ERGONOMIC ASSESSMENTS OF LABORATORY WORKING WITH SEATING AND STANDING POSTURES

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ABSTRACT

Ergonomics is important to ensure that the worker can work in the safe condition whether they work in standing, sitting, walking and so on. The use of ergonomics study is to improve the workers safety and health, increase job satisfaction and enhances performance. Lack of ergonomics criteria in workspace and workstation design can cause physical and biological hazards to the workers. Ergonomics evaluations in industrial setting have recently received increased attention due to the cost incurred as a result of repetitive motion injuries. When we are working, the most common position involved is whether standing or seating. Working in seating position is widely available in the office and assembly line at the manufacturing floor. Because of some particular reason, working in standing position also widely used in manufacturing floor. Many industrial companies today have changed their plant layout to fit with standing operator. This paper reports on the impact of the types of handling the work station design, have specific ergonomic risk factors identified in these tasks. The field of study is focused on ergonomic problems encountered for every machine and workstation at the engineering school associated with the laboratory practicals in these labs. A well-designed workspace must be safe, efficient, satisfying to use, pleasant, durable, and users to interact safely. The results of this study create an ergonomics awareness with all staff and student of laboratory working with seating and standing postures.

KEYWORDS: *Ergonomics; workstation; manufacturing; practical; seating; standing*

1.0 INTRODUCTION

The primary use of anthropometric data is for fit and reach, but there are other uses too. People come in a variety of sizes and shapes. A few principles apply to the use of anthropometric data in design, although each principle may not work for every situation. One of the applications is to design so things are adjustable for different users. Office furniture manufacturers today provide many adjustable features in chairs, work surface heights and positioning the keyboards and monitors. Besides that, adjustments are beginning to appear in seating and workstation equipment in factories and shops. For example barber chair has adjustments in height, tilt and rotation for years, adjustable height at pallet platform that allow the user to adjust pallet height as the pallet is filled or emptied and many more. Because not everything can be designed for adjustment, the use of anthropometric data is used to design for the 95th percentile male to fit and the 5th percentile female to reach. The goal is to allow most people to fit within the

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dimensions. Designing a doorway, seating in airplanes or headroom in an automobile requires only one solution. If a person must reach a control or a part, the distance from the person to the object should not be longer than a short persons reach. If data on a particular population are available, a design can be fitted to them.

2.0 OBJECTIVES OF STUDY

The general objective of this study is to know the workspace design for standing and seated workers in Engineering Campus of University Malaysia Perlis. The specific objectives of this study is to know what is the problem that occur in the workspace in the laboratory and workshop in the engineering school and what action can be taken to improve the working environment and equipment uses. To find out whether the workplace is satisfied with the good ergonomics aspect of a workplace and what aspect should be given more attention to safety and health at the workplace. A safe work is also a positive factor for productivity and economic growth.

3.0 GENERAL PRINCIPLES

Ergonomics principles can be described as interaction between human - machine systems. It consists of three main components that interact with each other. These components are human components, machine components and the environment. In ergonomics criteria the interaction between human bodies to its surround should be optimized. The physical space requirements should be met (anthropometry data) and internal, external forces that exerted on the body are not harmful. Human components to the worksystem can be divided in three segments, which are the effectors, the senses and supportive processes. Human interaction with machines depends on the provision of suitable controls which can be acted on by the effectors. Workspace is the three-dimensional space in which work is carried out. Workspaces usually fixed which introduces design issues such as the need to determine the workspace dimensions. This requires the dimension of the machine, anthropometry, and activities required by both man and machine to carry the task to be considered. Besides that there are many other considerations in designing the workspace such as the choice and layout of furniture. Refer Table. 1.

Table 1. Recommended dimensions for work surface heights

Type task	**Recommended Height (cm.)**	
	Human Factors IS: 265- 268 (1973).	
Standing	**Male**	**Female**
Precision work, Elbows supported	109- 120	103- 112.6
Light assembly work	99.06- 109.22	87.63- 97.79
Heavy work	85.09- 100.33	78.74- 93.98
Seated	**Male**	**Female**
Fine work or assembly	99.06- 105.41	88.9- 95.25
Precision work (mechanical)	88.9- 93.98	92.55- 87.63
Writing or light work	73.66- 78.44	69.85- 74.93
Coarse, medium work	68.58- 72.39	66.04- 69.85

4.0 ERGONOMICS OF SITTING WORKERS

The chair is the main instrument for working in sitting position. In the past chair has been expected to provide both sitting and working comfort for employees who work at fixed height surfaces. With the increased use of computers at home and the office, there is a new trend of computer/ office work- related complaints. Most of the complaints were induced by poor work habits, poor workstation design, highly repetitive keyboarding and extensive use of the mouse. Recommendation for work with keyboard is the work surface often 3cm to 6 cm lower than a writing work surface to allow for the thickness of the keyboard. In addition, space must be provided for the sitter's leg. The researchers have suggested that a chair should be designed with forward tilted seats. These chairs should permit a user to sit with an erect trunk and less posterior pelvic tilting and flattening of the lumbar curve because the tilt of the seat increases the trunk-thigh angle. Some key features about a good chair and workspace design for visual display terminal (VDT) users has been pointed below .The recommended dimensions for office chairs are given in Table 2.

Table 2. Recommended dimensions for office chairs from ANSI

Seat	
Height from floor	40.64- 52.07 cm.
Width (breadth)	44.96 cm.
Length (depth)	38.1- 43.18 cm.
Pan angle	0- 10° or adjustable to this range
Seat back-to-pan included angle	90- 105°, adjustment preferred.
Backrest	
Height	Variable with task and back angle
Width	At least 31.75 cm in the lumbar
Armrest	Inside distances At least 43.68 cm.

5.0 ERGONOMICS OF STANDING WORKERS PROPER STANDING

As a rule of thumb, it is often suggested that all objects which are to be used by standing workers should be placed between hip and shoulder height to minimize postural stress caused by stooping or working with the hands and arm elevated. Work surfaces height should approximate the standing elbow height of workers, depending on the task, Charles D. Reese, (2000). Some workspace design faults, which increase postural stress in standing worker, can be summarized as follows:

- Working with the hand to height and/or far away compensatory lumbar lordosis.
- Working surfaces too low – trunk flexion and back muscle strain.
- Constrained foot position due to lack of clearance – worker standing far away.
- Working at the corner of the bench – constrained foot position, toes turned out too much.
- Standing with the twisted spine (having to work at the side rather than directly ahead.

Postural constraint in standing workers can be relieved by providing stools to enable workers to rest during quiet periods or to alternate between sitting and standing. Adequate space for the feet should be provided to permit workers to change the position of their feet at will.

6.0 WORKPLACE LAYOUT FOR STANDING W0RKERS

The critical features of the work-surface height for standing workers are in part the same as for seated workers, i.e., elbow height and the type of work being performed. For light and heavy work the recommended working height are below elbow height, whereas that for precision work is slightly above. In the standing position, it is actually energy efficient for human to adopt. Standing is the position of choice for many tasks in industries but it can lead to discomfort if insufficient rest is provided or unnecessary postural load is placed on the body. Prolonged daily standing is associated with low back pain. Where possible, jobs which require people to stand still for prolonged periods without some external form of aid or support must be redesigned to allow more movement to allow the work to be done in a combination of standing and sitting postures. It is often suggested that all objects which are used by standing workers should be placed between hip and shoulder height to minimized postural stress cause by stooping or working with the hands and arms elevated. Work surface height should approximate the standing elbow height of workers, depending on the task. For the fine work, a higher work surface is appropriate to reduce the distance of the eye and allow the workers to stabilize their forearms by resting them at the work surface. For heavy work, the lower work surface is needed to permit the worker to apply great vertical forces by transmitting part of the body weight through the arms. There are some workspace design faults which increase postural stress in standing workers. The purpose of the provision is for workstations, jobs and work environment condition to be designed and arranged in such way that risk of physical load both static and dynamic which are dangerous to health or unnecessarily fatiguing or stressful are averted. Employer duties include the responsibility to ensure that work which is physically monotonous, repetitive, close control or restricted does not normally occur.

7.0 OBSERVATION AND ANALYSIS OF DATA FOR SITTING WORKERS

This ergonomics study was started with the construction of a set of checklist, which was used during the observation made in the Manufacturing Engineering School. The main scopes of the questions in the checklist are like general review, symptoms of ergonomics problems, workplace characteristic, perceptual load, mental load, environment, specific equipment, physical demands, work method and others. All the workplace or workstation studied in the school then divided to either standing or sitting.

Table 3. Number of problems for every workstation and its percentage

Workstation/ equipment	Problems	%
Computer (CAD/CAM lab)	5	6
The Stress master Polariscope	7	8
Microscope	10	12
Gas Welding	17	20
Polymer Laboratory	14	17
Latex Laboratory	8	9

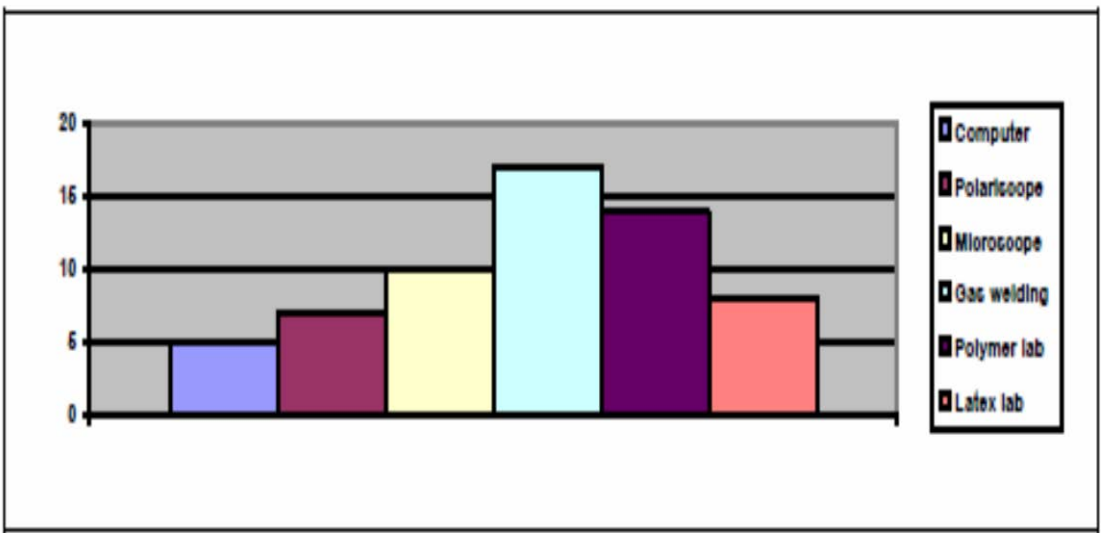

Figure1. Percentages of the problem identified in each workstation

From the Table 3.and Figure1. above, we have identified that gas welding has the highest problems with 17 % from questions are not satisfied the need for good ergonomic workspace and criteria. This follows by other laboratory, Microscope, Machine workshop. The Computer laboratory with CAD/CAM equipments have the lowest problem identified with only 4 % from the questions.

The computer in the CAD/CAM lab is used for many applications such as designing an object, simulation and programming with the used of software likes IDEAS, WITNESS, MATLAB, AUTOCAD, ANSYS, KATIA and many others. Student also can use the Internet to collect information relating to their coursework. All the computers are placed in several rows on a long table.

Table 4. Number of problem and satisfied condition identified in computer lab

A. Question Segment	Satisfied	Percentage	Problems	Percentage
1. General review	7	78 %	2	22 %
2. Symptoms	14	100 %	0	0 %
3. Workplace	14	82 %	3	18 %
4.Perceptual load	14	100 %	0	0 %
5. Mental load	4	100 %	0	0 %
6. Environment	18	100 %	0	0 %
7. Specific equipment	11	100 %	0	0 %
8. Physical demands	13	100 %	0	0 %
9. Work methods	13	100 %	0	0 %
10. Others	6	86 %	1	14 %

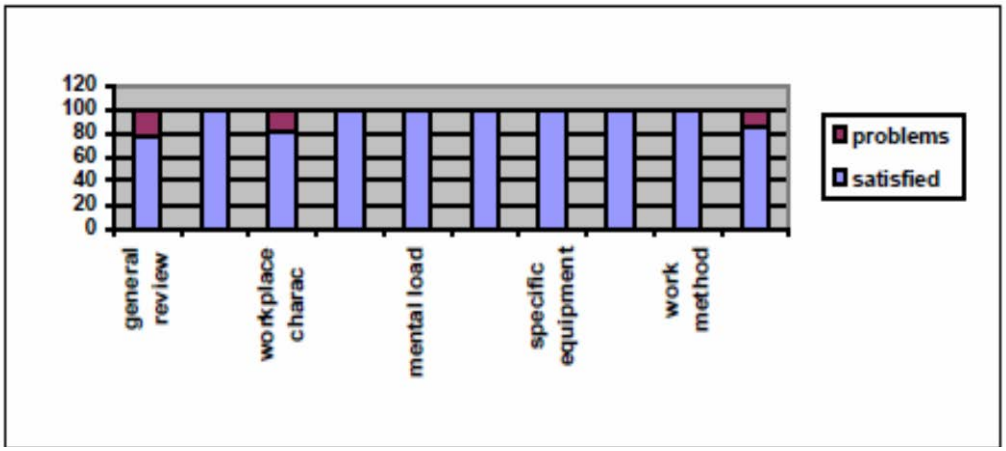

Figure 2. Percentages of problem and satisfied in each segment in computer lab

We can see from the Table 4. and Figure 2. There are problem in general review, workplace characteristic, and others segment. From the questions, there were total 6 problems to encounter, which is 5 %. There problem in general reviews are like no document annual review and no documented of ergonomics related finding and correctives action. The problems in workplace characteristic are like there is poor chair which difficult to adjust and no adjustability is built in the workplace. Others problem is lack of motivation among the users. Figure 3. show a student using a computer in the CAD/CAM laboratory.

Figure 3. Student using computer in CAD/CAM laboratory

The ten main segments in the question are about general working problems, workplace environment,work load,specific equipment, physical demand, working methods and other problems. It was observed that there were only symptoms of ergonomic problems, mental load and environment. Other segments don't have any problem. Refer Figure 4.

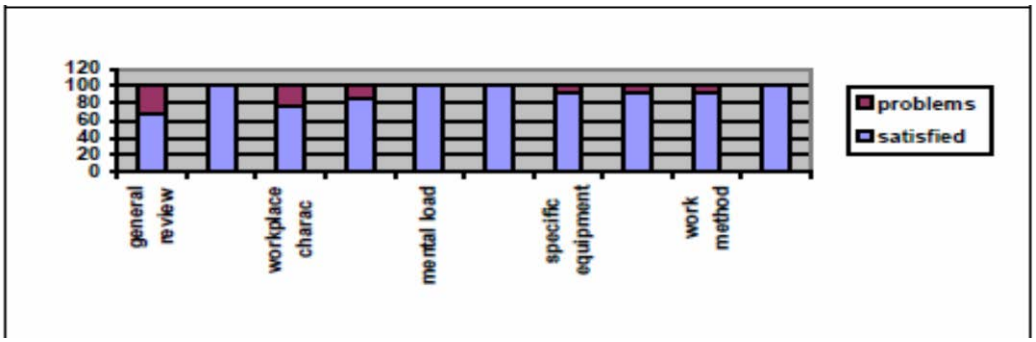

Figure 4. Percentages of problem and satisfied in each segment in CAD/CAM lab

In the microscope work station, there are problems like no documented annual review, no documented review of ergonomics related findings and corrective actions and no employee's ergonomics-related concern evaluation. There were 5 problems occured in the workplace characteristics, 2 problems in perceptual load and one each in physical demand and work method. Refer Figure 5. which shows the microscope station being used in the lab.

Figure 5. shows the microscope station being used in the lab

Oxyfuel gas welding (OFW) is a general term used to describe any welding process that is uses a fuel gas combined with oxygen to produce a flame. This flame is the sources of heat that is used to melt the metal at the joint [9]. In the Manufacturing School workshop, this type of welding is used for structural sheet-metal fabrication and various other repairs. Table 5. and Figure 6. shows the number of problem and satisfied condition identified for each segment and their percentages. Only mental load and others segment are satisfied with the questions that being asked.

Table 5. Number of problem and satisfied condition identified for each segment in OFW

B. ***Question Segment***	Satisfied	Percentage	Problems	Percentages
1. General review	6	67 %	3	22 %
2. Symptoms of ergonomics problem	12	86 %	2	14 %
3. Workplace characteristics	14	82 %	3	18 %
4.Perceptual load	12	86 %	2	14 %
5. Mental load	4	100 %	0	0 %
6. Environment	13	72 %	5	28 %
7. Specific equipment	10	91 %	1	9 %
8. Physical demands	11	85 %	2	15 %
9. Work methods	11	85 %	2	15 %
10. Others	7	100 %	0	0 %

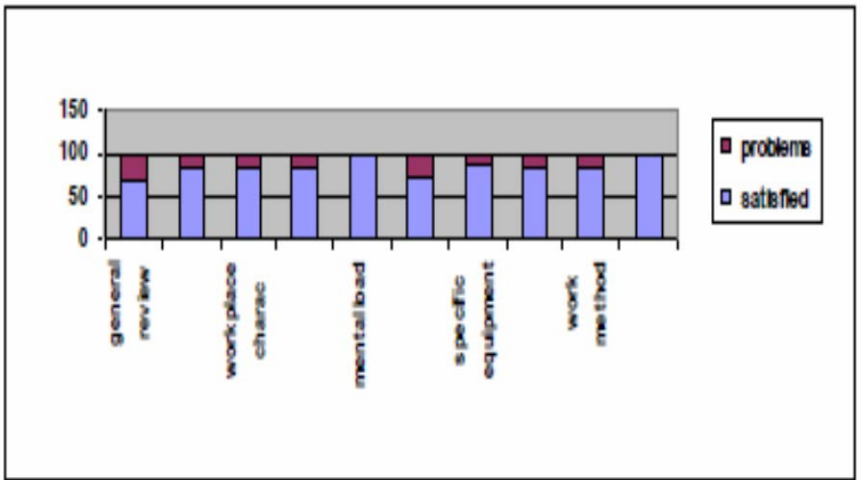

Figure 6. Percentages of problem and satisfied in each segment for OFW

The environment segment shows the highest number of problems with 5 problems, which is equal to 28 %. This is because the uncomfortable temperatures that exist in that area of workspace. The specific equipment segment only contains one problem, which is the lowest problem score. Figure 7. shows the layout at the gas welding area with a student performing the welding task.

Figure 7. Student performing the welding task

8.0 OBSERVATION AND ANALYSIS OF DATA FOR STANDING WORKERS

For the standing working position, five in Manufacturing Engineering School was selected for observation. We have analyzed the grinding machine, arc welding, milling machine, lathe machine and Rockwell Hardness Tester. From the ergonomic questions asked for each workstation, the number and percentage of problems or unsatisfied were summarized. Figure.8 shows the difference between each of the workstation. The highest problem occur in the grinding machine with 36 problems, followed by Spiral machine with 19 problems, arc welding with 15 problems, Ball and Roll Mill machine with 14 problems, milling machine and extruder machine with each 10 problem, Lathe machine with 8 problems and finally Rockwell Hardness tester with 6 problems.

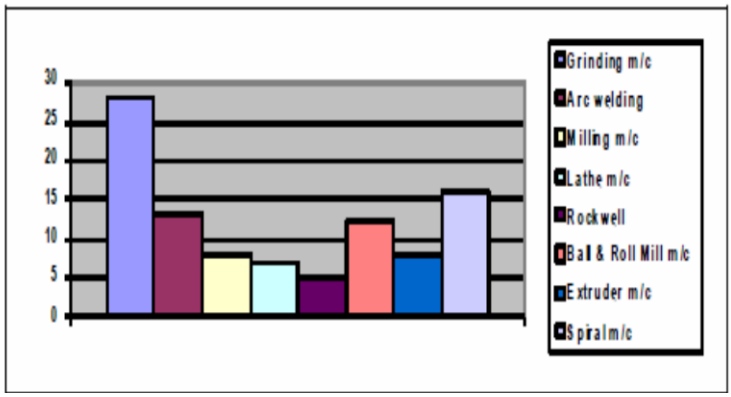

Figure 8. Percentages of the problem identified in each workstation

The problems that can be identified for the grinding machine from the general review are like no documented annual review, no evaluation about employee ergonomics-related concern and no document related to finding and corrective actions. There are 5 problems in workplace characteristic segment which are like awkward postures are required, no adjustability made into the workplace, the work surface appear to be too high or too low, worker are required to hold their arm without the assistances of armrests and the workers engaged to static holding work. Other problems are the task is repetitive and monotonous, critical task element exist where error are not tolerated and

many others. Figure.9. shows a student using the grinding machine.

Figure 9. Working with grinding machine

9.0 RESULTS AND DISCUSSION

In this work we have made the data analysis for standing and seated workers from the checklist for manufacturing engineering school. The Ergonomic Exposure assessments of workplace layout and working postures of sitting and standing workers will generate to improve the weakness in those ergonomics aspects. The result from this study showed that there was a reasonably good agreement between users' ratings of comfort and the ergonomists' observations. In the computer laboratory, besides there is no documentation about the ergonomics aspect, the main problem that can be identified is about the workplace characteristic. There is no adjustability built in the workplace, which is at the computer table beside the poor chair that is difficult to adjust with inadequate back support and no footrest. The number of chair in the laboratory is too much and cause the movement of the user difficult. The existed adjustability chair is hard to adjust for the comfortable of men and women users because the adjusting device has become rusty and the joint slip. The chairs also don't have arm support to support the user arm when they are using the keyboard. There is also less space between one computer to another computer, provide no space for the user to write or place their equipment that need to be used while using the computer. The arrangement of the computer is too close to each other and makes the space of one computer full when the computer needs to be share with two or three person.

There are two types of welding in the workshop, which is gas welding and arc welding. The first problem identified for both types of welding is there is no document concerning about the ergonomics aspect. There is high material waste but this is not to be considered as big problem because it is used for the purpose of student learning. For arc welding there is no adjustability built at the workplace. The work piece tables cannot be adjusted to suit the user height. This causes the user bend their trunk to do the welding. For gas welding, the chair height cannot be adjusted and user needs to hold their arm without assistant of armrest. The environment is uncomfortable because of the heat produce by the flames of the welding process and contained toxic substance. Improvement that can be suggested for arc welding is to built the workplace table so

that it can be adjusted and for gas welding, the chair need to be replaced to adjustable chair with footrest. The uncomfortable environment can be reduce by open more space of the room to outside so that the air can flow freely and bring the heat outside.

The problems at the grinding machines are small and mainly difficult to see the defects with eye movement. The critical displays are not within the normal line of sight. The environment is also not comfortable with excessive noise and vibration that is annoying, and the thermal environment is uncomfortable. There is also sharp edge in the work area and the hand tools may cause injuries if not used correctly. There is constant handling of material and the task required constant standing. Action that could be taken at this workplace is to do maintenance and checking of the machine to reduce the vibration and noise that happen. The user also needs to wear gloves, earplugs and eye protector to avoid injuries. For the uncomfortable thermal environment, the number of fan in the workshop needs to be increased.

The ten main segments in the question are about general working problems, workplace environment,work load,specific equipment, physical demand, working methods and other problems. These segments should take into account: the results of hazard and risk identifications and assessments; the results of performance monitoring and measurements; the investigation of work-related injuries, diseases, ill health and incidents, and the results and recommendations of audits. When the evaluation of the system or other sources show that preventive and protective measures for hazards and risks are inadequate or likely to become inadequate for sitting and standing postures for laboratory working, the measures should be addressed according to the recognized hierarchy of prevention and control measures, documented, as appropriate and in a timely manner.

10.0 CONCLUSION

From the observation and analysis of the data, the most similar problem in all workspace that need to be considered about the documentation of the ergonomics aspect and concern. The workspace design and the ergonomics aspects are important not only for efficiency of the work but also in economics aspect for reducing the cost. A well-designed workspace must be safe, efficient, satisfying to use, pleasant, durable, and users to interact safely. This study can create and maintain ergonomics awareness with all staff and student. An awareness program should be held to prevent new problems. For the future, motivate all members of the University, particularly managerial staff, lecturerer and laboratory instructors, students in applying appropriate occupational safety management principles and methods to continually improve performance. Arrangements should be established and maintained for the continual improvement for sitting and standing postures for laboratory working.

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