DESIGNING WORKSPACE FOR BETTER PERFOMANCE, SAFETY AND HEALTH IN MANUFACTURING INDUSTRY, AN ERGONOMICS CASE STUDY

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A report submitted in partial fulfillment
of the requirements for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
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NOVEMBER 2007

ABSTRACT

In manufacturing industry there are so many things happen. Human works in specific workspace and use what ever provided by the company. Therefore, it is necessary to provide good design of workspace in order to maximize the utilization of tools and improving the productivity. Thus, the research is carried out for identified the improvement of the current workspace. The research of designing workspace for better performance, safety and health is about identified potential problem and make improvement toward some adjustment. The focusing aspect in this research are design of seat, height of computer screen, height of mouse and procedure of worker while perform their task. In this research, the new design is develop by using theory of workspace design. Method to be use in this research is by observation and questionnaire. For intangible data questionnaire will be used and for tangible data observation by referring to the theory will be use. Anthropometry data of workers will be use to make improvement of current design in order to make sure the new design is suitable for them. The final stage of this research is implementing the new design of the workspace. After implementation expected result is the productivity, safety and health of the current design able to increase and enhance the satisfaction of the workers.

ABSTRAK

Terdapat banyak perkara berlaku didalam indusri pembuatan. Pekerja akan berkerja didalam ruang kerja yang disediakan oleh pihak kilang. Oleh yang demikian, adalah perlu untuk menyediakan ruang kerja yang selesa dalam menentukan sepenuh penggunaan ruang kerja yang disediakan secara tidak langsung dapat meningkatkan produktiviti. Oleh itu, kajian ini akan mengenal pasti perkara yang diperlukan untuk meningkatkan kualiti ruang kerja sekarang. Kajian ini memfokuskan tentang mereka ruang kerja untuk kualiti yang baik, keselamatan dan kesihatan di kilang pembuatan dan memfokuskan terhadap ergonomics konsep. Focus kajian ini di ruang kerja adalah rekaan kerusi, ketinggian skrin komputer and ketinggian tetikus komputer. Didalam kajian ini pembinaan ruang kerja akan menggunakan teori-teori berkaitan ruang kerja yang telah dilakukan oleh penyelididk terdahulu. Cara yang digunakan dalam kajian ini untuk mendapatkan maklumat adalah dengan menggunakan kaedah soal-selidik dan pemerhatian penyelidik. Data ukuran perkerja akan digunakan untuk melakukan rekaan baru ruang kerja. Ini untuk memastikan ruang kerja yang dicadangkan kepada mereka benar-benar sesuai untuk mereka. Langkah terakhir didalam kajian ini adalah mengaplikasi rekaan baru diruang kerja sekarang. Harapan rekaan baru adalah dapat meningkatkan produktiviti dan menjanjikan keselamatan kepada perkerja sekaligus meningkatkan kepuasan pekerja.

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X	percentile value being calculated
m	Mean of the distribution
F	multiplication factor corresponding to the requirement percentiles
s	Standard deviation of the sample
n	number of subjects in the sample

CHAPTER 1

INTRODUCTION

1.1 Project Background

Manufacturing Industry is an important industry in the world today and its play a big role in development of the country. In order to gain profit, the performance of the factory should be in high level. Productivity is one of the ways to measure the performance of the factory. Besides that safety and health is also influencing the productivity because without good safety the employee could not do their job properly. The employee is one of the important assets in manufacturing industry. Although automatic machine be used but its still need employee to run it.

Nowadays, ergonomics play an important role in designing workspace, tools, machines, systems, tasks, jobs and environment for safe, comfortable and effective human use and keeping environment in a safe and systematic way. The practice of ergonomics requires that knowledge about anatomy, physiology and psychology be applied to the design of workspace. Ergonomics also can be known as Humans Factors Engineering (HFE), Human Engineering, Occupational Psychology, Engineering Psychology, and Applied Experimental Psychology.

A major task of the ergonomist is to describe the human at all levels appropriate to the particular system. The goals of ergonomics are to enhance the productivity, increase the safety and health in workplace and increase the employee satisfaction. In measuring system productivity several terms need to be considering such as design of system component, state of the system leading up to the incident, operator's mental and physical workload, work organization and external factors. In

workspace system human error are often factor contributed to performance of the system. In order to maximally benefit of the final product, ergonomics principle must be involved as early as possible in the product design and system rather than performed as a final evaluation after product design.

Successful match of the design are functional efficiency, ease of use, comfort, health and safety and quality of working life. The ergonomic approach is to consider all relevant criteria not simply to design for one criterion at expense of others. Fitting the job to worker involves consideration of health and quality of working life just as much as of productivity, efficiency and quality of performance due to influencing of product, user and task itself.

Without considering ergonomics principle the workplace design may produce several injuries to the employee. Most common ergonomics Hazards are Musculoskeletal Disorder (MSDs) and Cumulative Trauma Disorder (CTSs). Sign or symptom can be happen such as Painful aching joints and muscles, Back pain, tingling or numbness, fingers or toes turning white, shooting or stabbing pains, swelling or inflammation, stiffness or difficulty moving, buring sensation and pain during the night.

This project will be covered about ergonomics concept and principle in order to design the better performance, safety and health workspace. The anthropometry data will be used in colleting the data. The recommend will be suggested according to the problem occur at the selected department at the Manufacturing industry.

1.2 Problem Statement

The process is a manual operation and very human dependent. Therefore, the design of workspace that considers every aspect of people movement, sitting, standing, height of work surface and the interaction between workers and workstation such as computer or machine is very important and critical. Safety and health and surrounding environment is a very important factor influence the

performance of the operation at the manufacturing industry and should be fully considered in the workspace design. Workers have to do the repetitive work and do the task in same posture of body for long period time.

1.3 Project Objective

1. To analyze the current workspace problem in the manufacturing floor.
2. To recommend better design of workspace for better performance, safety and health.
3. To implement the new design of workspace at the selected area.

1.4 Scope of the project

1. A study on ergonomics concept and principles to improve a workspace design at selected area in the manufacturing industry.
2. Focusing to one section of the workspace.
3. Study for 1 shift working operation.
4. Design improvement in term of seating, height of work surface and environment factors that contribute to the workspace.
5. To collect various manufacturing data and use for improvement activity.
6. Analyze the current workspace and redesign the workspace by utilizing manufacturing data and ergonomics concept.
7. Using Anthropometry data of the worker at the selected workspace to redesign the workspace.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In our everyday experience all sorts of physical equipment and facilities have been uses, many of which identified are not suitable because of the design features. In manufacturing industry it involve many workers to run the operation and the equipment provided by factory sometimes not really suitable for workers such as chair, table, glove and goggle. All this aspect effect the comfortable of the worker at the workspace and it also will affect the performance of the process operation. Workplace play important role in every work, it including of design of tool, design of product, equipment and object being handle. For making the performance, safety and health at workspace in good condition several factors need to be considered such as ergonomics concept. Work involves the use of tools where ergonomics is concerned with the design and extension with the design of artifacts and environments for human use in general.

Ergonomics defined by International Ergonomics Association as scientific disciple concerned with the understanding of interactions among humans and other elements of a system and profession that applies theory, principles, data and method to design in order to optimize human well-being and overall system performance [5]. Many studies about ergonomics have been done by researcher and scientist. The objectives of the study are focusing on human being and interaction with products, equipment, facilities, procedures and environments used in work and everyday living. The emphasis is on human being and how the designs of things influence

people. In engineering field it more emphasis on strictly technical engineering aspects.

Example of previous study of ergonomics is about work related Musculoskeletal Disorder (MSDs), Ergonomics risk to health care workers by Alison G.Vredenburgh and Ilene B.Zackowitz. The objectives of the study are to find the most prevalent type of injuries susceptible to musculoskeletal disorder injuries, what are the most prevalent types of injuries sustained by healthcare worker and which types of healthcare tasks are most likely to produce work related musculoskeletal disorder (WMSDs). This study has carried out some recommendation to the problem identified early of the study. Second example is about ergonomics solutions in electric energy generation by Thomas G.Barracca, Manager, Research & Development, Kesypan Energy. This research is focusing on the equipment use in the industry and making decision which equipment is most suitable to be used.

Research of designing workplace for better performance, safety and health is focusing on ergonomics concept in the designing. Objectives of this study is to analyze the current workplace problem in manufacturing industry, in term of productivity, safety and health and the utilization of the workplace in the ergonomics views. Better design of workplace will be recommended at the end of this study according to problem identified at the selected department in manufacturing industry.

2.2 Workspace Definition

Workspace means space the worker need to do the task. Workspace involves workers, tools, equipment and work environment. The workspace design needs to improve the fit between human and machines and environments. All there characters enhance of increasing production and efficiency of the operation and decreased injury rates for the human operator. There are no exactly formula can be used to measure the successfulness of the design but the general guidelines can be used before design the workspace and prevent the designing from being not optimal.

2.2.1 Principle of Workspace Design

2.2.1.1 Clearance requirement of the largest users

Clearance problem such as the space between and around equipment, the height and weight of passageways and the dimensions provided for the knees, elbow, feet and head are important issues in workspace design. Some worker may not be able to access certain work areas without good clearance. Clearance dimension are lower limit dimension and should be adequate for the largest user, typically 95% who are planning to use the workspace. When design the lower limit dimensions it does not mean male data should used all the time because for female worker workplace, female data should be used. In case for mixed sex workspace the consideration of male and female data should be used [2].

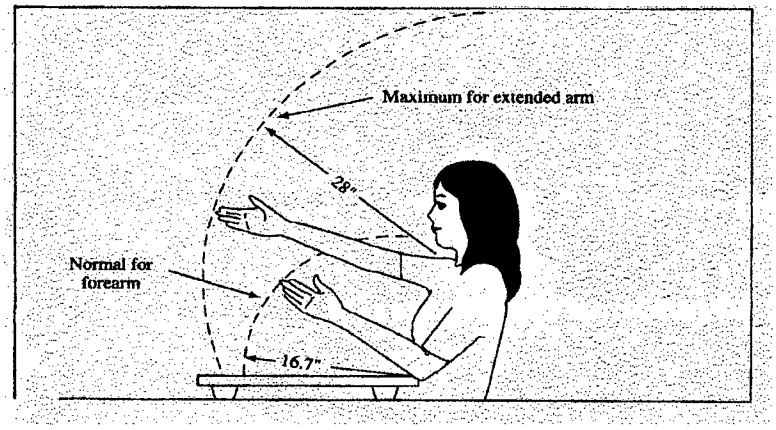

Figure 2.1: Normal and maximum working areas in the vertical plane.

Figure 2.1 show the normal and maximum working area in the vertical plane for women worker. (All units in inch)

2.2.1.2 Reach requirements of the smallest users

Workspace did not only for certain people, it use for variety of worker so the workspace should be able suitable for those who maybe small compare to the other worker. Workers often need to extend arms to reach and operate a hand operated

device or to use their feet to actives a foot pedal. Reach dimensions should be determined on the basis of the reach capabilities of the smallest users typically 5^{th}-percentile. An important concept is to reach area which is the 3-D space in front of a person that can be reaching without leaning forward or stretching. Object that must be reached frequently should be located within the reach area and as close to the body as possible. If the objects have different sizes and weight, large and heavy ones should be placed closer to the front of the worker.

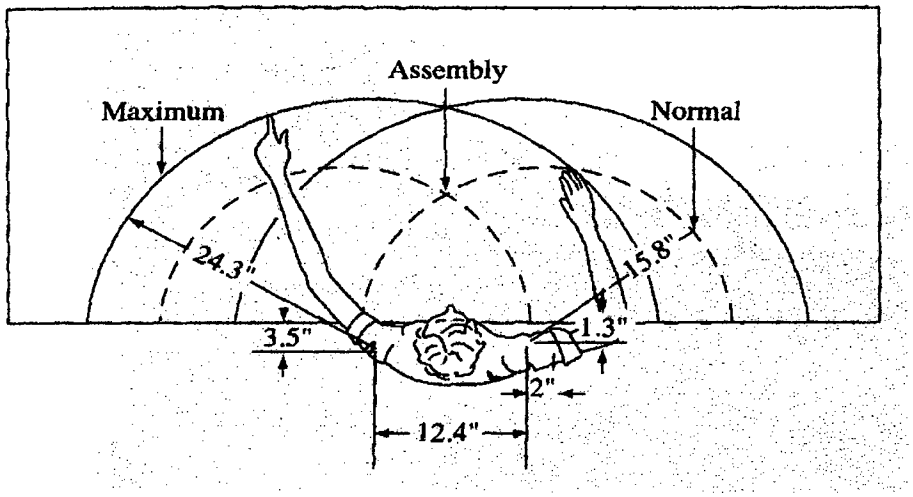

Figure 2.2: Normal and maximum working areas in the horizontal plane

Figure 2.2 show the maximum working areas in the horizontal plane for women. (All unit in inch)

2.2.1.3 Special requirement of maintenance people

A well design workspace should consider not only the regular functions of the workspace and workers who work there but also the maintenance need and special requirement of maintenance personnel [2]. The workspace need to consider this because without proper space for maintenance it will disturb worker area and hard for maintenance to do the job. Regular workers and maintenance people often have different needs an adjustable workspace becomes particularly desirable.

2.2.1.4 Adjustability requirement

In order to make workspace comfort adjustment mechanisms should be easy to use, otherwise worker are often intimidated by the complexity of the adjustment method and refuse to used. Several term used in adjustability requirement is adjusting the workspace which means the shape, location and orientation of the workspace may be adjusted to achieve a good fit between worker and the task. Second one is adjusting the worker position relative to the workspace which means when workspace adjustment are not feasible because worker conflict with the requirement of other vital equipment or services or because of exceed budget constraint. Third is adjusting the work piece which means lift table or forklift truck can be used to adjust the height of a workspace. Device can be used such as jigs, clamp or other related devices. Lastly is adjusting the tool which means tool that used by worker can be adjust according to their need.

2.2.1.5 Visibility and normal line of sight

The visual display in the workspace can be easily seen and read by worker. The eye should at proper positions with respect to viewing requirement. The normal line sight is the preferred direction of gaze when eyes are at condition. It is consider being about 10° to 15° below the horizontal plane.

2.2.1.6 Component arrangement

In workspace design component arrangement really play significant role. The component should be considered is the frequency of use principle, the most frequently used component need to place in the most convenient location. Important principle means that the components that are more crucial to the achievement of system goals should be located in the convenient location. It depending on the levels of important for a specific application, display and controls can be prioritized as primary and secondary. Third is sequence of use principle, component used in sequence should be located next to each other and should reflect the sequence of

operation. Fourth is consistency principle where the component be laid out with the same component located in the same spatial location to minimize memory and search requirement. The last one is control display capability principle of collocation which means the control devices should be close to associated display and in the case of multiple controls and display the layout of controls should reflect the layout of displays to make visible the control display relationship.

2.2.1.7 Determine work surface height by elbow height

The work surface height whether the worker is seated or standing should be determined by a comfortable working posture for the workers. Upper arms are hanging down naturally and the elbow is flexed at 90 degrees so that the forearms are parallel to the workspace surface. If the work surface is too high it will lead to shoulder fatigue and if the work surface too low the neck and back is flexed forward and lead to back fatigue.

2.2.1.8 Adjust the work surface height based on the task performed

Adjustability is the important things in designing workplace. If we refer to first point state above, the workspace surface height should similar with height of elbow at 90 degree but for rough assembly involving the lifting of heavy parts it is more advantages to lower surface by as much 20cm to take advantages of the stronger trunk muscles [8].

2.2.1.9 Provide a comfortable chair for the seated worker

Comfort is very individual response, strict principle for good seating are somewhat difficult to define. When standing erect the lumbar portion of spine curves naturally inward which is termed lordosis but when seat the pelvis rotates backward, flattening the lordotic curve and increasing the pressure on the disks in the vertebral colum. In order to overcome this situation lumbar support need to provide in the form of an outward bulge in the seat back.

A second consideration is providing easy adjustability for specific seat parameters. With adjustability function, the height of the seat can be adjusted by workers according to the task performed and comfortable. A seat that too high will uncomfortably compress the underside of the thighs and a seat that is too low will raise the knees uncomfortably high and decrease trunk angle and lead to disk pressure.

2.2.1.10 Encourage postural flexibility

The human body is not designed for long periods of sitting or standing. The work surface height should be adjustable so that the work can be performed efficiently either sitting or standing. The sit/stand stool can be used in order to provide easier to worker to change postures. The stool needs to have height adjustability and a large base of support so that the stool does not tip.

Standing for extended periods of time on a cement floor is fatiguing. Anti fatigue mats should be provided to the standing workers. The mat allow small muscle contractions in the leg, forcing the blood to move and keeping from tending to pool in the lower extremities [9].

2.2.1.11 Locate all tools and materials

Location of tools and material play significant role in productivity of the operation. In every motion a distance is involved. The greater the distance the larger the muscular effort, control and time. Minimize the distance is very important in order to prevent muscular effort and maximize the productivity of the operation. The normal working area in the horizontal plane of the right hand includes the area circumscribed by the arm below the elbow when it is moved in an arc pivoted at the elbow. The normal area of the left hand may be similarly established. The normal working area represents the most convenient zone within which motions may be made by hand with a normal expenditure of energy [9]. The normal working area also applies to the vertical plane and the concept of area determination is same as on horizontal plane.

Beside that, fix location for all tools and materials to permit the best sequence of the operation. With fix location of tools and materials able to minimize time required to search and select the object needed to do the work so the movement can be reduced and productivity can be increased.

2.2.1.12 Design of seating workspace

Seating is the one method that can be used in designing the workspace. Seating method can be applied according to the type of work done by the workers. Seated workspace should be used for long term duration jobs because a seated posture is much easier to maintain and much less of a strain to the body. The purpose of a seat is to provide stable bodily support in a posture that is for comfortable over a period of time, physiologically satisfactory and appropriate to the task or activity in the workspace. Comfortable is a main purpose in seating design which it will influence the task or activity that the workers are engaged while sitting. Main factors to be consider in design the seat are seat characteristic, user characteristic and task characteristic.

For seat characteristic, the term should be considered are seat dimension, seat angles, seat profile, stability and support and upholstery. These characteristic will influence the posture that will or can be adopted and the areas which provide support for the trunk, shoulders, head and lower body. Without considering these terms the sitting posture will affect the muscle of workers who sitting on chair. For user characteristic the factor should consider are body dimension, body aches and pains and circulation of the workers. For task characteristic the term should be consider are task duration, visual demand, physical demand and mental demand.

The visual and physical demands of the task have a strong influence on the posture which has to be adopted so the task demands influence the seat characteristics which are appropriate to provide support while performing the task. Task duration is a very important factor because physiological responses stated that when the time increasing the discomfort perceived. In order to properly assess to comfort of the seat, it is a necessary to sit in it for a period. A comparison between

seats to rank in order of comfort or discomfort can properly be made very quickly, within a few minutes [7]. Sitting for long periods is never healthy. If circulation is impeded and blood flow slowed by sitting in cramped condition over a long period of time, it will affect the lower legs.

2.3 Anthropometric aspects of seat design

Anthropometry concept need to be fully consider in the seat design because without considering these concept the objective of seating cannot be achieved. The target of using anthropometry data is because of the accuracy of user satisfaction. The design is according to the person who involve in the particular workspace and with this concept the when satisfaction guarantee, the productivity can be increasing. Figure 2.3 show the part of the human body that use in anthropometry data.

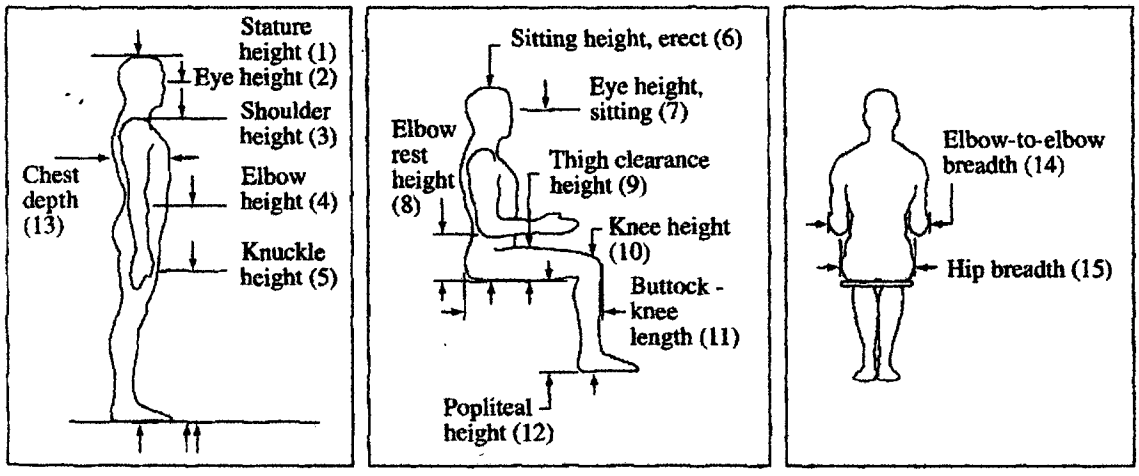

Figure 2.3: Selected body dimensions

Table 2.1: Definition terms of the selected body dimensions

1. Statute (Height)	2. Eye height	3. Shoulder height	4. Elbow height
5. Knuckle height	6. Height, sitting	7. Eye height, sitting	8. Elbow rest height, sitting
9. Thigh clearance height	10.Knee height, sitting	11. Buttock-knee distance, sitting	12. Popliteal height, sitting
13. Chest depth	14. Elbow-elbow breadth	15. Hip breadth, sitting	

Table 2.2 shows the definition each part of the body dimension that using in anthropometry data.

2.3.1 Seat Height

The height of the seat increases beyond height of the user, pressure will be felt on the underside of the thighs. When the height decrease the user will tend to flex the spine more due to the need to achieve an acute angle between thigh and trunk, experience greater problems in standing up and sitting down due to distance through which the center of gravity moved and required greater leg room. The most important things are the seat height is appropriate to the table or work surface height in order to minimize shoulder fatigue and back pain.

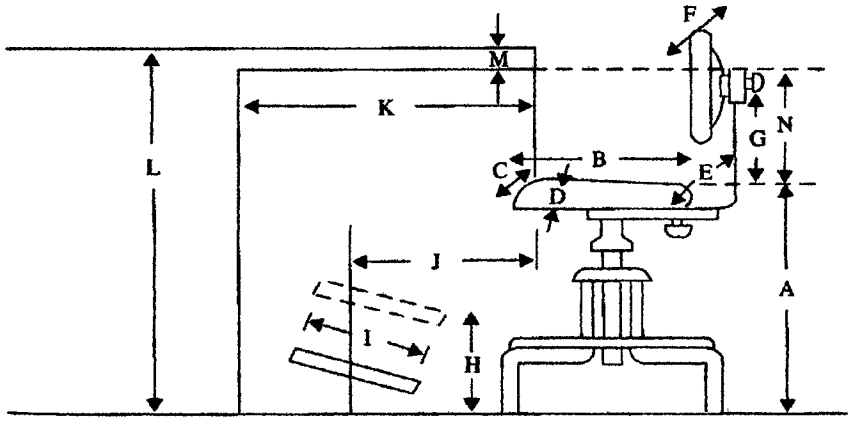

Figure 2.4: Seat parameter values

Figure 2.4 show the parameter should be consider in designing a seat. The definitions of each term are:

1. A- Seat height
2. B- Seat depth

3. C- Seat pan angle
4. D - Seat pan angle
5. E – Seat back to pan angle
6. F – Seat back width
7. G- Lumbar support
8. H- Footrest height
9. I- Foot rest depth
10. J- Footrest distance
11. K- Leg clearance

2.3.2 Seat Depth

If the depth is increased beyond the user length, the user will not be able to engage the backrest effectively without unacceptable pressure on the backs of the knees or leaning back without proper lower back support.

2.3.3 Seat Width

In order to support the user in comfort, a width of that is some 25mm less on either side than the maximum breadth of the hips [7]. If there are armrests or sides to the seat, the clearance between these must be adequate for the largest user.

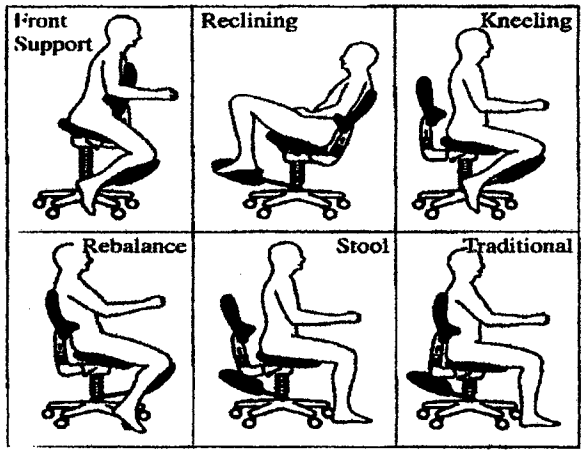

Figure 2.5: Basic seating posture

Figure 2.5 shows the six basic seating postures. Each posture gives difference affect to the body.