SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I declared that this dissertation entitled "Improvement of Office Chair for Ergonomics Purpose" is the result of my own research except as cited in the references. The dissertation has not been accepted for any degree and is not currently submitted in candidature of any other degree.

Signature : ……..
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Date :

To my beloved mother and father,

Mrs. Noor Hayati Binti Mohad Yazid
Mr. Mohd Yuden Bin Zakaria

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ABSTRACT

Ergonomic is the application of scientific principles, methods and data to the development of products and systems that interact with human. A product may be ergonomically designed for a specific application. The product selected must be matched the characteristics of the required operations and the characteristics of the people who use the products. Correct sitting posture is an important factor for the prevention of musculoskeletal symptoms. Then, ergonomic furniture should be designed because it can reduce pain and injury, increase productivity, improve morale and decrease complaints. Office chair has been one of the most required furniture for over hundreds of years especially for office use. However, as the increasing of the demand to produce the office chair, there are several problems commonly occur to clerk. So, the main objectives of this project are to improve the design of office chair with ergonomic features for the office use and to minimize the risk factor of musculoskeletal disorders faced by the clerk. At the end of this project, a new design of office is proposed by using Solid Work software. There are some improvements have been made to the some parts of existence office chair including back support, seat pan, armrest and seat height. The proposed design is different in terms of shape, measurement and also equipped with the ergonomic features. As the result of this improvement, the objective to reduce disorders faced by the clerk can be achieved.

ABSTRAK

Ergonomik adalah satu aplikasi tentang prinsip sains, kaedah dan data untuk mengeksploitasi sesuatu bahan dan sistem yang berkait dengan manusia. Sesuatu bahan yang direkabentuk mungkin mempunyai satu applikasi yang khusus. Bahan yang dipilih tersebut haruslah setara dengan ciri-ciri yang diperlukan dalam sesuatu operasi dan juga sesuai dengan ciri-ciri orang yang menggunakannya. Membetulkan kedudukan badan ketika duduk adalah satu faktor penting untuk mengelakkan kecederaan. Oleh sebab itu, peralatan perabot haruslah direkabentuk supaya ia mempunyai ciri-ciri ergonomik kerana ia dapat mengurangkan sakit dan kecedreaan kepada pengguna, meningkatkan hasil pengeluaran, membaiki moral dan juga mengurangkan aduan. Seperti yang diketahui, kerusi pejabat adalah salah satu perabot yang paling diperlukan sejak zaman dahulu lagi terutamanya untuk kegunaan pejabat. Walaubagaimanapun, dengan jumlah permintaan yang semakin tinggi terhadap kerusi pejabat, masih wujud beberapa masalah yang dihadapi kerani. Oleh sebab itu, tujuan utama projek ini adalah untuk mengubah rekabentuk kerusi pejabat yang sedia ada seterusnya dapat meminimumkan risiko kecederaan yang dihadapi kerani. Di akhir projek ini, satu rekabentuk kerusi pejabat dicadangkan menggunakan perisian Solid Work. Perubahan telah dilakukan di beberapa bahagian kerusi pejabat termasuklah bahagian belakang, tempat duduk, pengalas lengan dan ketinggian kerusi. Rekabentuk yang dicadangkan ini berbeza dari segi bentuk, ukuran dan juga dilengkapi ciri-ciri ergonomik. Hasil daripada perubahan ini, tujuan untuk mengurangkan ketidakselesaan yang dihadapi kerani dapat dicapai.

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LIST OF ABBREVIATIONS

MSD	Musculoskeletal disorders
WMSDs	Work-related musculoskeletal disorders
CTDs	Cumulative trauma disorders
RSI	Repetitive strain injury

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is discussing about the project overview, project background, project problem statement, project objectives and project scopes.

1.2 Project Overview

Ergonomics is a scientific discipline, which is concerned with improving the productivity, health, safety and comfort of people, as well as promoting effective interaction between people, technology they are using and the environment in which both must operate.

A product may be ergonomically designed for a specific application. The product selected must be matched the characteristics of the required operations and the characteristics of the people who use the products. Some products are designed to specifically reduce risk factor. There are some major risk factors include repetition, awkward posture, force exertion, static posture, mechanical contact stress, temperature and vibration.

There are part of a broad category of injuries and disorders called Musculoskeletal Disorders (MSDs). Musculoskeletal Disorders are not usually caused

by acute trauma, but occur slowly over time due to repetitive injuries to the soft tissues such as muscles, tendons, ligaments, joints, cartilage and nervous system. Musculoskeletal Disorders can happen to anyone from office workers and industrial employees to athletes and hobbyists. Work-Related Musculoskeletal Disorders (WMSDs) are Musculoskeletal Disorders that are caused or made worse by work methods and environment. It does occur when the physical capabilities of the worker do not match the physical requirements of the job.

Departments are encouraged to purchase adjustable equipment for the reasonable accommodation of users. Some users may have special needs, such as left-handedness, color blindness and vision impairment. The goal should be flexibility to accommodate the user population so that personnel may interface effectively with equipment. Equipment should be sized to fit the individual user.

Ergonomic furniture should be designed to facilitate task performance, minimize fatigue and injury by fitting equipment to the body size, strength and range of motion of the user. Office furnishings, which are generally available, have adjustable components that enable the user to modify the workstation to accommodate different physical dimensions and the requirements of the job. Ergonomically designed furniture can reduce pain and injury, increase productivity, improve morale, and decrease complaints.

Chair design considers intended usage, ergonomics how comfortable it is for the occupant, as well as non-ergonomic functional requirements such as size, stack ability, fold ability, weight, durability, stain resistance and artistic design. Intended usage determines the desired seating position.

1.3 Project Background

Office chair has been one of the most required furniture for over hundreds of years. In Malaysia, the demand for the office chair is certainly very high. This is because, every companies especially big companies use the office chair every day at their office to comfort the workers.

Office chair is one of important furniture design that cause people especially who are work in the office feel uncomfortable after prolong sit. Each parts of office chair should be designed properly so that it can have more ergonomics characteristics to ensure the user get a good posture. It also can assist the user to minimize fatigue and injury by fitting the chairs to the body size, strength and range of movement. Correct sitting posture is an important factor for the prevention of musculoskeletal symptoms.

Nowadays in the market there are many resources that can produce the office chair in various shapes, sizes and types. However, as the increasing of the demand to produce the office chair, there are several problems commonly occur to the office chair that has been produced such as measurement of the seat height, width and depth, shape of lumbar support and backrest, seat material and finally type of chair either it can adjustable or not. The problems occurred then will affect to the user. As the office worker has to sit on the office chair for a long time before take rest, there will high probability for the workers fill uncomfortable and easy to get injuries during sits.

As the objectives of the ergonomics are to enhance performance, increase safety and increase user satisfaction, the problems occurred to the office chair should be analyzed and identified first. Then, the new design of ergonomics office chair is decided to overcome the existence problem.

1.4 Project Problem Statement

From the previous project background, there are many consideration should be cautioned to design and produce an office chair that have ergonomics characteristic. Sits for prolong period will cause problems occur to the user.

First of the main problem which generally occur are back pain and fatigue because of poor back support and inappropriate postures. For example, an office chair without a suitable or adjustable backrest will not provide adequate lumbar support or help maintain the natural S-shape curvature of the spine. No supported at the neck also will make the area of this human body feel little bit of fatigue.

Awkward posture at the arm also is one the problem for the user because of armrests that are not adjustable, or those that have not been properly adjusted. Armrests that are made of hard materials or that have sharp corners can irritate the nerves and blood vessels located in the forearm. This irritation can create pain or tingling in the fingers, hand and arm.

Using an office chair with a seat that is too high may force the user to work with their feet unsupported or encourage them to move forward to a point where their back is unsupported making it more difficult to maintain the S-shape of the spine. These awkward postures can lead to fatigue, restricted circulation, swelling, numbness and pain especially at the user knee.

Finally, an inappropriately sized seat pan can be uncomfortable, provide inadequate support to the legs and restrict movement. One that is too short can place excess pressure on the buttocks of taller users and one that is too long can place excess pressure on the knee area of shorter users then will minimize back support. One that is too small can restrict movement and provide inadequate support. Prolonged use can restrict blood flow to the legs and create irritation and pain.

1.5 Project Objectives

i. To improve the design of office chair (clerk) with ergonomic features for the office use.
ii. To minimize risk factor of musculoskeletal disorders of the clerk.

1.6 Project Scopes

i. Investigation and identification on office chair that are used by the clerk in Universiti Malaysia Pahang.
ii. Identification of type of musculoskeletal disorders faced by the clerk.
iii. Measurement of office chair size and human body dimension.

CHAPTER 2

OVERVIEW OF OFFICE CHAIR

2.1 Introduction

This chapter will explain about the previous design and concept of office chair for the ergonomics purpose. It also gives information about the design of office chair which help the designer especially engineer to improve and develop the new one. Office chair that has been produced should have all the ergonomics characteristics to satisfy the user and also minimize the problem occur.

2.2 History of Chair

A chair is a kind of furniture for sitting, consisting of a back, and sometimes arm rests, commonly for use by one person. Chairs also often have four legs to support the seat raised above the floor. Chairs as furniture typically can be moved. The back often does not extend all the way to the seat to allow for ventilation. Likewise, the back and sometimes the seat are made of porous materials or have holes drilled in them for decoration and ventilation. The back may extend above the height of the head. There may be separate headrests.

Figure 2.1: Early Twentieth Century Chair

The 20th century saw an increasing use of technology in chair construction with such things as shown in Figure 2.1 as all metal folding chairs, metal-legged chairs, the slumber chair, molded plastic chairs and ergonomic chairs. The recliner became a popular form, at least in part due to radio and television, and later a two part. The modern movement of the 1960s produced new forms of chairs, the butterfly chair, bean bags, and the egg shaped pod chair. Technological advances led to molded plywood and wood laminate chairs, as well as chairs made of leather or polymers. Mechanical technology incorporated into the chair enabled adjustable chairs, especially for office use [19].

2.3 Musculoskeletal Disorders

Musculoskeletal disorders affect the bones and muscles of the body and the tissues that form the body joints [6]. There are two categories of disorders, based on the type of event that caused it:

i. Conditions caused by an acute trauma, such as a slip or fall resulting in, for example, a strained back, bruised leg or sprained ankle
ii. Conditions due to exposure to a repeated or chronic, type of physical activity, resulting in, for example, soreness from inflamed tendons or ligaments.

Conditions associated with repeated exposure to physical activity are called cumulative trauma disorders (CTDs). Repetitive strain injury (RSI) is another term for a cumulative trauma disorder specifically related to repetitive tasks.

Someone also consider low back pain a type of CTD, if a single acute cause cannot be identified. CTDs can result from, be precipitated by, or be aggravated by intense, repeated, sustained or insufficient recovery from exertion, motions of the body, vibration or cold. CTDs generally develop over periods of weeks, months and years. Physical activity risk factors related to CTD's include:

i. **Application of force**. Higher forces translate into higher loads on the muscles, tendons and joints which can quickly lead to muscular fatigue
ii. **Repetitive motion**. This is defined as performing the same motion every 30 seconds or less or where 50% of the work cycle involves similar upper extremity motion patterns.
iii. **Awkward posture**. An awkward posture requires more muscular force because muscles cannot work as effectively.
iv. **Contact stress**. Tools, objects or equipment that creates pressure against the body (usually the hands and arms) can inhibit nerve function and blood flow.
v. **Overall muscular fatigue**. Insufficient recovery time between muscular contractions may lead to overall muscular fatigue [13].

The magnitude of risk associated with specific quantity of exposure of these factors is not well defined, but there is consensus that exposure to high levels or combinations of these risk factors increase the risk of the CTD's [17].

2.4 Anthropometric Measurements

Actual chair dimensions are determined by measurements of the human body or anthropometric measurements. The two most relevant anthropometric measurements for chair design is the popliteal height and buttock popliteal length.

For someone seated, the popliteal height is the distance from the underside of the foot to the underside of the thigh at the knees. It is sometimes called the stool height. The term sitting height is reserved for the height to the top of the head when seated. The popliteal height, after adjusting for heels, clothing and other issues is used to determine the height of the chair seat.

For someone seated, the buttock popliteal length is the horizontal distance from the back most part of the buttocks to the back of the lower leg. This anthropometric measurement is used to determine the seat depth. Mass produced chairs are typically 38-43 cm deep.

Additional anthropometric measurements may be relevant to designing a chair. Hip breadth is used for chair width and armrest width. Elbow rest height is used to determine the height of the armrests. The buttock-knee length is used to determine leg room between rows of chairs. Seat pitch is the distance between rows of seats. For adjustable chairs, such as an office chair, the aforementioned principles are applied in adjusting the chair to the individual occupant.

2.4.1 Body Size

Anthropometrics, measures of the human body, have collected body size data for many years. The term anthropometry is derived from two Greek words: antropo(s), or human, and metricos, or measurement. Anthropometry is used widely by ergonomists to design tools, equipment, plants, manufacturing lines, clothes, shoes and the like to ensure the proper fit to the person. Therefore, to achieve proper fit, it is important to have details on the dimensions of the appropriate body part.

Two primary categories of anthropometric data interest ergonomics:

i. Structural anthropometry also referred to as static anthropometry or static dimensions. These are measurements with the body in a still or fixed position; for example, stature or height, weight, head circumference.

ii. Functional also referred to as dynamic anthropometry or dynamic dimensions. These are measured with the body engaged in various work postures, indicating the ranges of motion of individual body segment; for example, arm reach.

It is important to point out that static anthropometry data are often measured on unclothed (nude) individuals, mainly to ensure consistent results. Therefore, corrections must be made to account for increase in body size due to clothing. In addition, allowances must be made for wearing safety shoes and hard hats which could add about 10-12cm (4-5in) to the stature that must be considered in the design [6].

2.4.2 Body Size Variability

The various genetic, biological and physiological differences between humans influence the way they vary with respect to body dimensions in term of height, weight, shape and the like. Therefore, anthropometric data should be used carefully if in case the human influence is to be of value [14] [15].

In ergonomics the common practice is to specify anthropometric data in terms of percentiles. A percentile refers to a percentage of the population with a body dimension up to a certain size or smaller.

When a particular design is expected to be used by many people, variables in influencing body size and adjust the design should be followed accordingly:

i. **Gender**. Men are generally larger than women at most percentiles and body dimensions. The extent of the difference varies from one dimension to another. Women, in general exceed men in five dimensions: chest depth, hip breadth and circumference, thigh circumferences and skin fold thickness [8].

ii. **Age**. Bodies dimensions generally increase from birth to early twenties, remain constant to around age 40 and decline afterward into old age as part of the

normal aging process. For example, stature or height reaches full growth at around age 20 for males and 17 for females [18]. Decline in stature is more pronounced in women than in men. Therefore, it is important to define the user population early in the design cycle.

iii. **Body position**. Posture affects body size. For example, restraints such as seat belts, affect data applicability of forward reach.

iv. **Clothing**. Almost all anthropometric data are obtained from nude individuals. Therefore, the type (material) and amount of clothing add to body size and can also create restriction of movement such as affecting overhead and forward reach. Another example is the use of gloves where allowances must be made to accommodate different thicknesses of gloves.

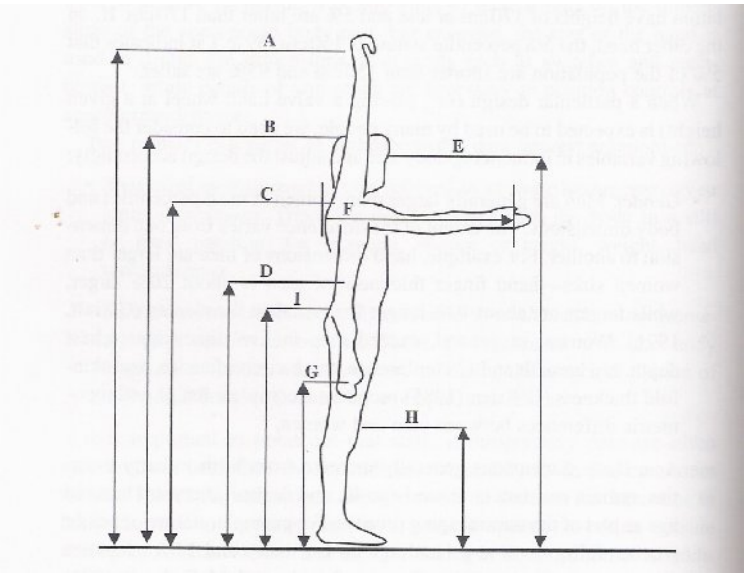

Figure 2.2: Anthropometry Figure to Guide Table 2.1

Figure 2.2 shows the human parts of body that are related with condition during seat. It is important to analyse the measurement of human body to fix to the chair.

Table 2.1: Selected Anthropometry Data for 2 Different Regions in Centimeters (cm)

Anthropometric Dimensions	America		Asia	
	95th% Man	5th% Woman	95th% Man	5th% Woman
	Centimeters (cm)			
A. Vertical reach	217.5	177.8	207.5	168.0
B. Head height	184.4	149.5	175.0	145.0
C. Shoulder height	152.4	121.1	143.0	170.5
D. Elbow height	119.0	93.7	110.5	89.5
E. Eye height	172.7	138.2	163.5	135.0
F. Forward reach	88.3	64.0	75.0	57.0
G. Knuckle height	80.5	64.3	80.5	65.0
H. Knee height	59.2	45.2	53.0	42.0
I. Waist height	110.5	86.4	89.5	70.0

Table 2.1 shows that there are different human body dimensions between two regions, America and Asia. Note that, this table is related to the Figure 2.2.

2.4.3 Anthropometric Aspects of Seat Design

The design factors influencing the major dimensions of seat are discussed as in the following sections:

2.4.3.1 Seat Height

As the height of the seat increases beyond the popliteal height of the user, pressure will be felt on the underside of the thighs. The resulting reduction of circulation to the lower extremities may lead to 'pins and needles', swollen feet and considerable discomfort. As the height decreases, the user will

i. Tend to flex the spine more (due to the need to achieve an acute angle between thigh and trunk)

ii. Experience greater problems in standing up and sitting down, due to the distance through which his or her centre of gravity must move
iii. Require greater leg room

In general, therefore, the optimum seat height for many purposes is close to the popliteal height and where this cannot achieved a seat that is too low is preferable to one that is too high. For many purposes, therefore, the 5th percentile female popliteal height (380 to 400 mm depending on style of shoes worn) represents the best compromises. If it is necessary to make a seat higher than this, the ill effects may be mitigated by shortening the seat and rounding off its front edge in order to minimize the under thigh pressure. If it is overriding importance that the height of a seat should be appropriate to that of its associated desk or table.

2.4.3.2 Seat Depth

If the depth is increased beyond the buttock politeal length (which for a 5th percentile woman is 435 mm), 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. Furthermore, the deeper the seat, the greater the problems of standing up and sitting down. The lower limit of the seat depth is less easy to define. As little as 300 mm will still support the ischial tuberosities and may well be satisfactory in some circumstances. Tall people sometimes complain that the seats of easy chairs are too short; and inadequate backrest may well be to blame.

2.4.3.3 Seat Width

For the purpose of support, a width that is some 25 mm less on either side than the maximum breath of the hips is all that is required, hence 385 mm will be adequate. However, if there are armrests or sides to the seats, the clearance between these must be adequate for the largest user. The hip breadth of the 95th percentile woman unclothed is

435 mm. In practice, allowing for clothing and leeway, a minimum clearance of 500 mm is required.

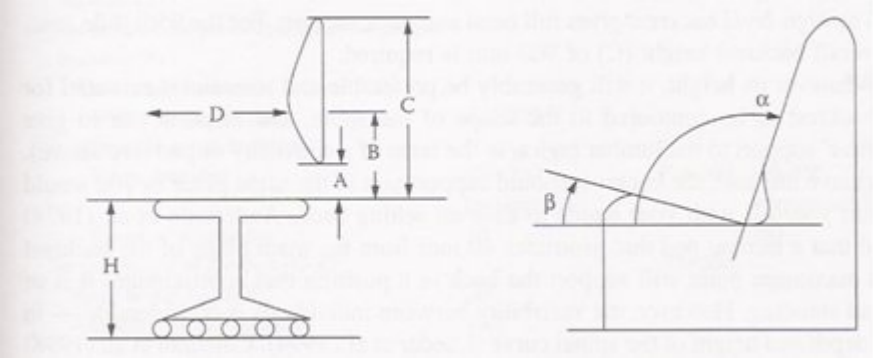

Figure 2.3: Seat Dimensions

2.4.3.4 Backrest Dimensions

The higher the backrest, the more effective it will be in supporting the weight of the trunk. There are three varieties of backrest including low level backrest, medium level backrest and high level backrest.

The low level backrest provides for support the lumbar lower thoracic region only and finishes below the level of the shoulder and arms. To support the lower back and leave the shoulder regions free, an overall backrest height of about 400 mm is required where this should be measured from the compressed seat surface.

The medium level backrest also supports the upper back and shoulder regions. For support to mid thoracic level, an overall backrest height of about 500 mm is required and for full shoulder support about 950 mm.

The high level backrest gives full head and neck support. For the 95th percentile man, an overall backrest of 90 mm is required.

Whatever its height, it will generally be preferable and sometimes essential for the backrest to be contoured to the shape of the spine and in particular to give positive support to the lumbar region. A lumbar pad that protrudes 40 mm from the main plane of the backrest at its maximum point will support the back in a position that approximates that of normal standing [1]. There are preferences for the position of lumbar support on office chair and that mean preferred height was 190 mm above the compressed seat surface and the mean preferred depth from the front of the seat was 387 mm [4].

To use the lumbar support to its full advantage, it is necessary to provide clearance for the buttocks. Similarly in high backrest, it is important to leave free shoulder space. If the contour of the back rest is too far forward in the scapular region, it is no longer possible to gain advantage from support in the lumbar region [9].

2.4.3.5 Backrest Angle or 'Rake' (α)

As the back angle increases, a greater proportion of the weight of the trunk is supported. Hence the compressive force between the trunk and pelvis is diminished. Furthermore, increasing the angle between trunk and thighs improves lordosis. However, the horizontal component of the compressive force increases with the backrest angle. This will tend to drive the buttocks forward out of the seat unless counteracted by an adequate seat tilt, high friction upholstery and muscular effort from the sitter.

2.4.3.6 Seat Angle or 'Tilt' (β)

A positive seat angle (backwards tilt) helps the user maintain good contact with the backrest and helps counteract any tendency to slide out of the seat. Excessive tilt reduces hip-trunk angle and ease of standing up and sitting down. For most purposes 5 to 10° is a suitable compromise.

2.4.3.7 Armrests

Armrest may give additional postural support and be an aid to standing up and sitting down. The latter is particularly important for elderly people and for pregnancy women. By using armrest, pregnant women can maintain the body stability and less forward leaning posture when sitting down or rising from chair [11].

An elbow rest 200 to 250 mm above the seat surface is generally considered suitable. An elbow rest that is somewhat lower than sitting elbow height is probably preferable to one that is higher, if a relaxed posture is to be achieved.

2.4.3.8 Leg Room

If the user is to adopt a satisfactory posture, the adequate lateral, vertical and forward leg room is essential. Lateral leg room must give clearance for the thighs and knees. In a relaxed position the legs are somewhat separated. A width of 790 mm would be suitable [12].

Vertical leg room requirements will, in some circumstances, be determined by the knee height of a tall user (95^{th} percentile shod man = 620 mm). Alternatively, thigh clearance above the highest seat position may be more relevant (95^{th} percentile man = 185 mm). The vertical surface required adding the 95^{th} percentile male popliteal height shod and thigh thickness is at least 700 mm. Forward leg room is rather more difficult to calculate. At knee level, clearance is determined by buttock-knee length from the back of a fixed seat.

2.4.3.9 Seat Surface

The purpose of shaping or padding the seat surface is to provide an appropriate distribution of pressure beneath the buttocks. The consensus of ergonomics opinion suggests the following:

i. When compressed, most of the seat surface should be more or less flat rather than shaped, although a rounded front edge is highly desirable
ii. Upholstery should be firm rather than soft
iii. Covering materials should be porous for ventilation and rough to aid stability

2.5 Seating

The office chair may be the most important piece of personal furniture. Certainly, it is the piece of furniture with which the sedentary worker has the most contact.

When the human body is changed from a standing to a seated position, the curvature of the spine changes and more pressure knocked on the intervertebral discs [10]. The upright seated posture is difficult to maintain for long periods of time; hence, people who sit on the chair will slump forward. This posture relaxes the back muscles but increases the pressure on the intervertebral disc.

The more angles increased between the body and legs, the less pressure will knock on the disc. If the seat pan is tilted downward in the front to increase the angle, more body weight is taken by the chair, thus reducing muscles stress. So, a seated position that allows an angle of 110-120° between trunk and legs reduces the pressure squeezing our discs and stress on the back muscles.

2.5.1 Fundamentals of Seating

The purpose of a seat is to provide stable bodily support in a posture that is comfortable over a period of time, physiological satisfactory and appropriate to the task or activity in question. Comfort or uncomfortable during sits will depends on the interaction of seat characteristics, user characteristics and task characteristics.

The seat characteristics influence the posture that will or can be adopted and the areas which provide support for the trunk, shoulders, head and lower body. If the body is not adequately supported, the sitter's posture will only be maintained through muscle effort and if the seat profile does not match the sitter's body shape and size, additional pressure may be imposed on soft tissues. A frequent cause of discomfort is a raised or hard edge at the front of a seat, causing pressure on the underside of the thigh and this is exacerbated when the seat is even slightly too high for the user. Muscle effort and localized pressure lead in a relatively short time to physiological responses of muscle fatigue, impeded blood circulation and venous blood pooling resulting in swelling at the ankles and feet.

Task characteristics are equally important [7]; the visual and physical demands of a task have a strong influence on the posture which has to be adopted, so the task demand influence the seat characteristics which are appropriate to provide support while performing the task. For example, if the sitter needs to perform an intricate assembly task, a reclined backrest will be ineffective and the posture tiring. If force must be exerted during the task, the seat must be stable and provide a surface against which the force can be reacted.

Task duration is very important factor. The physiological responses already mentioned will increase with time, as will the discomfort perceived. In order properly assess the comfort or discomfort of a seat, it is necessary to sit in it for a period. However, sitting still for long periods is never healthy. If circulation is impede and