greek ergo means work and nomos means law [1]. So Ergonomics means laws of work. Ergonomics is used to fit the job to the worker. In the USA, it is called human factors. Human factors focuses on human beings and their interaction with products, equipment, facilities, procedures, and environments used in work and everyday living. The emphasis is on human beings and how the design of things influences people. Human factors, then, seeks to change the things people use and the environments in which they use these things to better match the capabilities, limitations, and needs of people. Human factors have two major objectives. The first is to enhance the effectiveness and efficiency with which work and other activities are carried out. Included here would be such things as increased convenience of use, reduced errors, and increased productivity. The second objective is to enhance certain desirable human values, including improved safety, reduced fatigue and stress, increased comfort, greater user acceptance, increased job satisfaction and improved quality of life.

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The approach of human factors is the systematic application of relevant information about human capabilities, limitations, characteristics, behavior, and motivation to the design of things and procedures people use and the environments in which they use them. In many industries ergonomics is implemented primarily as a means of reducing high injury rates and high insurance premiums. In the USA, a worker's compensation premiums often amount to 15% of the salary. This is because there are many back injuries due to materials handling and injuries to the joints in the arms, shoulders and neck due to poor work posture. The scope for the application of ergonomics in our working environment is tremendous. The correct matching of man, technology, task and organization to form a total entity capable of higher job performance is now an important function of management, and the ergonomic approach can go a long way to help meet this objective.

1.1. Ergonomics Aspects

Ergonomics has two distinct aspects: Firstly study, research, and experimentation, in which determine specific human traits and characteristics that need to know for engineering design; Secondly application and engineering, in which design tools, machines, shelter, environment, work tasks, and job procedures to fit and accommodate the human and equipment in the environment to assess the suitability of the designed human-machine system and to determine possible improvements [2].

1.2. Man- Machine- Environment Interaction:

At the workplace, ergonomics places equal emphasis upon greater system efficiency and improved health of the individual. Ergonomics must be involved in fitting the tool and machine to the worker by design, fitting the worker to the machine by selection and training, and the optimization of the ambient environment to suit the man or the adaptation of the man to tough environmental conditions. To fulfill the general aim of ergonomics in integrating man-machine and man-environment relations, the interaction between these elements must be optimized. This approach has to consider (1) the operator's interaction with the tool, (2) the immediate workplace around him, and (3) the work environment in which he has to work.

II. WORKPLACE AND ANTHROPOMETRY

Backaches, neck aches and other muscular strains due to bad seating and incorrect working posture are common in industry, where many jobs require people to remain sitting or standing in a fixed posture for a long period of time.

It is common to find in many industries and offices glaring examples of poor work design. Chairs, tables, workbenches, tools and machines are introduced without any consideration of their relationship to one another. Incorrect and awkward postures associated with either the level of working height or with the poor design of the machine could result in discomfort and fatigue. In addition, neglect of ethnic and anthropological differences through the unthinking importation of foreign technology developed in a different cultural and social framework can have a generally negative effect. Workplace design and layout should conform to ergonomic principles, while both physical and physiological aspects of the working environment should be considered. The use of ergonomics is essential in such areas as working posture, tool design and workplace layout, together with environmental factors such as ventilation and lighting. Temperature and humidity should be kept at a comfortable level through the use of ventilation systems. The noise level should be low enough not to cause interference with communication and distraction from work. Lighting has to be adequate and glare should be minimized.

Work organization is an important factor to be considered for reducing musculoskeletal strain at the workplace. Measures such as reducing the work rate in paced operations, reducing shift length, and the provision of extra rest breaks have proved helpful in repetitive operations. Tasks consisting of lifting, pushing, or pulling objects without the assistance of mechanical devices are referred to as “manual material handling”. Manual material handling tasks carry a high risk of injury not only because of the interaction between the worker and the object itself but also because there is a potential for overloading the body’s supporting structure, the musculoskeletal system. Lifting of heavy objects presents a high risk of over-exertion injuries and cumulative damage to the soft tissues around the spine. These injuries to the back constitute the largest single category of worker’s compensation claims in many developed countries, amounting to 25% of all disability cases.

A workstation may be defined as a place within the workplace where equipment or instrumentation is positioned in such a convenient way that users can perform their tasks properly [3, 4]. Workstation design deals with choosing and arranging equipment, machinery, tools, and accommodations for users so that workflow and organization are optimized. Workstation design is the object of several recent developments in ergonomics, particularly regarding increasing level of competition and technological development in modern enterprise environments among others. In the design of workstations, designers are often faced with the task of eliciting components to be included in the project Workstation components (WCs) may be divided into two major groups [5]:

a) Functional such as work seats, worktables, machinery, and accessories, and

b) Environmental, related to psychological, social, and climatic inputs that affect worker’s behavior. The best choice takes into consideration ergonomic criteria, such as anthropometric and biomechanical characteristics, and commercial criteria, such as warranty length and service level provided by manufacturers.

2.1. Anthropometry in Workstation Design

The basic philosophy of ergonomics is to design workstations that are comfortable, convenient and productive to work at. Ideally, workstations should be designed to fit both the body and the mind of workers.

Anthropometry is the branch of human sciences that deals with the body measurements, particularly with measurements of body size, shape, strength, mobility and flexibility and working capacity [6]. By the use anthropometric design principles it is possible for a variety of people to find physical comfort at workstation. On the other hand, by not taking into consideration these physical requirements, one may create bad work postures, which lead to fatigue, loss of productivity and sometimes injury. Anthropometry is not only a concern about appropriate working height, but also about how the operator can easily access controls and input devices. Typically the normal reach area (NRA) dimensions are presented as 5th, 50th and 95th percentile curves. In theory, using the 5^{th} percentile curve results in a design within which the majority (95 %) of operators could comfortably perform the intended tasks.

III. ERGONOMICS AND THE PREVENTION OF MUSCULOSKELETAL STRAIN

Musculoskeletal problems have been reported as occurring in a wide range of industries. The National Institute for Occupational Safety and Health (NIOSH) in the USA reported that 15-20% of workers employed in construction, food preparation, the electronic industry, clothing and bag manufacturing, and clerical work are at risk for cumulative trauma disorders. Cumulative musculoskeletal problems are not the result of single events; they stem from (a) the repeated performance of certain tasks (b) bad working posture (c) application of force, and (d) inadequate rest. There are two major factors that can affect the health and performance of industrial operators through their musculo-skeletal system: static load and awkward posture.

(1) static muscle load: when tools or equipment are used in situations where the arms have to be held for extended periods, such as during grinding operations, muscle of the shoulders, arms and hand may be loaded statically. This loading can result in fatigue and reduced capacity to continue the work, and it may produce soreness in the muscles. The primary strategy to prevent musculo-skeletal trauma is the use of ergonomic principles to modify hand tools and to improve workstation design and work practices. Workload should be distributed between hands and feet wherever feasible. The following ergonomic rules are suggested for repetitive use: The tool should be designed for operation with a straight wrist-bend the tool handle, not the wrist. Use power tools whenever feasible. Make tool light-heavy tools should be suspended or otherwise counterbalanced. Handle surfaces should be so shaped as to contact the largest possible surface of the inner hand and fingers, distributing the forces evenly and not creating power points.

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(2) Awkward posture: the necessity to adopt one posture, or a very limited range of awkward work positions, may result in wrist and hand fatigue, and difficulty in sustaining a proper work position. The primary strategy to prevent cumulative trauma disorders is the use of ergonomic principles (a) to modify hand tools, (b) to improve workstation design, and (c) to improve work practices.

3.1. Back Injuries At Work

Back pain is one of the most common work related injuries and is often caused by ordinary work activities such as sitting in an office chair or heavy lifting. Applying ergonomic principles – the study of the workplace as it relates to the worker – can help prevent work-related back pain and back injury and help maintain a healthy back. The goal of an ergonomics program in industry is to adapt the workplace to a specific worker, dependent on the job description, required tasks and physical make up of the employee performing those tasks. Two types of situations typically cause people to begin having back pain or to sustain a back injury while on the job: (a) Non accidental injury, where pain arises as a result of normal activities and requirements of the task. Poor body mechanics (such as slouching in an office chair), prolonged activity, repetitive motions, and fatigue are major contributors to these injuries. This may occur from sitting in an office chair or standing for too long in one position. (b) Accidental injury results when an unexpected event triggers injury during the task. A load that slips or shifts as it is being lifted, and a slip and fall or hitting one's head on a cabinet door are typical examples. These accidents can jolt the neck, back and other joints with resulting muscle strain or tearing of soft tissue in the back.

3.2. 3.2 Back Injury From Physically Demanding Jobs

Occupations that are physically demanding and require repetitive lifting (such as in nursing or heavy industry) are at greatest risk for both non-accidental and accidental back injury. For example, many healthcare workers have back problems because patients are of different stature and weight with varying needs. Often, the patients need help changing position, rising from a chair and walking. Similarly, the physical effort needed on an accident or fire scene to release a trapped person or save a life is unpredictable. The same problems occur in the construction industry where consistencies of tasks are a challenge.

3.3. Office Chair Back Injuries

People who sit most of the day, such as those who work at a computer while sitting in an office chair, is also at high risk for non-accidental back injury. Office ergonomics, or computer ergonomics, can help minimize the risk of repetitive injury, such as carpal tunnel syndrome, and the risks associated with prolonged sitting in an office chair, such as neck strain, lower back pain and leg pain.

IV. PREVENT BACK INJURY

There are certain basic ergonomic guidelines that may help an employee avoid back pain or back injury:

- Develop a job description based on the forces present in a particular work environment; the time spent performing the task and the biomechanics (which define human motions and seated posture in an office chair) used in the task.
- Use body posture as a tool that can be changed to meet the job demands with minimum stress on the muscles, ligaments, bones and joints.
- Learn and use appropriate body mechanics to limit extra mechanical stress in completing the task.
- Maintain fitness and flexibility and develop a reserve of strength.

4.1. Identifying Poor Posture and Risks

Many potentially harmful situations that lead to back injury can be identified and avoided by following four basic rules of thumb:

1. Prolonged static posture is the enemy. The healthy body can only tolerate staying in one position for about 20 minutes. That is why sitting on an airplane, at a desk in an office chair, or at a movie theatre becomes uncomfortable after a short time. Standing in one place, such as standing on a concrete floor at an assembly line for extended periods of time tends to cause back pain. Holding the same position slowly diminishes elasticity in the soft tissues (muscles ligaments and tendons in the back). Then, stress builds up and causes back discomfort and/or leg discomfort. The solution is simple. Whether you're sitting in an office chair or standing in a line, change positions frequently. Just move. Stand or sit, stretch, take a short walk. After returning to the standing or sitting posture, use an alternate posture for just a few moments and some of the tissue elasticity needed to protect the joints will return.

2. Frequent or repetitive stretching to the end range of motion or awkward, angled postures can bind the joints. Unlike jobs that require long-term seating in an office chair, jobs that require frequent repetitive motion can cause great discomfort. Such jobs involve lifting from the floor, lifting overhead, moving bulky loads, or using rotational force or twisting while handling material and which signal back injuries might be on the way.

3. Heavy loads offer greater risk. If the job requires moving heavy or bulky objects, it is important to have the proper tools or get help.

4. Fatigue from sitting in an office chair for days, from work or from insomnia can make people move more awkwardly. If one is overtired or feels fatigued, it is advisable to avoid lifting heavy objects alone or quickly.

If following these ergonomic rules of thumb is a frequent problem, the worker is at risk of sustaining or aggravating a back injury.

4.2. Manual Material Handling to Prevent Back Injury

Any job that involves heavy labor or manual material handling may be in a high-risk category. Manual material handling entails lifting, but also usually includes climbing, pushing, pulling and pivoting, all of which pose the risk of injury to the back. Lifting from the floor places strain on the structures in the lumbar spine. Ergonomic lifting techniques involve the use of a diagonal foot position, and getting as close to the load as possible. The load should be kept as close to the body as possible when standing up.

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It is easier to move loads that are waist high than ones that are on the floor. Stacking pallets to raise the height of the load is one ergonomic solution. A scissors lift will mechanically raise the load to a comfortable lifting level. Repetitive lifting from the floor is particularly risky, so try to get the material off the floor. Keep all loads as close to one's center of gravity as possible. Carrying loads on one shoulder is safer for long and narrow material. This would include construction material or rolls of carpet. When lifting anything with a handle, place one hand on one knee to get additional leverage and use a diagonal foot position. Carrying two objects of the same weight will balance the load as long as the weight of the load is reasonable.

When climbing with a load, "three-point" contact is important for safety. This means two hands and a foot or both feet and a hand must be in contact with the ladder or stairs at all times. If the load is bulky, get another person or a mechanical device to assist. Manual material handling may require pushing or pulling. Pushing is generally easier on the back than pulling. It is important to use both the arms and legs to provide the leverage to start the push.

- A handle would ideally be waist high for ease of pushing.
- If it is necessary to pull, avoid twisting the lower back
- Sometimes, for very large loads, turning around and using the back to push against an object allows the legs to provide maximum force while protecting the low back from strain or twisting. The opposite of twisting is pivoting. Pivoting means moving the shoulders, hips and feet with the load in front at all times. The lower back is not designed to torque or repetitive twisting. Whether using a shovel or moving material or products, always avoid twisting the back. Practicing these techniques, both at work and at home, will go a long way to help prevent back injury and protect the structures in the low back.

V. IMPLENTATION

This ergonomics approaches has been implemented in a local Ceramic factory and found that their employee turnover has been reduced to 20 percent and productivity has been increased to 10 percent. Although the company has to spend some money for the implementation of the ergonomics approach but this cost is very small compared to their benefit.

VI. CONCLUSION

Occupational ergonomics is a part of industrial medicine, and is essentially applied to reduce work injuries and discomfort. The discipline deals with the body size of the workers, strength and stress while at work. Recent studies have suggested that many of the occupational diseases are connected to poor design of tools, machines and workplace. To prevent unnecessary error and overt and cumulative injuries, ergonomics has an essential role to play in increasing work efficiency and productivity by making the tool or machine fit the users and the worker's capability.

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