



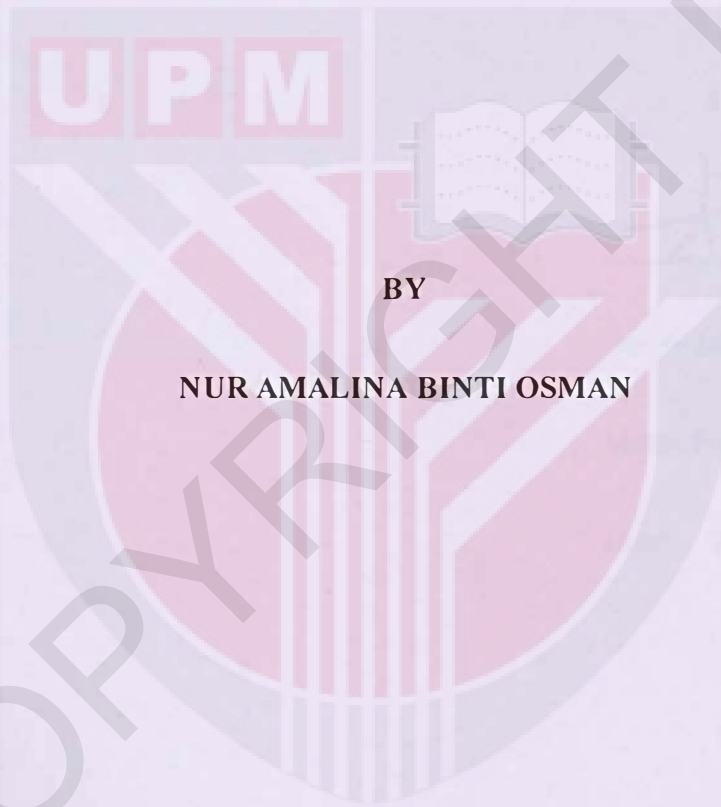
**UNIVERSITI PUTRA MALAYSIA**

***THE EFFECTIVENESS OF ERGONOMIC CHAIR ON DISCOMFORT AND  
BACK MUSCLE ACTIVITY AMONG YOUNG ADULTS***

**NUR AMALINA BINTI OSMAN**

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**THE EFFECTIVENESS OF ERGONOMIC CHAIR ON DISCOMFORT  
AND BACK MUSCLE ACTIVITY AMONG YOUNG ADULTS**



**BY**

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**This thesis submitted in fulfillment of the requirement for the degree of  
Bachelor Science (Environmental and Occupational Health) from the  
Faculty of Medicine and Health Sciences, Universiti Putra Malaysia**

1000714861

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## ABSTRACT

### THE EFFECTIVENESS OF ERGONOMIC CHAIR ON DISCOMFORT AND BACK MUSCLE ACTIVITY AMONG YOUNG ADULTS

NUR AMALINA BINTI OSMAN

**Introduction:** A well-designed office chair provides individual or workers with varieties of anthropometric dimension to perform their job or works in a comfortable office environment. Although there are many 'ergonomic' office chairs in the market, it is quite difficult to purchase a 'genuine' ergonomic chair. Thus, in this study, the two set of ergonomic chair (Chair 1 and Chair 2) were from a local chair company. **Objective:** The general objective of this study is to determine the effectiveness of Chair 1 and Chair 2 compared with a general office chair (Chair 3). **Methodology:** Thirty respondents were participated in this study, all in good physical condition and with no immediate complaint of musculoskeletal disorder. Each respondents was measured their anthropometric dimension (seat height, shoulder height, elbow height, shoulder breadth, hip breadth, popliteal height and buttock-popliteal length while sitting). The chair dimension (seat height, seat depth, seat width and backrest height) was also measured. Each respondent was asked to sit for 90 minutes on each three different type of chair and their muscle activation (erector spinae muscle) while doing few tasks was recorded using electromyography (EMG). At every 30 minutes of interval, respondents were required to rate their discomfort level on the questionnaire of General Comfort Rating (Shackel's scale). At the end of session, respondents required to answer a questionnaire on Ergonomic Seating Evaluation. **Results:** This study shows that there is a mismatch (seat depth, seat width and back rest height) between three chairs and the anthropometric measurement of the respondents. In term of discomfort rating of the chairs, the results highlighted that there is a significant differences between the discomfort rating and the three chairs. It was found that the rate of discomfort level (in all body parts) increases over time during the testing period. The EMG result on muscle activation revealed that there is no significant difference between the three chairs. However the muscle activation for the Chair 1 and Chair 2 are better compared to Chair 3 user. The Ergonomic Design Score indicates that the Chair 3 (64.8%) has the more ergonomic features compared to Chair 1 (64.5%) and Chair 2 (49.6%). **Conclusions:** Overall, it can be concluded that this three office chairs are not truly meet the characteristics of an ergonomic chair. However, each of this chairs have their own superior criteria. Therefore as a recommendation, this chairs need to be redesign to meet the ergonomic features.

Keywords: *Ergonomic, Anthropometric, Mismatch, Discomfort, Electromyography*

## ABSTRAK

### KEBERKESANAN KERUSI ERGONOMIK TERHADAP KETIDAKSELESAAN DAN AKTIVITI OTOT BELAKANGDI KALANGAN ORANG DEWASA

NUR AMALINA BINTI OSMAN

**Pengenalan:** Kerusi pejabat yang direka dengan baik menyediakan individu dengan pelbagai dimensi antropometri untuk melaksanakan tugas atau kerja-kerja dalam persekitaran pejabat yang selesa. Walaupun terdapat banyak kerusi pejabat 'ergonomik' di pasaran, tetapi agak sukar untuk membeli kerusi ergonomik 'tulen'. Dua set kerusi ergonomik (Kerusi 1 dan Kerusi 2) dan satu kerusi biasa telah digunakan. **Objektif:** Objektif kajian adalah untuk menentukan keberkesanan Kerusi 1 dan Kerusi 2 dibanding dengan kerusi biasa. **Kaedah:** 30 orang responden terlibat dalam kajian ini. Kesemuanya di dalam fizikal yang baik. Setiap responden diukur dimensi antropometri (ketinggian tempat duduk, ketinggian bahu, ketinggian siku, bahu lebar, lebar hip, ketinggian popliteal dan punggung-popliteal panjang sambil duduk). Dimensi kerusi (ketinggian tempat duduk, kedalaman tempat duduk, lebar dan ketinggian penyandar kerusi) juga diukur. Setiap responden diminta untuk duduk selama 90 minit pada setiap tiga kerusi dan pengukuran pengaktifan otot (otot spinae ) semasa melakukan tugas telah direkod menggunakan elektromiografi (EMG). Pada setiap 30 minit, responden dikehendaki untuk menilai tahap ketidakselesaan menggunakan soal selidik *General Comfort Rating* (GCR) (skala Shackel). Pada akhir sesi, responden dikehendaki menjawab soal selidik *Ergonomic Seating Evaluation*. **Keputusan:** Ada ketidaksesuaian (kedalaman tempat duduk, lebar tempat duduk dan belakang ketinggian rehat) antara tiga kerusi dan ukuran antropometri responden. Keputusan tahap ketidakselesaan kerusi menekankan bahawa terdapat perbezaan yang signifikan antara tahap ketidakselesaan dan tiga kerusi. Tahap ketidakselesaan (dalam semua bahagian badan) meningkat dari masa ke masa dalam tempoh ujian. Hasil EMG pada pengaktifan otot mengatakan bahawa tidak ada perbezaan yang ketara antara ketiga-tiga kerusi. Kadar pengaktifan otot untuk Kerusi 1 dan Kerusi 2 adalah lebih baik berbanding dengan Kerusi 3. *Ergonomic Seating Evaluation* menunjukkan bahawa Kerusi 3 (64.8%) mempunyai ciri-ciri yang lebih ergonomik berbanding Kerusi 1 (64.5%) dan Kerusi 2 (49.6%). **Kesimpulan:** Secara keseluruhan ketiga-tiga kerusi pejabat ini yang tidak benar-benar memenuhi keseluruhan ciri-ciri kerusi ergonomik. setiap kerusi ini mempunyai kriteria mereka tersendiri. Oleh itu, kerusi perlulah direka bentuk semula untuk memenuhi ciri-ciri ergonomik.

Kata kunci: *Ergonomik, Ukuran Antropometrik, Ketidaksesuaian, Ketidakselesaan, Elektromiografi*

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## LIST OF ABBREVIATIONS

%	Percentage
AEMG	Average Electromyography
BMI	Body Mass Index
BPL	Buttock popliteal length
EDS	Ergonomic Design Score
EH	Elbow height
EMG	Electromyography
HB	Hip Breadth
MSD	Musculoskeletal Disorder
MVC	Maximum Voluntary Contraction
PH	Popliteal Height
RMS	Root Mean Square
SEMG	Surface Electromyography
SH	Shoulder Height
SPSS	Statistical Package for Social Science

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

The word "Ergonomics" comes from two Greek words "ergon," meaning work, and "nomos" meaning "laws". Today, however, the word of ergonomics is defined as the science which seeks to adapt work or working conditions to suit the worker (Peck, 1992).

A well-designed office allows each individual to work comfortably without needing to over-reach, sit or stand too long, or use awkward postures (correct ergonomic design). Sometimes, equipment or furniture changes are the best solution to allow an individual to work comfortably (National Institute for Occupational Safety and Health, 2012).

Finding the right "ergonomic" chair is a common problem especially for people who want to purchase new equipment to make workstations safer and healthier places. There are many "ergonomic" chairs available but it can be a mistake to purchase one simply because it is labeled "ergonomic". Ergonomic chairs are designed to suit a range of people; however, there is no guarantee that they will suit any one person in particular. For example, a chair could be too high and the arm rests too far apart for a short, slim person. In addition, chairs may not suit every task or arrangement at the workstation. A chair becomes ergonomic only when it specifically suits a worker's size (body dimensions), his or her particular workstation, and the tasks that must be performed there. It is possible to find the right chair although it is not always easy (Canadian Centre for Occupational Health and Safety, 2005).

Back pain problems have been one of the main reasons for high absenteeism rate in many countries (Saraji et al., 2004). Prolonged seated work positions have been linked to an increased risk of low back pain (Fenety & Walker, 2002). Besides, back pain problem has been a culprit to many occupational safety and health problems. In 2006, more than 1000 cases of back injuries have been reported in Malaysia and none of the cases were promptly solved (Perkeso, 2007). Lack of ergonomics knowledge and interventions in daily activities of the workers as well as excessive manual material handling are among the many factors contributing to study related disorders (Koda and Ohara, 1999; Yeung et al., 2003).

One way to detect fatigue in muscle is using surface electromyography (SEMG). It allows the objective quantification of the energy of muscle. Researcher can study the muscle energy at rest and changing continuously over the course of movement and posture (Cram & Holtz, 1998). Whilst root mean square (RMS) and power spectrum median frequency of the EMG were considered (Schumann et al., 1998). This method is safe, easy, non-invasive and widely used (Aaras & Larsen et al., 1996).

## 1.2 Problem Statement

Long working hours of sitting can cause health problems and occupational disorders, especially disorders of the musculoskeletal system (Landrigan et al., 1991). Low back pain is very common that almost half of the adult population suffered from low back pain which last for more than 24 hours at times during the year (Tessa, 2010) and often causes lost workdays (Guo *et al.*, 1999). About 11.6% out of 2600 populations in a semirural area, Malaysia were diagnosed with low back pain problem (Veerapen *et al.*, 2007). Low back pain does not only signify poor quality of individuals' life, but also showed decreased in labor productivity due to off work, absenteeism and early retirement (Tsuboi *et al.*, 2002).

The issue of musculoskeletal problems in adult population is overwhelming. A study in Canada and North America proved that low back pain was the leading cause of disability and morbidity in middle-aged person which was by far the most expensive source of workers' compensation costs (Manga et al., 1993). It has been reported in the US, there were 70,580 cases of occupational Musculoskeletal Disorders (MSD) and that includes back pain (Bernard, 1997).

### 1.3 Study Justification

Also, in our country, there are only few studies conducted on mismatch of office chairs and the anthropometric measurement. This study is important due to the potential of mismatch which may lead too much bad risk to the office workers. An individual might think that a chair is in a good condition if it is not broken and suit the seat, without thinking the risks of prolonged sitting. If the design of the office furniture does not follow ergonomic principles, and if there is lack of exercises or relaxation during working hours, it is possible that various forms of physical deformations can occur. (Ivelic, Ž. et al., 2002)

Prolonged sitting is one of the major risk factor that will cause discomfort which can lead to muscle fatigue. Through this study, the ergonomic chair efficacy in reducing the discomfort and muscle fatigue and increase the performance of work in the office. Currently, there is lack of literature available regarding the effectiveness of ergonomic chair that related to muscle activity, discomfort, and work performance in Malaysia.

Ergonomics is about integrating knowledge derived from the human sciences to match jobs, systems, products and environments to the physical and mental abilities and

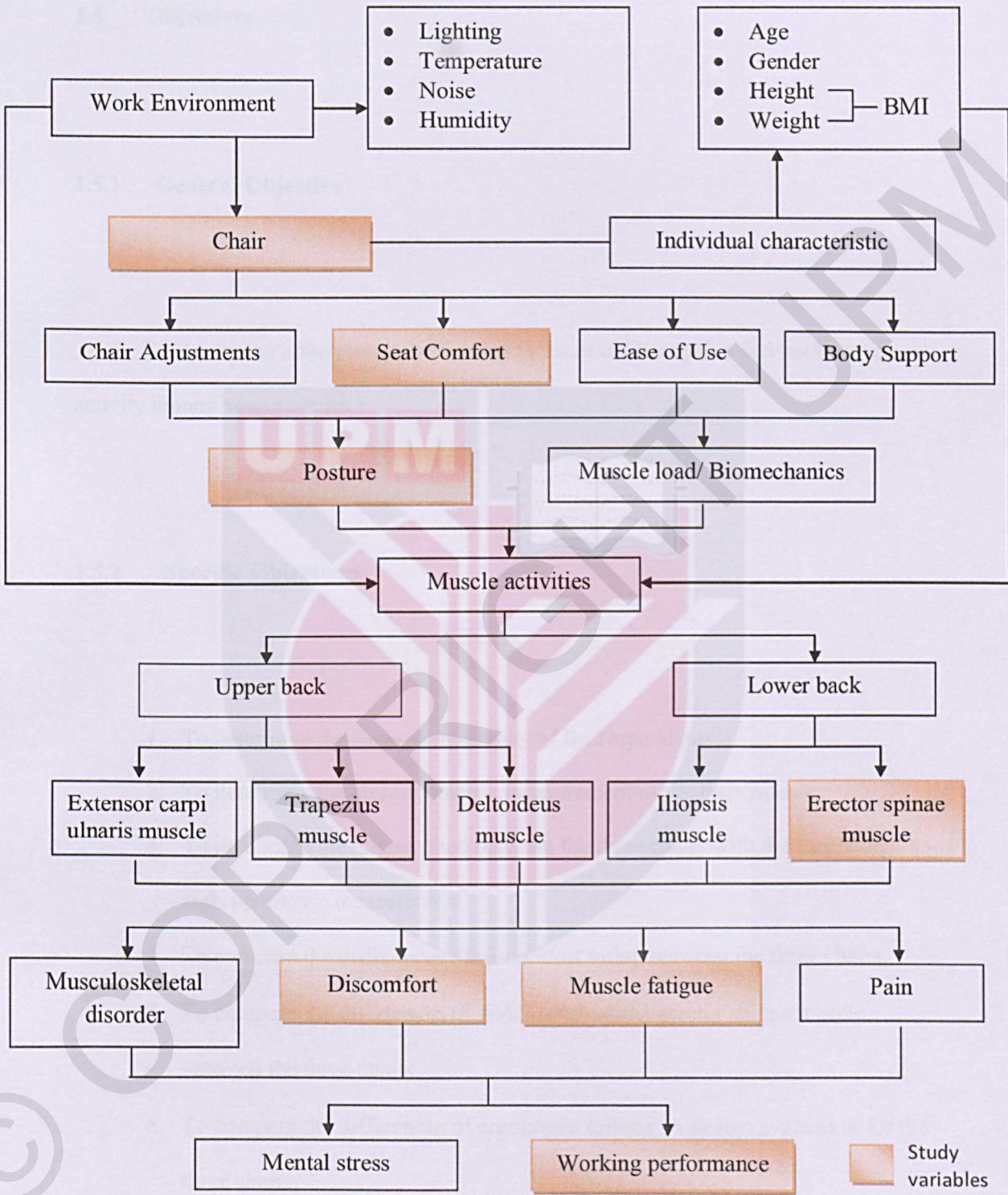
limitations. Ergonomics is an important facet of occupational safety and health (OSH) that needs to be optimized for the wellbeing of people at work. When ergonomic principles are not applied at the workplace, chronic musculoskeletal disorders such as back injuries, hand problems, accidents and eye-strain. (DOSH, 2012). Therefore, this study will be able to provide an evidence to reduce the discomfort by using ergonomic chairs

#### 1.4 Conceptual Framework

This study is to determine the effectiveness of ergonomic chair on the discomfort and back muscle activity among the young adults.

There are many factors that relate to the discomfort and back muscle activity. Discomfort, muscle fatigue and muscle activity recruitment is factors that relate to the prolonged sitting.

Factors that can lead to the sitting discomfort, muscle fatigue and muscle activity recruitment is the biological factors, environmental factors and physical condition.



**Figure 1.1: Conceptual framework of the variables affected by ergonomic chair.**

## **1.5 Objectives**

### **1.5.1 General Objective**

To determine effectiveness of ergonomic chair on discomfort and back muscle activity among young adults.

### **1.5.2 Specific Objectives**

1. To determine the socio-demography of the respondents.
2. To determine the anthropometric measurement of the respondents.
3. To determine the mismatched between the three chairs with the respondent's anthropometric measurement.
4. To compare the differences of discomfort rating between the three chairs.
5. To compare the differences of EMG levels at the erector spinae muscle between the three chairs.
6. To compare the differences of ergonomic criteria on design evaluation for the three chairs.

## 1.6 Study Hypothesis

1. There is a significant difference between the mismatched of the three chairs with the respondent's anthropometry.
2. There is a significant difference between discomfort rating and the three chairs.
3. There is a significant difference between the EMG levels at the erector spinae muscle between the three chairs.
4. There is a significant difference between the ergonomic evaluation designs between the three chairs.

## 1.7 Definition

### 1.7.1 Discomfort

#### Conceptual Definition

Discomfort is based on associations of pain, tiredness, soreness and numbness (Helander and Zhang, 1997).

#### Operational Definition

Discomfort is the complaint of a person of certain body region after performing 20 minutes of task. It is determined with aid of VAS Discomfortness Scale.

## 1.7.2 Electromyography (EMG)

### Conceptual Definition

EMG studies muscle function through analysis of the electrical signals emanated during muscular contractions (Gobel, 2005). It will indicate which muscles are active and the relationship between a level of an activity and the worker's capacity (Ankrum, 2000).

### Operational Definition

A measuring, recording, and evaluation process of an erector spinae muscle activity that has been measured using electromyography measurement.

Parameters in this study are AEMG and MPF.

### 1.7.3 Root Mean Square (RMS)

#### Conceptual Definition

It is an elevation of amplitude characteristic which detected during fatiguing submaximal contraction. are often related to changes in neural drive (central factors). (Arabadzhiev TI et al., 2008)

#### Operational Definition

Measurement of the muscle fatigue is in the unit of microvolt ( $\mu\text{v}$ ).

#### 1.7.4 Average Electromyography (AEMG)

##### Conceptual Definition

The AEMG is calculated in order to quantify the EMG spectra and is used as an index of muscle recruitment (Megawin User Manual, 2006).

##### Operational Definition

Measurement of muscle recruitment is in the unit of microvolt ( $\mu\text{v}$ ).

## 1.7.5 Anthropometry

### Conceptual Definition

Anthropometry is the science that defines physical measures of a person's size, form, and functional capacities. As applied to occupational injury prevention, anthropometric measurements are used to evaluate the interaction of workers with tasks, tools, machines, vehicles, and personal protective equipment, especially in regard to determining degree of protection afforded against hazardous exposures. (Centers for Disease Control and Prevention, 2012).

### Operational Definition

The measurement of human body based on the parameters needed in centimeter (cm). The anthropometry component is to collect high quality body measurement data using standardized examination procedures and calibrated equipment. Accurate data are fundamental to the evaluation of anthropometric trends over time.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Characteristics of ergonomic chair

The main ergonomic requirements for work chairs are the following:

- a. Safety: The chair should not be the source or cause of accidents.
- b. Adaptability: The chair's dimensions and control features should be such that they meet the anthropometric characteristics of at least 90% of the potential users.
- c. Comfort: The chair should be physiologically comfortable for the user.

(Source: Occhipinti et al., 2006)

Also, the important features of the chair which can be categorized as ergonomic chair include these criteria:

1. **Seat height:** Office chair seat height should be easily adjustable. A pneumatic adjustment lever is the easiest way to do this. A seat height that ranges from about 16 to 21 inches off the floor should work for most people. This allows the user to have his or her feet flat on the floor, with thighs horizontal and arms even with the height of the desk.
2. **Seat width and depth:** The seat should have enough width and depth to support any user comfortably. Usually 17-20 inches wide is the standard. The depth (from front to back of the seat) needs to be enough so that the user can sit with his or her back against the backrest of the ergonomic office chair while leaving approximately 2 to 4 inches between the back of the knees and the seat of the chair. The forward or backward tilt of the seat should be adjustable.
3. **Lumbar support:** Lower back support in an ergonomic chair is very important. The lumbar spine has an inward curve, and sitting for long periods without support for this curve tends to lead to slouching (which flattens the

natural curve) and strains the structures in the lower spine. An ergonomic chair should have a lumbar adjustment (both height and depth) so each user can get the proper fit to support the inward curve of the lower back.

4. **Backrest:** The backrest of an ergonomic office chair should be 12 to 19 inches wide. If the backrest is separate from the seat, it should be adjustable in height and angle. It should be able to support the natural curve of the spine, again with special attention paid to proper support of the lumbar region. If the office chair has the seat and backrest together as one piece, the backrest should be adjustable in forward and back angles, with a locking mechanism to secure it from going too far backward once the user has determined the appropriate angle.
5. **Seat material:** The material on the office chair seat and back should have enough padding to be comfortable to sit on for extended periods of time. Having a cloth fabric that breathes is preferable to a harder surface.

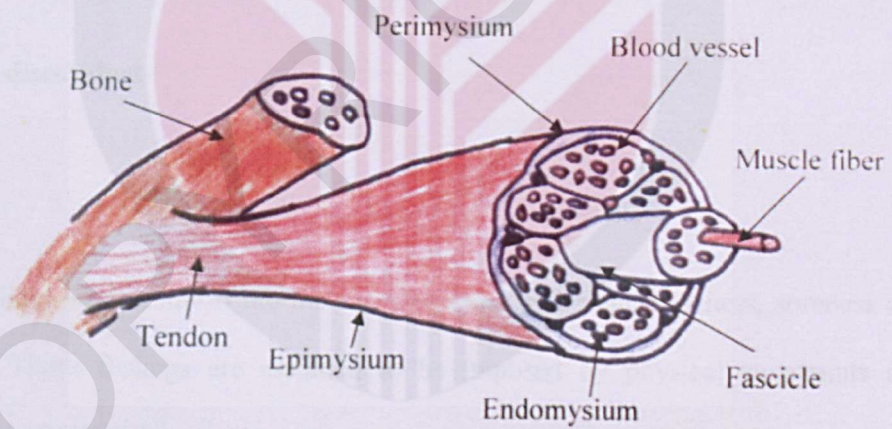
6. **Armrests:** Office chair armrests should be adjustable. They should allow the user's arms to rest comfortably and shoulders to be relaxed. The elbows and lower arms should rest lightly, and the forearm should not be on the armrest while typing.
7. **Swivel:** Any conventional style or ergonomic chair should easily rotate so the user can reach different areas of his or her desk without straining.

(Source: Lefler, 2004)

## 2.2 Overview of muscle

There are three types of the muscle tissue in the human body, which are skeletal, cardiac and smooth muscle. These three muscles are differ from their structure of cell, location of body and how they stimulated to contract. Skeletal muscle attached to bones or some facial muscles to skin. Cardiac muscle are located at walls of the heart whereas smooth muscle mostly located at the walls of hollow visceral organs (Marieb, 2006).

Moreover, the back muscle are made up by muscle fibers, connective tissues, nerves and blood vessels (Martini & Bartholomew, 2003). Each muscle fibers are enclosed in a delicate connective tissue sheath called an endomysium. Several sheathed muscle fibers are wrapped by a coarser fibrous membrane called perimysium to form a bundle of fibers called fascicle. Many fascicles are bound together by an even tougher 'overcoat' of connective tissues called epimysium, which covers the entire muscle. The epimysia blend into the strong, cordlike tendons or into sheetlike aponeuroses which attach muscle indirectly to bones, cartilages or connective covering each other (Marieb, 2006) as shown in Figure 2.1.



**Figure 2.1: Skeletal muscle**

### **2.2.1 Erector Spinae muscle**

In the human anatomy, the erector spinae is a prime mover of back extension. These paired muscles are deep muscles of the back. Each erector spinae is a composite muscle consisting of three muscle columns which are longissimus, iliocostalis and spinalis that collectively span the entire length of the vertebral column. These muscles not only act as powerful back extensors, but they also provide resistance that helps to control the action of bending over at the waist. The common source of injury of back structures is the lower back pain (Marieb, 2006).

### **2.3 Sitting discomfort**

Feelings of discomfort are mainly associated with pain, tiredness, soreness and numbness. These feelings are assumed to be imposed by physical constraints and mediated by physical factors like joint angles, tissue pressure and circulation blockage. Comfort, on the other hand, is associated with feelings of relaxation and well-being (Zhang et al. 1996).

## 2.4 Muscle fatigue

Muscle fatigue is the temporary reduction in muscle strength, either power or endurance. Muscle fatigue coincides with a buildup of lactic acid in the cells of the muscle. Recovery is not complete until the lactic acid is processed through the system (Adams, 2003).

Muscle fatigue is believed to result from the oxygen debt that occurs during prolonged muscle activity. It is because a person is not able to take in oxygen fast enough to keep the muscle supplied with all the oxygen they need when they are working vigorously. In addition, the muscle's ATP supply starts to run low. The increasing acidity in the muscle and the lack of ATP cause the muscle to contract less and less effectively and finally stop contracting entirely (Marieb, 2006).

However, in the aspects of ergonomics, muscle fatigue can be defined as failure to maintain the required or expected force or power. Muscle fatigue is associated with physically monotonous or repetitive work but more recent studies also report an

association between psychosocial factors at the work place and musculoskeletal disorders (Jensen et al., 2000)

## 2.5 Low back pain

Gender differences in the prevalence of low back pain have been reported by Le Resche et al. (2001) who found a prevalence ratio of 1.2:1 between women and men. A preliminary research by Dunk and Callagan (2005) stated that they have found gender differences in lumbar and pelvic posture during sitting on the office chair. In an office chair, females have a slighter greater lumbar lordosis measured externally, a more vertical trunk and the tendency to sit more upright on their pelvis and to “perch” at the front edge of the seat. Males on the other hand tend to slouch with more posteriorly rotated pelvis and they tend to sit farther back in the seat.

**Table 2.1: Summary research on low back pain.**

<b>Researcher</b>	<b>Title</b>	<b>Study Outcome</b>
Abdul Samad et al. (2001)	Prevalence and Associated Factors of Back Pain among Dental Personnel in North-Eastern State of Malaysia	High prevalence of back pain among dental personnel in North-Eastern State of Malaysia. Poor sitting posture and being a dental auxiliary were associated with back pain.
John C. Peck (1992)	A benefits study of ergonomically designed chairs with direct labour employees.	Employees using ergonomically designed chairs appear to experience considerably less physical discomfort during the day.
Groenesteijn L. et al (2009)	Effects of differences in office chair controls, seat and backrest angle design in relation to tasks.	Computer work showed the lowest physical activity in all body parts, together with the upright trunk and head position and low backrest inclination.

## 2.6 Anthropometry

Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties and strength capabilities of human body (Leilanie and Prado, 2007). The anthropometric data provide important information in product/equipment and workplace/workstation design (Hanson et al., 2009; Tayyari, 2000).

In order to accommodate a wider range of people and population, anthropometry and ergonomics have been used to develop a new furniture forms which include task, or office desks and chairs by incorporating adjustability. One of the conditions to support the productivity is to ensure that the work spaces and equipment that people use conform to the anthropometric and biomechanical characteristics of the users. (Jung, 2005)

The specific anthropometry measurement that should be taken such as shoulder height, hip breadth, popliteal height and buttock-popliteal length is necessary in order to determine the chair dimension that enable the correct sitting posture (Parcells et al., 1999).

It should be noted that there are different methods been used for measuring body dimensions for the purpose of equipment design. Some of the methods such as three-dimensional scanners are expensive, highly sophisticated and not available to all the researchers, while other method such as the traditional anthropometric tools is simple and inexpensive. In addition, the anthropometric data was obtained by traditional measurement were shown to be as reliable and accurate as those obtained by some of the high-tech methods (Ghoddousi et al., 2007).

## 2.7 Electromyography (EMG)

One of the widely used forms of physiological discomfort measurement has been the measurement has been the measurement of electromyography activity (EMG), of large muscle group.

EMG is a process in recording, presenting and measuring electrical activity during a muscle fiber contracts (USDHHS, 1992). General uses of EMG as listed below:

- Tool in evaluation of work performance
- Assessment of bodily muscle during performing task.

- Comparing specific musculoskeletal stress associated with various work positions, postures or activities and for validating of ergonomic principles.
- Input to biomechanical models that describe the synergistic effects of muscle activities on a joint.
- When suspected specified muscle or group of muscle is affected adversely because of the design of work place.

For assessment of the EMG signals, the root mean square (RMS) values were calculated from the raw EMG data over consecutive time windows (60 s). The RMS values were normalized by the performance of reference activities at the beginning of each measurement; all muscle activities are therefore relative to a maximum voluntary contraction (% MVC). The 100% MVC values for erector spinae muscle were defined as the 50th percentile RMS values of a calibration interval at the beginning of each measurement (duration: 60 s), in which the respondents were seating on the chair before the actual reading for EMG measurements were taken. The respondents must bend their body as maximum as they can and lean to the right, left, forward and backward. The 0% MVC values for each muscle were set as the minimum values of another calibration interval at the beginning of each measurement (duration 60 s), in which the respondents were seating upright on the chair in a neutral relaxed posture (Ellegast et al., 2009)

## CHAPTER 3

### METHODOLOGY

#### 3.1 Study Design

This is an experimental study, which was designed to evaluate the effectiveness of ergonomic chairs on muscle activities, discomfort and individual preference.

### **3.2 Study Location**

This study was conducted in the Occupational Safety and Health Laboratory, Faculty of Medicine and Health Science, University Putra Malaysia (UPM).

### **3.3 Study Population**

The study populations were conducted among the students at Faculty of Medicine and Health Science, University Putra Malaysia (UPM).

## **3.4 Sampling**

### **3.4.1 Sampling Framework**

The sampling frame was obtained from a list of all the male students at Faculty of Medicine and Health Science, University Putra Malaysia (UPM). The name lists were obtained from the Student Affairs Division and Dean's Office at Faculty of Medicine and Health Science, UPM.

### **3.4.2 Sampling Unit**

The sampling unit is the student that meet the inclusion criteria which are male, age between 19-30 years old, no present complaint on low back pain or episodes of serious low back pain in the past 5 years, no reported abnormal spinal x-ray finding and no history of major physical or mental illness (Durkin et al., 2006; Falou et al., 2003; Otmani et al., 2005; Tanaka et al., 2002; Mori et al., 2004; Shephard, 1998)

### 3.4.3 Sampling Method

The sampling method for this study is purposive sampling where the respondents in this study were selected based on the inclusion criteria's.

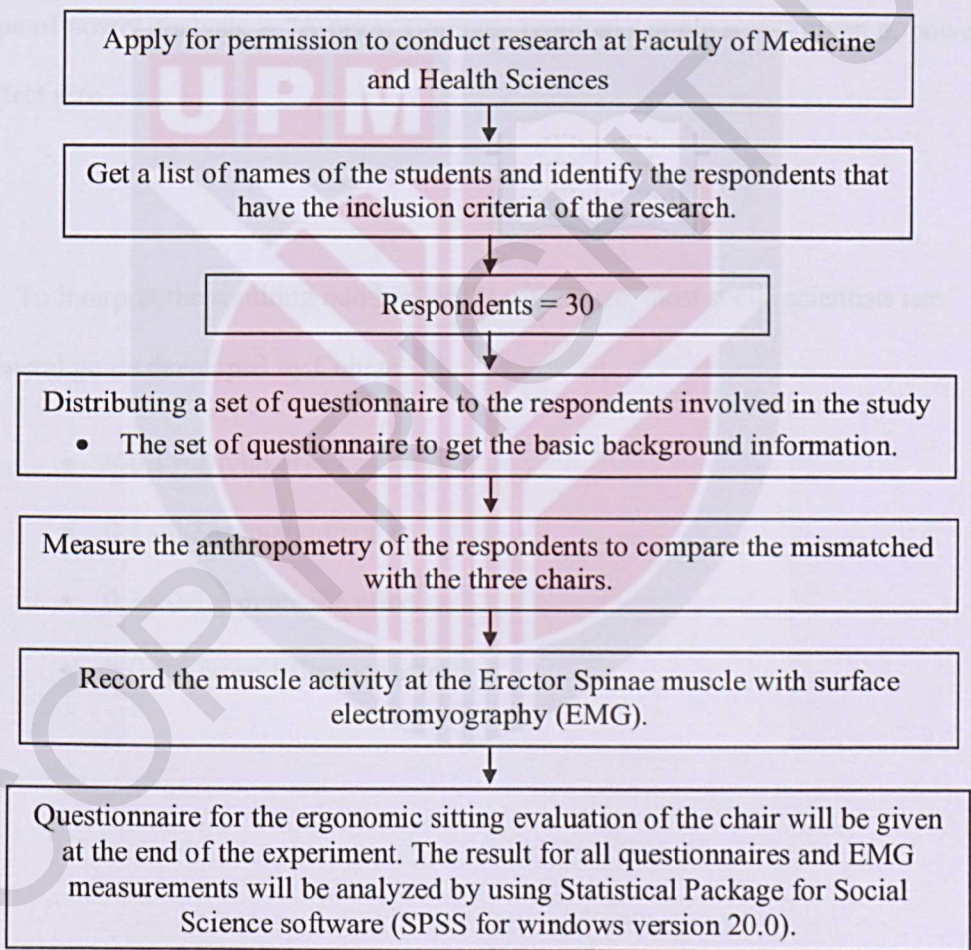


Figure 3.1: The flow chart of the research procedure.

### 3.4.4 Sample Size Calculation

The sample size is calculated based on the G\*Power 3.1.5 software. It covers statistical power analyses for many different statistical tests where I choose F test for this study. The statistical test used is ANOVA: Repeated measures, within factors where the type of power analysis is “A priori: Compute required sample size – given  $\alpha$ , power, and effect size.

To interpret the resulting number for the effect size, most social scientists use this general guide developed by Cohen:

- $< 0.1$  = trivial effect
- $0.1 - 0.3$  = small effect
- $0.3 - 0.5$  = moderate effect
- $> 0.5$  = large difference effect

The effect size chosen is 0.3 where it is categorized as the small effect. This was calculated by taking the difference between the two groups and dividing it by the standard deviation of one of the groups.

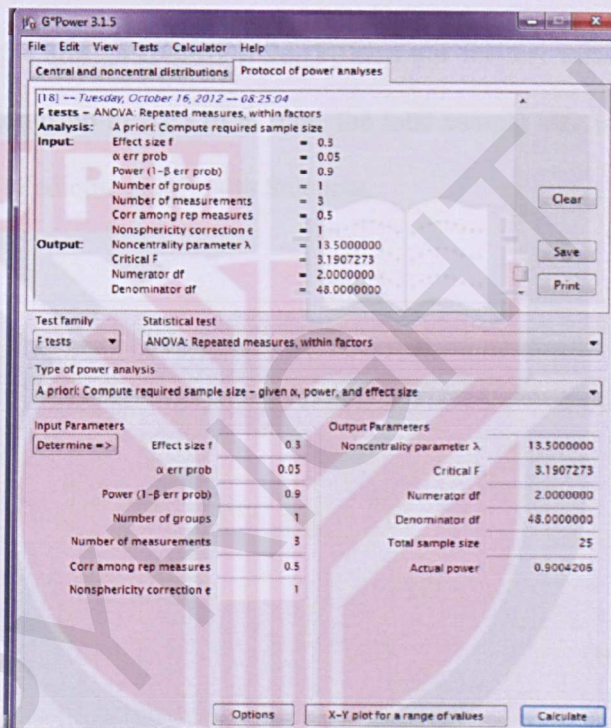


Figure 3.2: The calculation of G\*Power

The number of group for this study is only 1 group and the number of measurements is three where it compares between ergonomic chair I, ergonomic chair II and control chair. The significant level ( $\alpha$ ) is 0.05 and 1-the power of study ( $\beta$ ) is 0.9.

The total sample size calculated is 25. To account for any missing data during data collection, rounded it up to 20% of n, thus, the total sample size to collect was 30 students from Faculty Medicine and Health Sciences.

### 3.4.5 Inclusion Criteria

Respondents were chosen among student at Faculty of Medicine and Health Science, UPM. Among them, the selections of the respondents were based on the purposive sampling, which all of the respondents should fulfill the inclusion criteria as listed below:

1. Male
2. Age between 19-30 years old
3. No present complaint on low back pain or episodes of serious low back pain in the past 5 years
4. No reported abnormal spinal x-ray finding
5. No history of major physical or mental illness

(Durkin et al., 2006; Falou et al., 2003; Otmani et al., 2005; Tanaka et al., 2002; Mori et al., 2004; Shephard, 1998)

### 3.4.6 Exclusion Criteria

The respondents will be excluded out from the study if:

1. Inadequate sleep prior to experiment

(Balasubramaniam & Adalarasu, 2006; Thiffault & Bergeon. 2003; Yung & Tsun, 2009)



## **3.5 Variables**

### **3.5.1 Independent Variables**

- a. Type of chairs
- b. Time

### **3.5.2 Dependent Variables**

- a. Discomfort
- b. Muscle activities

### 3.6 Study Instrumentations

#### 3.6.1 Chairs

The characteristic of this ergonomics chair that it can help align back bone. The material used for the chair is fiber glass, and have an addition of a steel bar support at the back of the seat. The seat cover is made of Leather or PVC leather.

This is the two ergonomic chairs:



Front View



Top View



Side View

**Figure 3.3: Chair 1**



Front View



Top View



Side View

**Figure 3.4: Chair 2**

### Control chair

This is the control chair used for the research which has armrests. This is due the same characteristics for 2 of the ergonomic chair which have armrest on each chair. While sitting on the chair during the experiment, the respondents was given 7 tasks where they have to do.

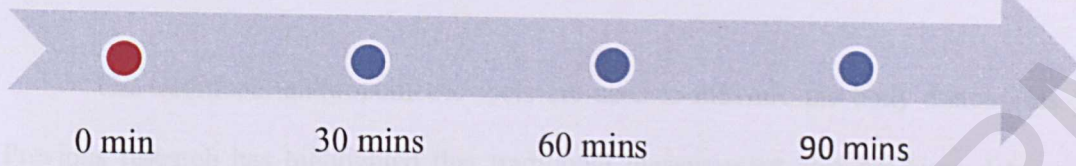


**Figure 3.5: Chair 3**

### 3.6.2 Questionnaire

Preliminary questionnaire (Appendix 3) was distributed among male student at Faculty of Medicine and Health Sciences, UPM. Each of the respondents was given brief regarding the questionnaire. At the end of the session, each questionnaire answered was checked to verify if the respondents answer the questionnaire completely and meet the inclusive criteria of the study.

Also, questionnaire that was given based on standard questionnaire of socio-demographic (Appendix 4). This questionnaire is also to determine the health status of the respondents. The second questionnaire (Appendix 5) that was used is the General Comfort Rating (Shackel's scale, 1969). It was given every 30 minutes in duration of the experiment. This questionnaire is to evaluate the rating of discomfort and compare it between 3 chairs.



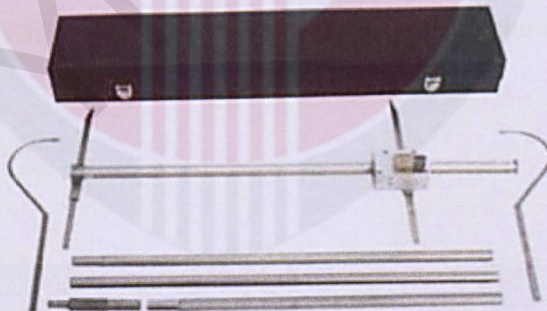
● : Time of the questionnaire of General Comfort Rating is given.

**Figure 3.6: Timeline for General Comfort Rating**

The third questionnaire (Appendix 6) that was used is Ergonomic Seating Evaluation (Cornell, 2007) which to make comparative design about different ergonomic chairs. The content of the evaluation form is based on the questions that most differentiate between chairs (or sitting experiences) and those that relate to ergonomic design considerations. For this questionnaire to be used, it is preferably that the respondents to sit at least 90 minutes.

### 3.6.3 Anthropometry

The traditional anthropometric tools are used to measure the body dimensions. Previous research has highlighted that traditional measurement also produces data as reliable and accurate as those obtained from the high-technology methods (Mokdad and Ansari, 2009; Ghoddousi et al., 2007). The anthropometry measurement was based on methods in MS ISO 7250-1:2008. The parameters that were measured are shoulder height, hip breadth, popliteal height and buttock-popliteal length was measured to compare with the chair dimension of seat height, seat depth, seat width and backrest height for the mismatch.

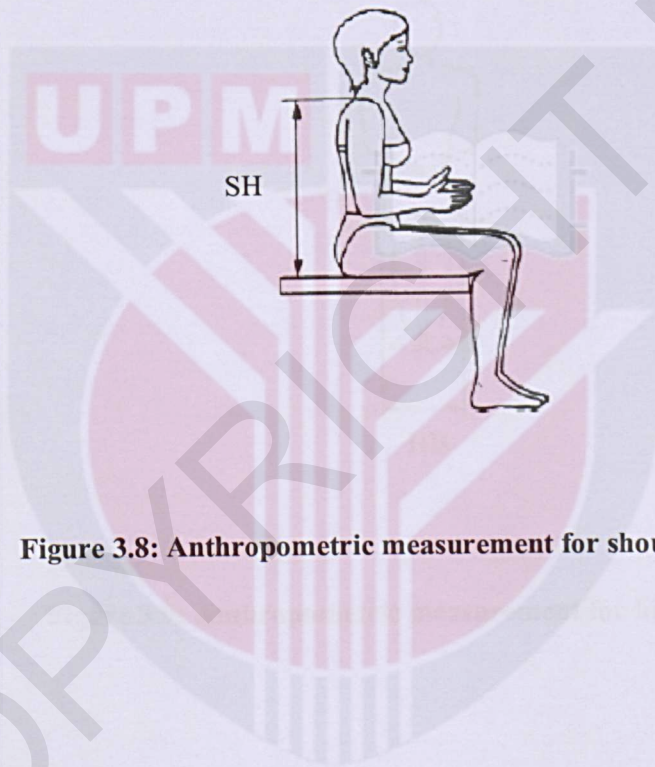


**Figure 3.7: Martyn type anthropometer.**

There are few parameters that have to be measured:

1. Shoulder Height, SH (cm)

Method: Respondent sits fully erect with thighs fully supported and lower legs hanging freely. Shoulders are relaxed, with upper arms hanging freely.



**Figure 3.8: Anthropometric measurement for shoulder height.**

2. Hip breadth, HB (cm)

Method: Respondent sits with thighs fully supported and lower legs hanging freely, knees together. Measurement is taken without pressing into the flesh of the hips.

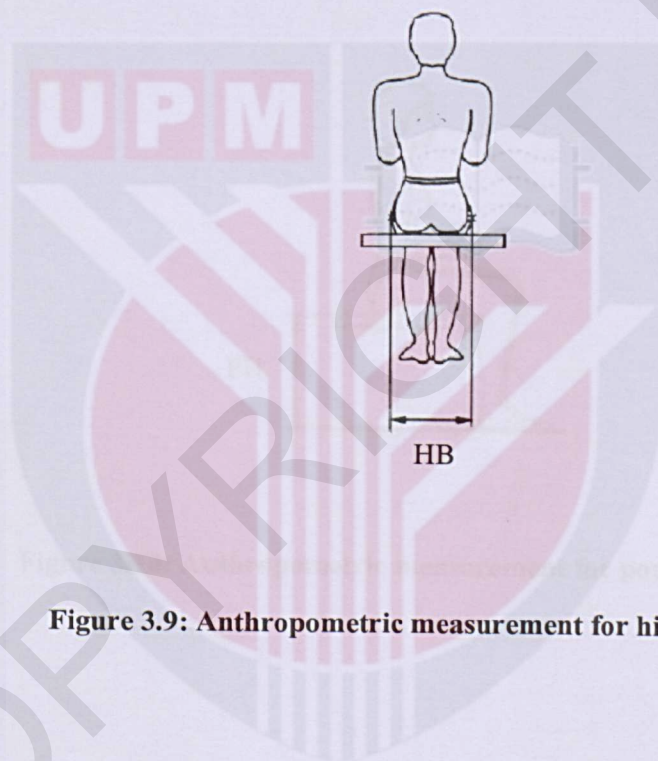


Figure 3.9: Anthropometric measurement for hip breadth.

### 3. Popliteal Height, PH (cm)

Method: Subject holds thigh and lower leg at right angles during measurement. Subject may sit, or stand with the foot placed on a raised platform. The movable arm of the measuring instrument is pushed gently against the tendon of the relaxed biceps femoris muscle.



**Figure 3.10: Anthropometric measurement for popliteal height.**

#### 4. Buttock-popliteal length (cm)

Method: Subject sits fully erect with thighs fully supported and the sitting surface extending as far as possible into the hollow of the knee, lower legs hanging freely. The position of the rearmost point of the buttock is vertically projected onto the sitting surface by means of a measuring block which touches the buttocks. Distance is measured from the measuring block to the forward edge of the sitting surface.



**Figure 3.11: Anthropometric measurement for buttock-popliteal length.**

### 3.6.4 Electromyography (EMG)

Electromyography (EMG) signals were used to monitor recorded the muscle activity for the right and left of the erector spinae muscle with the surface of electrode attached.

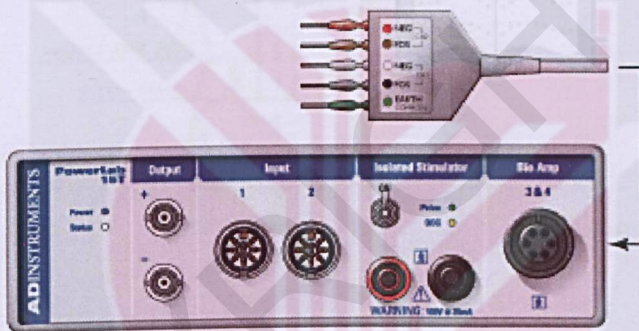
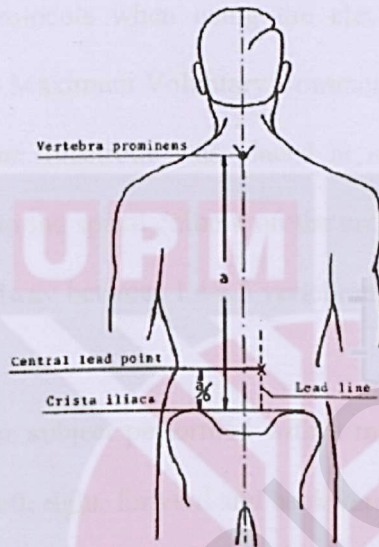


Figure 3.12: Electromyography (ADInstrument powerlab)

This is the recommendations for the standardization of lead positions in surface electromyography:

1. Lead placement at erector spinae muscle.



(Source: Zipp P, 1982)

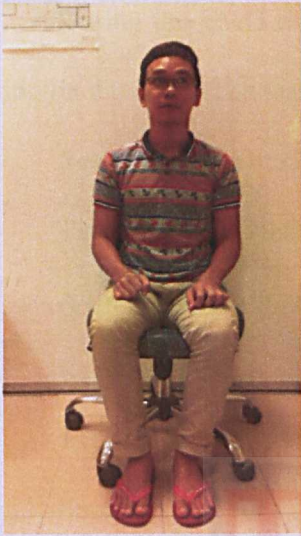
**Figure 3.13: The lead placement at Erector Spinae muscle (trunci).**

The muscle activities of erector spinae muscle were tested to determine the force-muscle activity relationship, which would showed the pattern of muscle's work. In this study, electromyography activities of the left and right sides of lower body at the erector spinae muscle will be recorded by a commercial EMG system. The raw data will sample at 1kHz and recorded online with a portable PC and monitored in real time for

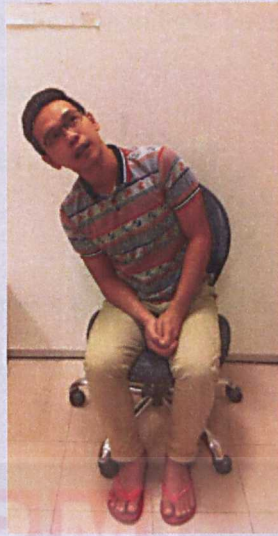
quality control. The EMG signals were recorded for 1200 seconds. The text-entry task was very static allowing a short sample to adequately represent muscle activity levels.

There are protocols when using the electromyography (EMG) measurement which we have to do Maximum Voluntary Contraction (MVC) of Erector Spinae Muscle. *Electrodes placement:* Electrode was placed at each side (left and right) over back muscle and parallel to the spinal column on the crest of the erector muscle. The position of electrode was midway between L4-L5 vertebrae spine and the acromion process. (Jan Seghers, 1994)

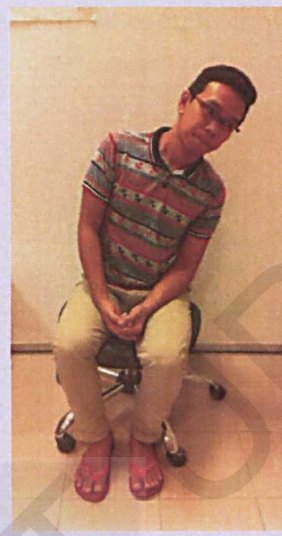
*Subject's action:* The subject performed with a maximum bending while standing and sitting. (lean to the left, right, forward and backwards).



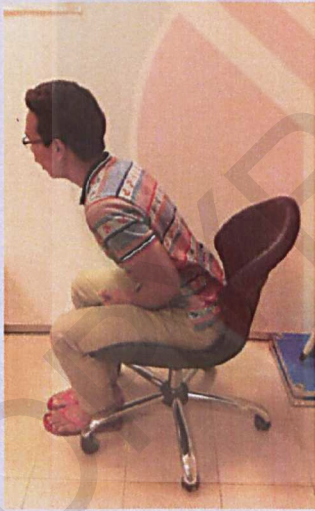
Sitting



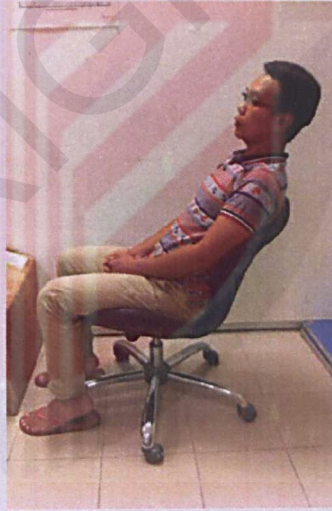
Lean to the right



Lean to the left



Lean forward



Lean backward

**Figure 3.14: MVC while sitting on a chair.**

During the EMG reading, the respondents have few tasks to be completed while sitting on the chair. The tasks were:

1. Reading and correcting text data (10 mins)
2. Typing words (20 mins)
3. A tracking task with intensive mouse use (20 mins)
4. Reading and correcting text data (10 mins)
5. Typing words (20 mins)
6. Sorting paper files (5 mins)
7. Telephoning (5 mins)

### 3.7 Data Analysis

All the statistical analysis was conducted using the Statistical Package for Social Science (SPSS) Version 21.0. Descriptive analysis was used to analyze socio-demographic data collected from the respondents and to determine mean value, standard deviation, median, and frequency. Also, the EMG data, the score of discomfort level and the data of ergonomic seating evaluation was analyzed to obtain the mean value, standard deviation, median, frequency and the percentage for the basic descriptive data.

### 3.7.1 Type of data analysis

The type of data analysis that was used is in Table .

**Table 3.1: Type of data analysis**

Objectives	Tests
To determine the socio-demography of the respondents.	Descriptive analysis
To determine the anthropometric measurement of the respondents.	Descriptive analysis
To determine the mismatched between the three chairs with the respondent's anthropometric measurement.	Repeated measure ANOVA
To compare the differences of discomfort rating between the three chairs.	Repeated measure ANOVA
To compare the differences of EMG levels at the erector spinae muscle between the three chairs.	Repeated measure ANOVA
To compare the differences of ergonomic criteria on design evaluation for the three chairs.	Descriptive analysis

### 3.8 Quality Control

Quality control is important in every measurement especially when using instrument. This is to ensure the result of the data that was obtained throughout the study is avoided with biases and error. In this study, there are quality control are questionnaires, ergonomic chairs, electromyography (EMG), and anthropometric measurements.

#### 3.8.1 Questionnaire

Modified Version of Standardize Nordic Questionnaire (Kourinka et al., 1987) was used to know the information background, general health status as well as prevalence of the back pain and fatigue among the respondents. The form was provided in Bahasa Malaysia so that the respondent can easily understand the questions given. The questionnaire was also undergone constructive testing and reliability testing.

For the constructive test, pre-test was conducted by taking 10% from the sample size. Three subjects who were homogenous with the respondent's criteria's were selected to do pre-test. The function of this test was to know either the subjects

understand the questions in the questionnaire or not. Next, the questionnaire was edited based on the criticism from the respondents and were given to answer it again. As for the next day, the same questionnaire was given again to ensure the answer is the same.

### **3.8.2 Anthropometric measurement**

Approximately 10% from the sample size were taken to conduct pre-test. There were three respondents to perform the pre-test of anthropometric measurement. For each respondent, the measurements were taken three times in order to determine the average measurement.

The anthropometric measurements were taken using Martyn type anthropometer and each of the respondent need to sit on a customized made chair. All the anthropometric measurements were made by the same measurer and recorded by an assistant for three different sessions. During the measurement, the respondents must not wear their shoes. Accuracy and repeatability of the measurements were achieved by intra-tester reliability test.

### 3.8.3 Electromyography pre-test

Pre-test was conducted approximately 10% from the sample size which were three respondents with an equal socio-demographic and physical were recruited to perform the pre-test session. The function of this pre-test was to ensure that the electromyography's instruments working properly and in a good condition. Furthermore, other purpose was to familiarize the researcher in the placement of electrodes on the erector spinae muscle and also with the EMG instruments.

To ensure the good quality control when using EMG, the measurement using ADInstrument powerlab were followed the fixed procedure from the ADInstruments ML138 Octal Bio Amps (ADInstruments, 2013). Before the placement of the electrodes, the surface of the skin was cleaned using the alcohol swabs to remove any surface residues and oils or other substance that might affect the reading while measurement was taken.

### 3.8.4 Standard Operating Procedure

Standard Operating Procedure (SOP) were followed for the measurement tasks during the measurement of height and weight using weighing scale and measuring tape, anthropometric measurement using anthropometric tools and muscle activity using an EMG.

The SECA® Bodymeter measuring tape had the accuracy of 0.1 cm and the readings were taken three times where the average value was recorded. The respondents were not allowed to wear shoes or cap and must stand straight while the measurement were taken.

TANITA® digital weighing scale had the accuracy of 0.1 kg and the respondents were asked to stand on the weighing scale without wearing shoes. The measurements were taken three times where the average value was recorded

### 3.9 Study Limitation

Throughout the study, there were several limitations that are inevitable as listed:

- When using surface electromyography, the muscle will move under the skin, thereby creating different volumes of muscle tissue from which the electrode was recording.
- The other activities that committed by the respondents outside the experiment duration that can lead them to muscle fatigue. It can cause bias and affect the outcome of the data collected.
- Cannot control the sleep adequacy of the respondents, however they can be remind to get adequate sleep before the experiment is done.

### 3.10 Study Ethics

Before the start of any data collection procedures for this research, human subject's approval was obtained from the university's Ethics Committee of Medicine and Health Science Faculty, University Putra Malaysia. As shown in Appendix 1 (Ref.: UPM/FPSK/100-9/2-MJKEtika(JKPP(U)\_Oct(12)37). All participants were given a consent form (Appendix 2) to read and sign. The consent stated that participation in the research study was voluntary and the form also included the study's purpose, risks and benefits, and the participants' role in the study, as well as their freedom to withdraw from the study at any time. This researcher told participants that there are no known risks to participating other than the possibility that they would feel uncomfortable recalling stressful events.

## CHAPTER 4

### RESULT

#### 4.1 Respondent Background

The first objective of this study is to determine the socio demographic information of the respondents. The purpose of this study is to determine the effectiveness of three chairs while sitting among young adults at Faculty of Medicine and Health Sciences. The data collection was conducted from early February 2013 until the end of March 2013.

There were 30 respondents selected as experimental to test all the three chairs. The demographic information such as age, race and the education level were asked in the pre-questionnaire (Table 4.1).

The respondents were taken from the age of 19 to 30 years old. The muscle strength peaks around 25 years of age, plateaus through 35 to 40 years of age, and shows an accelerating decline with 25% loss of peak force by the age of 65 years (Shephard, 1998). Therefore, it is important to choose the respondents between the age of 19 to 30 years old to avoid as factor that may affect the result of muscle activity. Thus, the mean age of the experimental group is 23 years old. Besides, majority of the respondent were Malay (80%) and they were from the Bachelor background education (83.3%). The mean for height and weight of the respondents are 1.66 m and 61 kg respectively.

**Table 4.1: Demographic Information of Respondent**

	Respondent (n=30)	
	Mean $\pm$ SD	Frequencies (%)
Age (years)	23 $\pm$ 2.4	
Race		
Malay		24 (80%)
Non-Malay		6 (20%)
Education Level		
STPM/Matriculation		2 (6.7%)
Diploma		3 (10%)
Bachelor		25 (83.3%)
Height (cm)	166 $\pm$ 6.4	
Weight (kg)	61 $\pm$ 10.3	
BMI (kg/m <sup>2</sup> )	18 $\pm$ 2.6	

#### 4.1.2 Information on Daily Activities

Information regarding respondents' daily activities status was also obtained through questionnaire. The result is summarized in Table 4.2. The average sleeping per day for the respondents ranged from 5 to 12 hours with a mean of 6.3 hours and a standard deviation of 1.5 hours. While the average sitting per day for the respondents ranged from 3 to 10.5 hours with a mean of 6.8 hour and a standard deviation of 2.2 hours. Besides, most of the respondents actively involved in heavy work (73.3%) and sport (83.3%).

**Table 4.2: General Information of Daily Activities**

Daily Activity	Experimental Group (n=30)			
	Min	Max	Mean $\pm$ SD	
Average sleep per day (hours)	5.0	12.0	6.3 $\pm$ 1.5	
Average sitting per day (hours)	3.0	10.5	6.8 $\pm$ 2.2	
			Frequency (%)	
			Yes	No
Heavy work			22 (73.3%)	8 (26.7%)
Sports			25 (83.3%)	5 (16.7%)

## 4.2 Anthropometry of Respondents

The second objective is to determine the anthropometry of the respondents. The anthropometric dimension was collected from the respondent and presented in Table 4.3 below. The sitting height, shoulder height, elbow height, shoulder breadth, hip breadth, popliteal height and buttock-popliteal length were measured and presented in this table. The lowest value chosen is 5<sup>th</sup> percentile while the highest value is 95<sup>th</sup> percentile.

The popliteal height of the respondent is  $43.1 \pm 1.4$  which is taken into consideration for the designing of seat height of chair. The shoulder height is  $57.3 \pm 4.3$  is compared with the backrest height of the chair dimension.

Meanwhile the hip breadth of respondent is  $32.8 \pm 3.0$  which is used for designing seat width of chair. Simultaneously, body dimension of buttock-popliteal length recorded dimension are  $43.3 \pm 2.5$  to compared with seat depth.

**Table 4.3: Anthropometry Background**

Variable	Experimental Group (n=30)							
	Mean ± SD	Min	P5	P25	P50	P75	P95	Max
Shoulder Height	57.3 ± 4.3	51.9	52.0	54.4	57.1	58.9	70.0*	74.6
Hip breadth	32.8 ± 3.0	28.4	28.4	31.2	32.0	34.4	39.4*	40.2
Popliteal Height	43.1 ± 1.4	40.1	40.4*	42.1	43.4	44.0	45.7	45.7
Buttock-popliteal Length	43.3 ± 2.5	39.7	39.8*	41.2	42.6	45.5	48.0	48.7

\*Percentile considered in designing

N = 30

P5 = 5<sup>th</sup> Percentile

P25 = 25<sup>th</sup> Percentile

P50 = 50<sup>th</sup> Percentile

P75 = 75<sup>th</sup> Percentile

P95 = 95<sup>th</sup> Percentile

### 4.3 Dimension of Chairs

In this study, three different chairs was used in the testing by the respondents. The characteristics of each chair are presented in Table 4.4 below. Chair 1 and Chair 2 are representing the experimental chair given by the manufacturer. Meanwhile Chair 3 represents the standard chair that is currently used in the office environment.

**Table 4.4: The Dimension of Chairs.**

Characteristics	Dimension (cm)		
	Chair 1	Chair 2	Chair 3
Seat Height	40.6 – 47.8	40.6- 47.7	42.2 – 49.5
Seat Depth	41.5	42.2	46.0
Seat Width	29.5	29.6	50.5
Backrest Height	58.0	51.0	58.8

The seat height of Chair 3 recorded the highest dimension of 42.2 – 49.5 cm among the three chairs. The lowest seat height was recorded by Chair 2 with the dimension of 40.6 – 47.7 cm is nearly the same as Chair 1. Moreover, Chair 3 have the highest reading of seat depth which is 46.0 cm and Chair 1 have the lowest reading of seat depth which is 41.5 cam. As for the seat

width, Chair 3 also has the highest dimension of 50.5 cm and Chair 1 has the lowest dimension of 29.5 cm. The chair dimension of backrest height for Chair 3 is 58.8 cm which is the highest reading among all three chairs, however Chair 2 is only 51.0 cm.

#### 4.4 Mismatch of Chairs Dimension with Respondent Anthropometric Dimension.

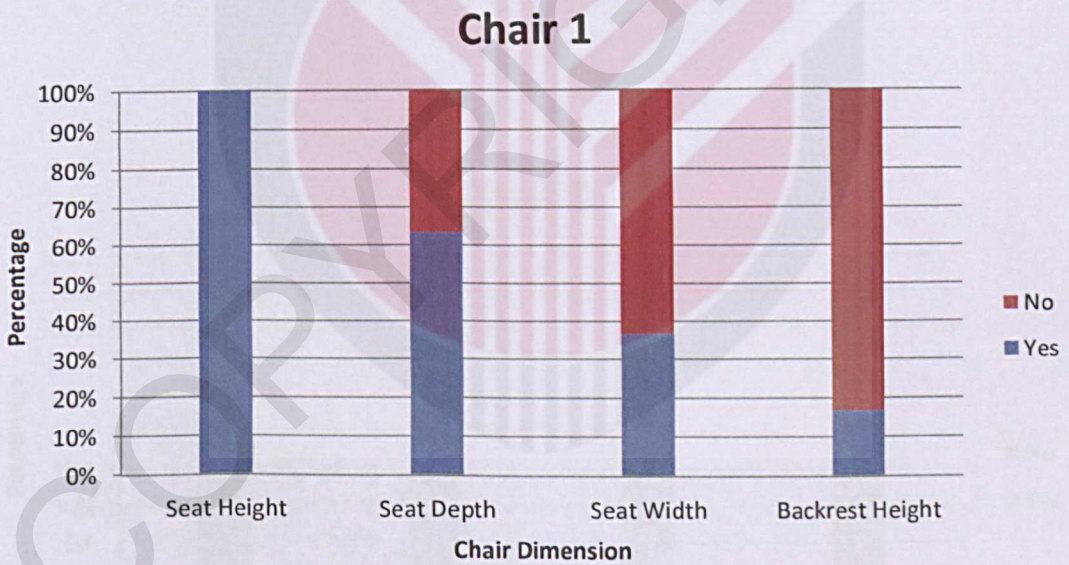
The third objective of this study is to determine the mismatched of the three different chairs with the anthropometry of respondents. Table 4.5, Figure 4.1, Figure 4.2 and Figure 4.3 represent the percentage of the match mismatch for the chair dimension of seat height, seat depth, seat width and backrest height. There was 100% match reported for all three chairs in the seat height.

However, there were mismatch in all three chairs at the seat depth which is 36.7% (Chair 1), 63.35% (Chair 2) and 70% (Chair 3). As for the seat width, only Chair 1 and Chair 2 have the mismatched dimension with the percentage of 63.3% and 80% respectively. Finally, the highest mismatched was recorded on the back rest height with 83.3% (Chair 1 and 2) and 96.7% (Chair

3).

**Table 4.5: Mismatch between the Dimension of Chairs and Anthropometric Measurements.**

Chair Dimension	Chair 1		Chair 2		Chair 3	
	Match	Mismatch	Match	Mismatch	Match	Mismatch
Seat Height	100%	0%	100%	0%	100%	0%
Seat Depth	63.3%	36.7%	36.7%	63.3%	30.0	70.0%
Seat Width	36.7%	63.3%	20.0%	80.0%	100	0%
Backrest Height	16.7%	83.3%	16.7%	83.3%	3.3%	96.7%



**Figure 4.1: Percentage of match/ mismatch for Chair 1.**

### Chair 2

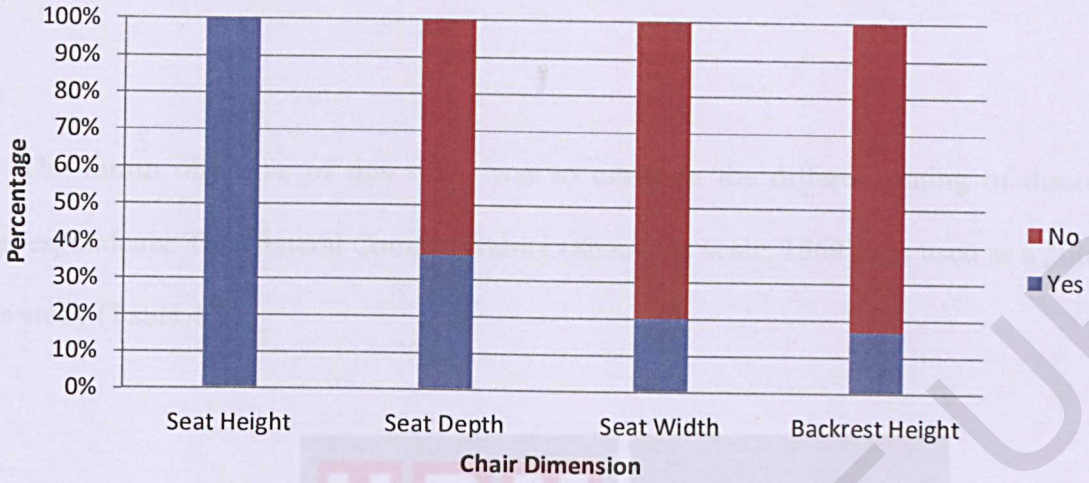


Figure 4.2: Percentage of match/ mismatch for Chair 2.

### Chair 3

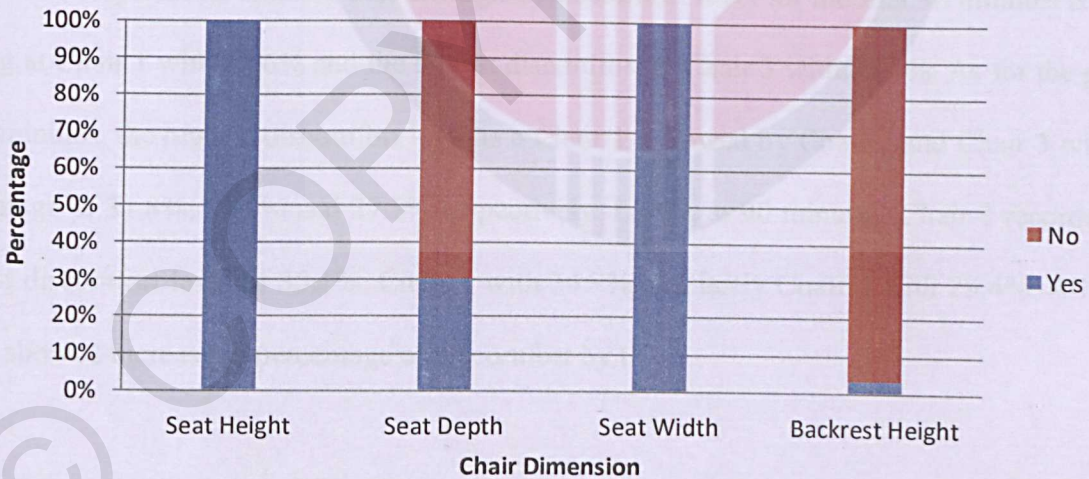


Figure 4.3: Percentage of match/ mismatch for Chair 3.

#### 4.5 Discomfort level between Three Chairs

The fourth objective of this study was to compare the different rating of discomfort among respondents. The General Comfort Rating (Shackel's scale, 1969) was used as a guideline for this study (Table 4.5)

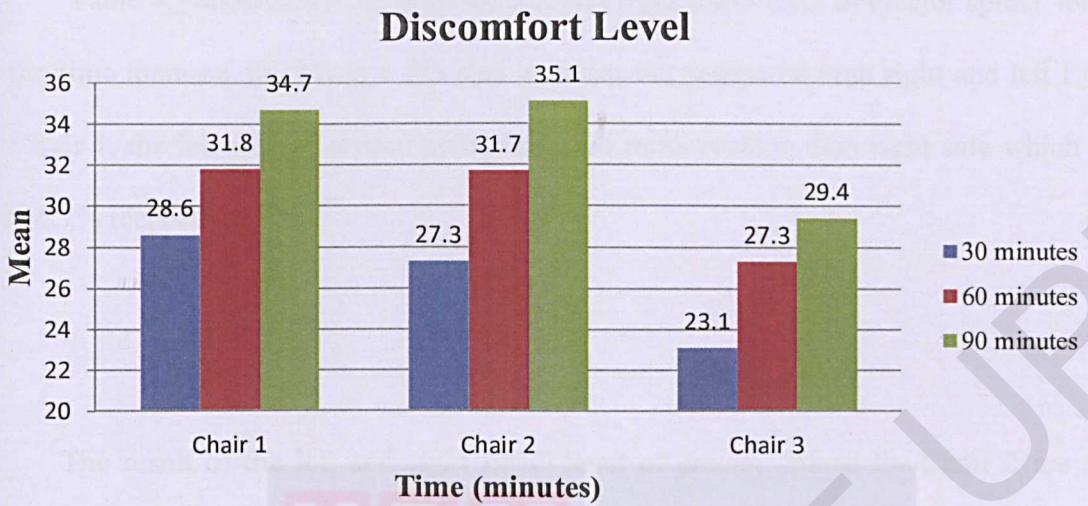
The statistical analysis of discomfort level differences between the three chairs was determined by conducting repeated-ANOVA. There is a significant difference ( $p < 0.05$ ) on the discomfort at each type of chair as the increase in the duration of time.

The respondents claimed that the highest discomfort level for the first 30 minutes is when seating at Chair 1 with 28.6% and the lowest discomfort is Chair 3 with 23.1%. As for the period of 60 minutes, the highest discomfort level is a Chair 1 followed by Chair 2 and Chair 3 with the percentage of 31.8%, 31.7% and 27.3% respectively. Lastly, at 90 minutes, Chair 2 recorded the highest discomfort level of 35.1%, Chair 1 with 34.7% and lastly Chair 3 with 29.4%. All three chairs showed increase in percentage of discomfort by time.

**Table 4.6: The percentage of discomfort level between three chairs.**

Time (minutes)	Percentage of Discomfort, % (Mean ± SD)			df	F value	p value
	Chair					
	1	2	3			
30	28.6 ± 9.5	27.3 ± 10.4	23.1 ± 8.4	1.571, 45.564	12.930	0.000*
60	31.8 ± 9.9	31.7 ± 12	27.3 ± 10.2	1.421, 41.212	22.079	0.000*
90	34.7 ± 11.9	35.1 ± 14.0	29.4 ± 10.7	1.432, 41.523	21.694	0.000*

p-value is significant at  $p < 0.05$



**Figure 4.4:** The percentage of discomfort level between three chairs.

#### 4.6 The Electromyography level between Three Chairs

The fifth objective of this study was to compare the differences of EMG levels at the left and right of the erector spinae muscle between the three different chairs. The statistical analysis of discomfort level differences between the three chairs was determined by conducting repeated-ANOVA. The result of EMG level of both right and left erector spinae muscle on each type of chair showed there is no significant different ( $p > 0.05$ ) as the time increase.

Table 4.7 showed the result of the left and right EMG level of erector spinae for Chair 1. As the time increase, the Mean  $\pm$  SD also increase. As compared both right and left EMG level for Chair 1, the left side of erector spinae showed more reading than right side which is 26.4% and 26.7% respectively.

The result of the left and right EMG level of erector spinae for Chair 2 are shown in Table 4.8. The right of the erector spinae muscle has higher value compared to the left erector spinae, 44.5% and 28.4% respectively. However, towards the end of time (90 minutes), the right erector spinae have higher reading of 55.1% compared to the left erector spinae with 40.2%.

The result of the left and right EMG level of erector spinae for Chair 3 are shown in Table 4.9. Based from the table, at the start (10 minutes), right erector spinae have the reading of 54.7% as compared to the left erector spinae which is only 45.0%. Towards the end, left erector spinae showed high reading of 151.7% while right erector spinae is 138.0%.

In addition, the results of the comparison of right erector spinae EMG level for all three chairs are shown in Figure 4.5. Based on the result, Chair 3 has the highest value of EMG level followed by Chair 1 and Chair 2. Also, the result of the comparison of left erector spinae EMG level for all three chairs is shown in the Figure 4.6. This also showed that Chair 3 has the highest value of EMG level followed by Chair 1 and Chair 2.

**Table 4.7: The electromyography level of erector spinae muscle for Chair 1.**

Erector Spinae muscle	Chair 1					
	Time (minutes)	Activities	(Mean ± SD)	df	F value	p value
Right	10	Correcting	26.4 ± 30.2			
	30	Typing	31.0 ± 45.0			
	50	Mousing	35.6 ± 45.7			
	60	Correcting	73.0 ± 236.5	1.024,	1.089	0.307
	80	Typing	77.6 ± 249.0	29.697		
	85	Sorting	78.1 ± 252.2			
	90	Telephoning	87.7 ± 316.5			
10	Correcting	26.7 ± 20.5				
30	Typing	30.5 ± 26.8				
50	Mousing	34.7 ± 41.1				
Left	60	Correcting	36.2 ± 41.4	1.090,	1.158	0.295
	80	Typing	38.7 ± 61.2	31.613		
	85	Sorting	38.6 ± 41.7			
	90	Telephoning	82.8 ± 259.4			

p-value is not significant at  $p > 0.05$

**Right Erector Spinae**

Mauchly's test of sphericity  
 Mauchly's W = 0.000, df=20, p=0.000  
 Tests of within-subjects effects  
 Grenhouse-Geisser, df=1.024,  
 F=01.089, p=0.307

**Left Erector Spinae**

Mauchly's test of sphericity  
 Mauchly's W = 0.000, df=20, p=0.000  
 Tests of within-subjects effects  
 Grenhouse-Geisser, df=1.090,  
 F=1.158, p=0.295

**Table 4.8: The electromyography level of erector spinae muscle for Chair 2.**

Erector Spinae muscle	Chair 2					
	Time (minutes)	Activities	(Mean ± SD)	df	F value	p value
Right	10	Correcting	44.5 ± 57.2	2.496, 72.395	0.314	0.778
	30	Typing	40.4 ± 40.8			
	50	Mousing	40.7 ± 49.3			
	60	Correcting	43.9 ± 46.3			
	80	Typing	47.8 ± 83.8			
	85	Sorting	55.1 ± 105.6			
	90	Telephoning	55.1 ± 107.2			
Left	10	Correcting	28.4 ± 27.8	2.617, 75.882	2.343	0.088
	30	Typing	30.4 ± 38.3			
	50	Mousing	37.9 ± 55.5			
	60	Correcting	39.8 ± 53.6			
	80	Typing	38.9 ± 60.0			
	85	Sorting	40.2 ± 41.6			
	90	Telephoning	40.2 ± 52.5			

p-value is not significant at  $p > 0.05$

**Right Erector Spinae**

Mauchly's test of sphericity  
 Mauchly's  $W = 0.000$ ,  $df=20$ ,  $p=0.000$   
 Tests of within-subjects effects  
 Grenhouse-Geisser,  $df=2.496$ ,  
 $F=0.314$ ,  $p=0.778$

**Left Erector Spinae**

Mauchly's test of sphericity  
 Mauchly's  $W = 0.000$ ,  $df=20$ ,  $p=0.000$   
 Tests of within-subjects effects  
 Grenhouse-Geisser,  $df=2.617$ ,  
 $F=2.343$ ,  $p=0.088$

**Table 4.9: The electromyography level of erector spinae muscle for Chair 3.**

Erector Spinae muscle	Chair 3					
	Time (minutes)	Activities	(Mean ± SD)	df	F value	p value
Right	10	Correcting	45.0 ± 39.2			
	30	Typing	101.8 ± 275.7			
	50	Mousing	107.2 ± 215.7			
	60	Correcting	116.9 ± 342.3	1.397,	1.408	0.252
	80	Typing	145.1 ± 449.8	40.516		
	85	Sorting	149.8 ± 465.9			
	90	Telephoning	151.7 ± 405.7			
10	Correcting	54.7 ± 79.2				
30	Typing	58.7 ± 66.7				
Left	50	Mousing	61.3 ± 86.6			
	60	Correcting	67.9 ± 88.9	1.355,	1.869	0.177
	80	Typing	80.4 ± 99.6	39.289		
	85	Sorting	84.2 ± 115.0			
	90	Telephoning	138.0 ± 307.1			
	10	Correcting	54.7 ± 79.2			
	30	Typing	58.7 ± 66.7			
50	Mousing	61.3 ± 86.6				

p-value is not significant at  $p > 0.05$

**Right Erector Spinae**

Mauchly's test of sphericity  
 Mauchly's  $W = 0.000$ ,  $df=20$ ,  $p=0.000$   
 Tests of within-subjects effects  
 Grenhouse-Geisser,  $df=1.397$ ,  
 $F=1.408$ ,  $p=0.252$

**Left Erector Spinae**

Mauchly's test of sphericity  
 Mauchly's  $W = 0.000$ ,  $df=20$ ,  $p=0.000$   
 Tests of within-subjects effects  
 Grenhouse-Geisser,  $df=1.355$ ,  
 $F=1.869$ ,  $p=0.177$

**Table 4.10: The electromyography level of right erector spinae muscle for three chairs.**

Type of Chair	Time (minutes)								
	10 minutes	30 minutes	50 minutes	60 minutes	80 minutes	85 minutes	90 minutes		
Chair 1	26.4	31.0	35.6	73.0	77.6	78.1	87.7		
Chair 2	44.5	40.4	40.7	43.9	47.8	55.1	55.1		
Chair 3	45.0	101.8	107.2	116.9	145.1	149.8	151.7		

**Table 4.11: The electromyography level of left erector spinae muscle for three chairs.**

Type of Chair	Time (minutes)								
	10 minutes	30 minutes	50 minutes	60 minutes	80 minutes	85 minutes	90 minutes		
Chair 1	26.7	30.5	34.7	36.2	38.7	38.6	82.8		
Chair 2	28.4	30.4	37.9	39.8	38.9	40.2	40.2		
Chair 3	54.7	58.7	61.3	67.9	80.4	84.2	138.0		

### The EMG level of right erector spinae muscle

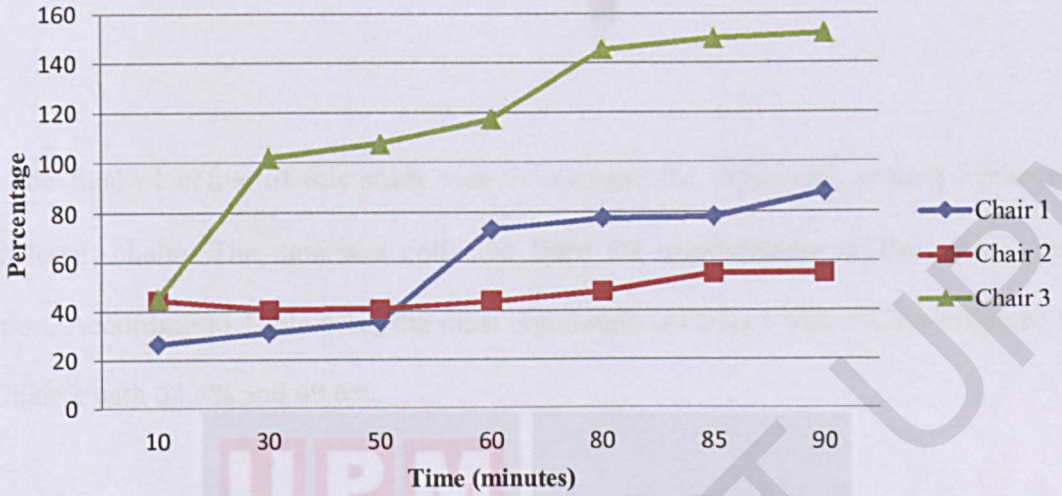


Figure 4.5: The EMG level of right erector spinae muscle of all chairs.

### The EMG level of left erector spinae muscle

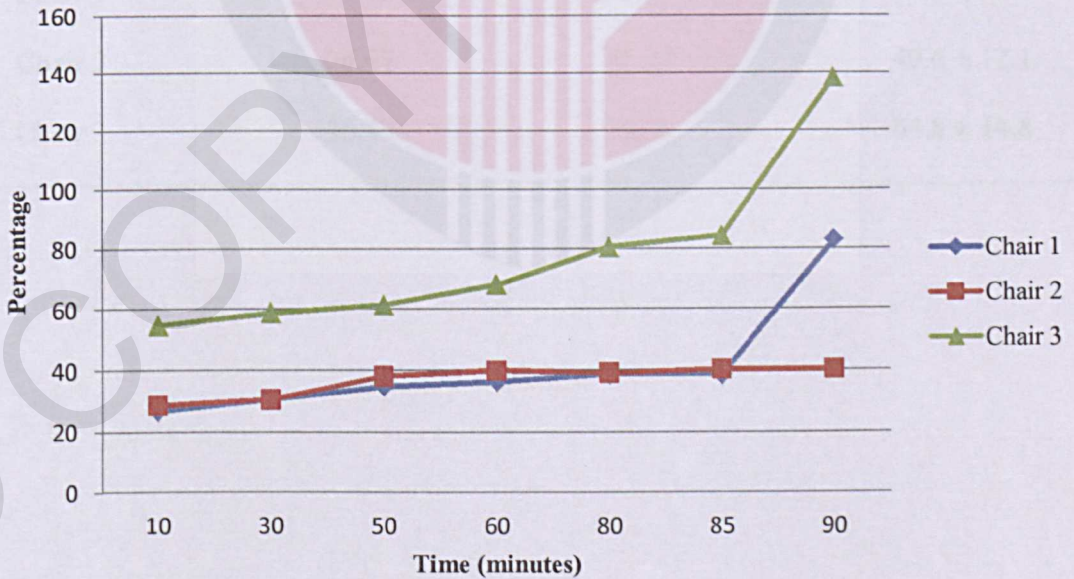


Figure 4.6: The EMG level of left erector spinae muscle of all chairs.

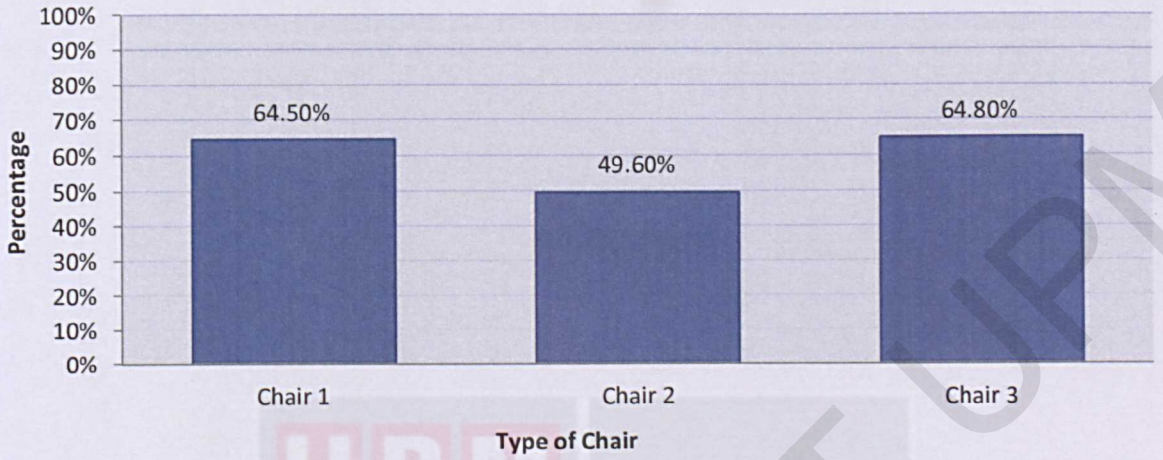
#### 4.7 Ergonomic Seating Evaluation

The final objective of this study was to compare the ergonomic seating evaluation of three different chairs. The data was collected from the questionnaire of Ergonomic Seating Evaluation. According to Table 4.12, the most ergonomic is Chair 1 with 64.8% followed Chair 1 and Chair 2 with 64.5% and 49.6%.

**Table 4.12: The Mean Percentage of the Ergonomic Seating Design.**

Type of Chair	Respondent (n = 30)		
	Min (%)	Max (%)	Discomfort (Mean $\pm$ SD)
Chair 1	41.43	88.57	64.5 $\pm$ 12.6
Chair 2	26.67	75.24	49.6 $\pm$ 12.1
Chair 3	36.19	90.00	64.8 $\pm$ 14.8

## Ergonomic Seating Evaluation



**Figure 4.7: The percentage of the Ergonomic Seating Evaluation.**

## CHAPTER 5

### DISCUSSION

#### 5.1 Discussion

##### 5.1.1 Respondent Background

In this study, there were 30 males at Faculty of Medicine and Health Sciences involved. Most of the respondents were Malay ethnicity and majority of them had tertiary educational level of background. In addition, the BMI for the respondents fall within the normal range and was significantly watch. Respondent were taken from the

age of 19 to 30 because it is the range of age which classified as young adults. The muscle strength peaks of human is within the range of 25 years old, plateaus through 35 or 40 years old, and shows an accelerating decline within 25% loss of peak force by the age of 65 years old (Shephard, 1998). Therefore, it is very important to choose the age between 19 to 30 years old as to avoid the potential factors that might affect the result of muscle activity.

#### **5.1.1.1 Information on Daily Activities**

Regarding their daily activities, highly number of respondents was involved in the heavy work and sports. There were no significant different show for the heavy work and sports for the respondents. Thus, the results were not a confounder between the muscle fatigues in the relation to their daily activities.

### 5.1.2 Anthropometric Background

During anthropometric measurement, the respondents were measured on the right side and in erect sitting posture on an adjustable chair with a horizontal surface, with their upper and lower leg at a 90° angle, and with their feet flat on an adjustable footrest (with the exception of stature and weight). The measuring methods as followed in MS ISO 7250-1:2008 (Basic Human Body Measurement for Technological Design – Part 1: Body Measurement Definitions and Landmarks, First Revision) is used.

During the process of measurement taken, the respondents were measured without their shoes. They were wearing a shirt and a pair of trousers which is wearing minimal clothing. Accuracy and repeatability of the measurement were achieved by intra-tester reliability test. In addition, pretest measurement was conducted to 10% of the study sample who have the same characteristics and background as inclusive criteria as the study sample group.

### 5.1.3 Dimension of Chairs

In this study, in order to determine the matching between the respondent's anthropometry and the chairs, an assessment using mismatch calculation was used. The application measures to determine the mismatch is as shown in Table 5.1.

**Table 5.1: Application of Measures.**

Parameter	Application of Measures
Popliteal height (PH) against seat height (SH)	$(PH + 3) \cos 30^\circ \leq SH \leq (PH + 3) \cos 5^\circ$
Buttock popliteal length (BPL) against seat depth (SD)	$0.8 \text{ BPL} \leq SD \leq 0.95 \text{ BPL}$
Hip width (HW) against seat width (SW)	$HW < SW$
Shoulder height (SH) against backrest height (BH)	$0.6 \text{ SH} \leq BH \leq 0.8 \text{ SH}$

#### 5.1.4 Mismatch of Chairs Dimension with Respondent Anthropometric Dimension.

This study found that there were no significant differences on the mismatches of three chair dimensions and the anthropometric dimensions of respondents. So, the first hypothesis is rejected which stated that there is a significant difference between the mismatched of the three different chairs with the respondent's anthropometry.

Result at Table 4.5 indicates the mismatch between the three chairs and the anthropometric data of the respondents. For Chair 1, 36.7% of mismatches of seat depth, 63.3% of mismatches of seat width and 83.3% mismatches of backrest height. As for Chair 2, there were mismatches reported at seat depth (63.3%), seat width (80.0%) and backrest height (83.3%). However, Chair 3 only has mismatches at the seat depth with 70.0% and at the backrest height with 96.7%. These results highlighted that the design of this chairs are lacks with some ergonomic criteria which is similar with the previous study's result.(Hernández (2009), Castellucci (2009) and Parcell (2009)).

This result was supported by studies from Hernández J. R. G. et al.(2009). The findings from this study indicated that a substantial degree of mismatch between the respondent's bodily dimensions and the chair available to them which stated that over 60% of the respondents had a mismatch with the seat height, the seat is too high. In addition, over 98% of the respondents had a mismatch with the depth of the seat, the seat is too short. Lastly, about 69.23% of the respondents had a length greater than the width of the hips of the seat, the seat is very narrow.

Besides, a study by Castellucci et al. (2009) is comparing the furniture sizes within three different groups of respondent with the anthropometric characteristics of Chilean respondents and found that on 14% of the respondent's popliteal height was appropriate to the seat in 2 out of 3 groups and 28% in the third group.

Also, according to Parcell et al. (2009) measurement of the dimension of the chair indicated that there was considerable mismatched between the respondent's body dimension and the chair. Fewer than 20% of respondents can find the acceptable chair combinations. Most respondents are sitting in chairs with seats that are too high or too deep.

5.1.5 Based on Table 5.2, it can be concluded that Chair 1 and Chair 2 have the most matches with the chair dimension. Chair 2 only matched with the seat height.

**Table 5.2: The mismatch of Chair Dimension with Anthropometric Measurement.**

Type of Chair	Chair Dimension			
	Seat Height	Seat Depth	Seat Width	Backrest Height
Chair 1	√	√	×	×
Chair 2	√	×	×	×
Chair 3	√	×	√	×

\*√ = Results that have >50% (matches)

### 5.1.5 Discomfort level between Three Chairs

Based on the result obtained, it showed that there are significant differences ( $p < 0.05$ ) in the discomfort level of all chairs. Therefore, the second hypothesis of this study which stated that there is significant difference rating of discomfort between the three chairs is accepted. It has been reported by the respondents that the most discomfort part of the body is at the lower back and buttocks for all three chairs. However, when comparing all three chairs, Chair 1 has the highest level of discomfort at the lower back and buttock. This may due to the seat material at the seat pan of the chair where it does not have enough seat padding. The material on the office chair seat and back should have enough padding to be comfortable to sit on for extended periods of time. Having a cloth fabric that breathes is preferable to a harder surface (Lefler, 2004).

Moreover, research by Ž. Ivelic et al. (2002) has shown that inappropriate sitting, caused by poorly designed furniture, accounts for headaches (14%), pain in the neck and shoulders (24%), backpain (57%), backside (16%), lower leg (19%) and pain in knees and feet (2%).

### 5.1.6 The Electromyography level between Three Chairs

The fifth objective of the study is to compare the differences of EMG levels at the erector spinae muscle between the three different chairs. The first indicator for muscle activity is AEMG levels that measure the muscle recruitment. The result showed that there is no significant effect for AEMG value for right and left erector spinae muscles with the seating duration for the respondents and three chairs.

However, based on the EMG data distribution during the testing, it can be concluded that the muscle activity at both right and left of the erector spinae increases by time. When comparing all three chairs, Chair 3 showed the highest percentage which up to 160 at the right and left erector spinae muscle. As for Chair 2 has the lowest muscle activity which is up to 50% for the right erector spinae and up 40% for left erector spinae. The force requirement is increasing with temporal factor. The AEMG amplitude increases with the increases in the force because the AEMG amplitude is closely related to the level of force. The greater number of muscle recruitment will lead to the greater the force will be demand.

Furthermore, a similar study by Ellegast et al. (2009) which stated that the muscle activation revealed no significant differences between the specific dynamic chairs and the reference chair. Also, Anderson et al. (1977) performed several studies of erector spinae activity during sitting tasks, and observed that maintenance of sitting postures required low-level muscle activity of erector spinae muscle.

Besides, the study needs longer time to detect fatigue in the muscle. According to Bellinger et al. (2007), muscle fatigue occurs due to the tiny leaks of calcium inside the muscles. One of the functions of calcium is to help control muscle contractions. This research found that after extended highly-intensity exercise, small channels in the muscle cells begin to leak calcium, which leads to weakened muscle contractions. This leaked calcium also stimulates an enzyme that attacks muscle fibers and also will lead to fatigue. In conclusion, the seating duration of 90 minutes unable to detect significant muscle fatigue as recommended by Durkin et al. (2006).

In conclusion, the third hypothesis stated that there is a significant difference between the EMG levels at the erector spinae muscle between the three chairs was rejected.

### 5.1.7 Ergonomic Seating Evaluation

The Ergonomic Seating Evaluation Form of questionnaire by the Cornell University Ergonomics is used to systematically gather information on the quality of chairs that is being assessed. This questionnaire has 21 items which include items that address some important issues and recent advances in the ergonomic design of seating. This questionnaire used the scoring system that calculates the Ergonomic Design Score (%EDS) that summarized how well a chair conforms to important ergonomic design principles.

The rating responses are subjective and the focus is on factors such as the usability and comfort of the chair. The scale is organized into 5 Separate sections (4 component sections: Chair Adjustments, Seat Comfort, Ease Of Use, Body Support, and 1 overall Comfort Rating Section). The scores for each section are totaled and the section scores are summed and an overall % ergonomic design score is calculated. In this way different chairs can be compared either on individual items, on each of the 4 feature sections and on overall subjective performance, or the total chair performance is indicated by the % ergonomic design score (%EDS).

Based on Table 5.3, by comparing all three chairs, the result showed that Chair 2 have many lack for the evaluation criteria at the chair adjustment, seat comfort and body support. This was due to the lack of arm rest available at Chair 2. One of the main characteristic of an ergonomic chair is to have an armrest. An Armrest of a chair should be adjustable. It should allow the user's arms to rest comfortably and shoulders to be relaxed. The elbows and lower arms should rest lightly, and the forearm should not be on the armrest while typing.

**Table 5.3: The Ergonomic Design Score.**

Type of Chair	Evaluation Criteria				Overall Chair Experience
	Chair Adjustments	Seat Comfort	Ease Of Use	Body Support	
Chair 1	√	√	√	√	√
Chair 2	×	×	√	×	√
Chair 3	√	√	√	√	√

\*√ = Results that have >50% (EDS)

## 5.2 Conclusion

In general, the conclusions are summarized as follows:

1. The anthropometrics data were collected, analyzed and summarized in order to achieve the second objective. The collected database used only 7 anthropometric dimensions. As a conclusion, it is suggested that there is a need to consider factors and ethnicity when designing a chair for the Malaysia population as there are various body dimension differences between the ethnics and gender.
2. This study presents the mismatch between three chairs and the anthropometric measurement of the respondents. According to the data obtained, it may be concluded that some of the chair dimensions were not matched with the selected anthropometric measurement of the respondents.
3. Discomfort rating of the chairs proves that there is a significant difference between the discomfort rating and all three chairs. It was found that the rate of discomfort level (in all body parts) increases over time during the testing period.

4. There is no significant difference between the EMG levels at then left and right erector spinae muscle between the three chairs. However the muscle activation at both right and left erector spinae increases by time as Chair 3 showed the highest muscle activation.
  
5. The Ergonomic Design Score indicates that the higher percentage of the scores means that the more ergonomics the chair is. This study proves that Chair 3 has the highest percentage which is nearly the score of Chair 1. The lowest score is Chair 2 which it does not have an arm rest.

### 5.3 Recommendations

1. As for the socio-demographic data, a large pool of population (samples from each state in Malaysia and race) and with different range of ages (18 to 65 years old) should be considered for the study regarding the extent of better results of data.
2. The anthropometric measurement also can improve by taking a large pool number of population (samples from each state in Malaysia and race) and with different range of ages should be considered in order to establish a better anthropometric database for the respondents. In addition, the measurement can be taken using an advance technique or equipment such as the three-dimensional (3D) body scan.
3. It is proven that some of the chair dimensions are not ergonomically design. The design is not according to the percentile of the respondents. To fit and match for the majority of the person, a redesign of the chair should be done according to the population that will be using the chair by which different chair dimension for different age of groups

4. To minimize the discomfort level of a person, they have to know the proper way of sitting on a chair by adjusting the chair height, start with the seat at the highest setting and then adjust downward until the legs and feet feel comfortable, and the back of the knees is at an open angle of 100 degrees or slightly greater. Also, the respondent must seat back in the chair, by adjusting the height or depth of the lumbar support to provide comfortable lower back support. This is same goes by adjusting the seat pan and arm rest. Also, add some seat padding at the seat pan of the chair to increase to comfort rating especially at the lower back of the body and buttocks.
5. A new measurement and verification should be developed using the electromyography (EMG) and conducted with longer duration of time. Measurements also need to be taken at different part of body.
6. The percentage of The Ergonomic Design Score can be increase if the chairs have all the characteristics of an ergonomic chair which are the seat height, seat pan depth and width, lumbar support, back rest, arm rest, and swivel.

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FAKULTI PERUBATAN DAN SAINS KESIHATAN  
FACULTY OF MEDICINE AND HEALTH SCIENCES

Ref: UPM/PPSE/106-W2-MTK/Enka(KPP/01-04/12/07)

Date: 04 December 2012

TO WHOM IT MAY CONCERN

Dear Sir/Madame,

RESEARCH PROJECT

THE EFFECTIVENESS OF ECONOMIC FIELD EXERCISES ON  
BACK MUSCLE ENDURANCE

RESEARCHER

SUPERVISOR

## APPENDIX 1

Ethical approval letter

The Medical Research Ethics Committee (MREC) of the Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM) has reviewed your research project and approved it for ethical conduct.

Your approval is subject to the following conditions: you must ensure that the rights and welfare of the subjects are protected at all times.

Thank you.

Yours faithfully,  
Dr. Roslan Yusoff

DR. ROSLAN YUSOFF

Research Ethics Committee  
Faculty of Medicine and Health Sciences  
Universiti Putra Malaysia

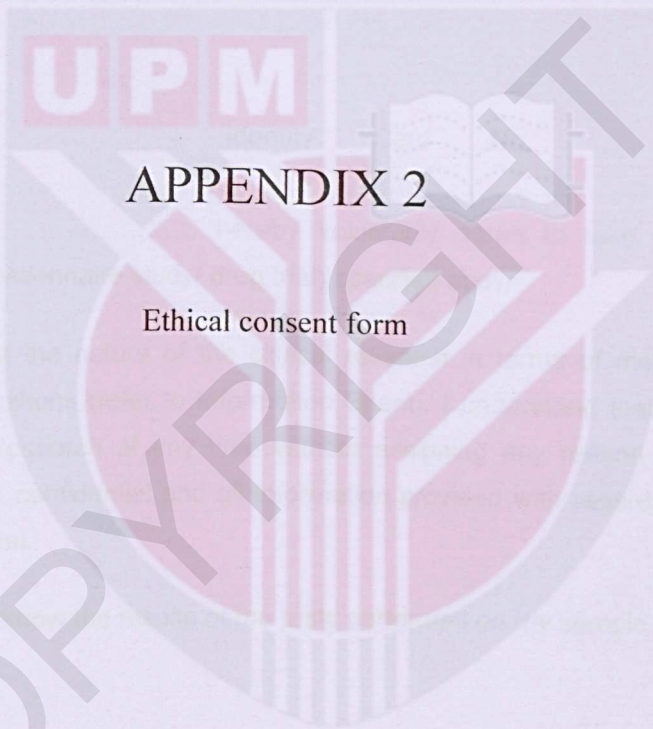
010-37610000



CONSENT FORM (RESPONDENT)

RESEARCH TITLE : THE EFFECTIVENESS OF ERGONOMIC CHAIR ON  
DISCOMFORT AND BACK MUSCLE ACTIVITY AMONG YOUNG ADULTS.

RESEARCHER: NUR AMALINA BT OSMAN



APPENDIX 2

Ethical consent form

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I have read and understand the above and I have agreed to participate in the study mentioned above.

Signature: \_\_\_\_\_  
Name: \_\_\_\_\_  
IC No: \_\_\_\_\_

Signature: \_\_\_\_\_  
Name: \_\_\_\_\_  
IC No: \_\_\_\_\_



**CONSENT FORM (RESPONDENT)**

**RESEARCH TITLE : THE EFFECTIVENESS OF ERGONOMIC CHAIR ON DISCOMFORT AND BACK MUSCLE ACTIVITY AMONG YOUNG ADULTS.**

**RESEARCHER :NUR AMALINA BT OSMAN**

I ..... Identity Card No. ....  
address.....

.....hereby voluntarily agree to take part in the clinical research \*(clinical study, questionnaire study/ drug trial) specified above.

I have been informed about the nature of the clinical research in terms of methodology, possible adverse effects and complications (refer to Information Sheet). I understand that I have the right to withdraw from this clinical research at any time without assigning any reason whatsoever. I also understand that this study is confidential and all information provided with regards to my identity will remain private and confidential.

I wish to \*know/don't wish to know the results of the tests performed on my sample.

\* delete where necessary

Signature .....  
(Respondent)

Signature .....  
(Witness)

Date :.....

Name :.....

I/C No.

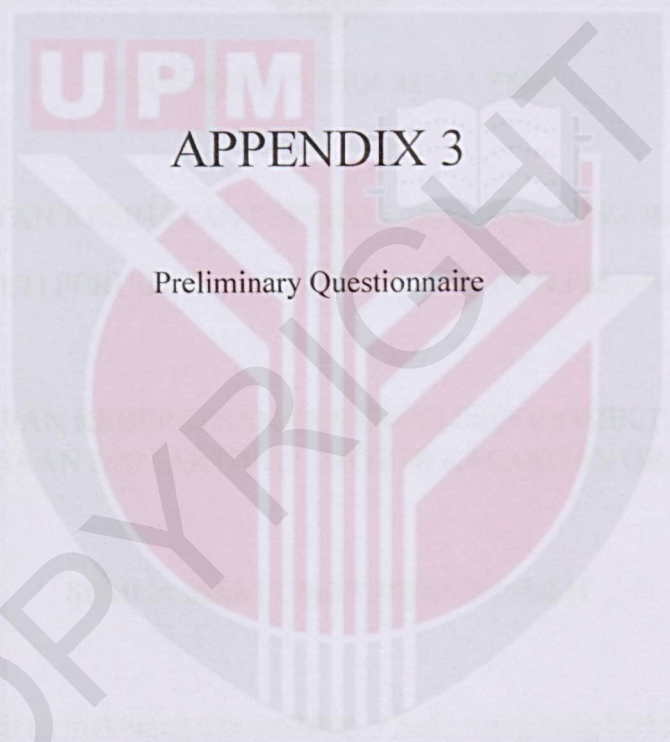
I confirm that I have explained to the respondent the nature and purpose of the above –mentioned clinical research.

Date .....

Signature .....  
(Researcher)

# APPENDIX 3

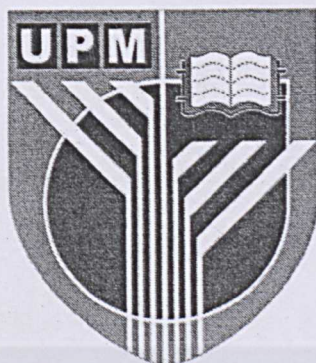
## Preliminary Questionnaire



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PRELIMINARY QUESTIONNAIRES

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UNIVERSITI PUTRA MALAYSIA

JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN

FAKULTI PERUBATAN PERSEKITARAN DAN PEKERJAAN

BORANG KAJIAN KEBERKESANAN KERUSI ERGONOMIK PADA TAHAP  
KETIDAKSELESAAN DAN AKTIVITI OTOT DI KALANGAN ORANG DEWASA

SEMUA MAKLUMAT DIJAMIN SULIT

Sila isikan maklumat dan tandakan  $\surd$  pada ruang yang berkenaan

1. Umur: \_\_\_\_\_ tahun

2. Pernahkan anda mengalami keadaan/ symptom berikut?

a. Kesakitan pada otot skeletal

Ya

Tidak

b. Sakit pada bahagian belakang atas (pada bahagian bahu)

Ya

Tidak

c. Kemalangan/ Trauma melibatkan bahagian belakang bawah dalam tempoh 5 tahun

kebelangan ini

Ya

Tidak

3. Adakah anda mempunyai laporan x-ray spina yang tidak normal?

Ya

Tidak

4. Adakah anda mempunyai sejarah kesakitan fizikal dan mental?

Ya

Tidak

5. Adakah anda mempunyai jumlah tidur yang cukup (6-8 jam sehari)?

Ya

Tidak

6. Selepas menggunakan kerusi ergonomik, adakah anda mempunyai symptom seperti di

bawah:

a. Keletihan

Ya

Tidak

b. Ketidakselesaan

Ya

Tidak

c. Sakit belakang

Ya

Tidak

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## APPENDIX 4

### Demographic Questionnaire

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BORANG KAJIAN KEBERKESANAN KERUSI ERGONOMIK PADA TAHAP  
KETIDAKSELESAAN DAN AKTIVITI OTOT DI KALANGAN ORANG DEWASA

SEMUA MAKLUMAT DIJAMIN SULIT

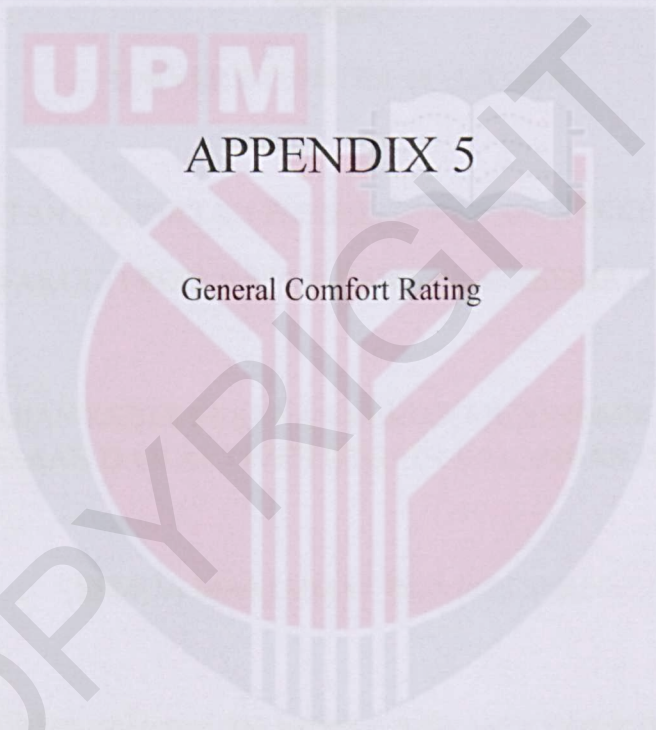
Sila isikan maklumat dan tandakan  $\checkmark$  pada ruang yang berkenaan

## BAHAGIAN A: MAKLUMAT AM RESPONDEN

1. Umur: \_\_\_\_\_ tahun
2. Berat: \_\_\_\_\_ kg
3. Tinggi: \_\_\_\_\_ cm
4. Bangsa:
  - a. Melayu
  - b. Cina
  - c. India
  - d. Bumiputra bukan Melayu
  - e.  Lain-lain: \_\_\_\_\_
5. Tahap pendidikan
  - a.  UPSR
  - b.  PMR
  - c.  SPM
  - d.  STPM/MATRIKULASI
  - e.  DIPLOMA
  - f.  SARJANA MUDA
6. Secara purata, dalam sehari berapa jamkah anda tidur?  
\_\_\_\_\_ jam \_\_\_\_\_ minit
7. Secara purata, dalam sehari berapa jamkah anda duduk di atas kerusi?  
\_\_\_\_\_ jam \_\_\_\_\_ minit

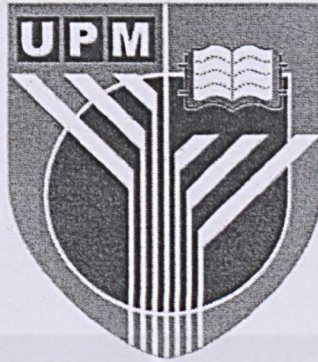
## BAHAGIAN B: AKTIVITI HARIAN RUMAH

8. Adakah anda melakukan aktiviti kerja berat?  
 Ya  Tidak
9. Adakah anda bersukan?  
 Ya  Tidak

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## APPENDIX 5

General Comfort Rating



UNIVERSITI PUTRA MALAYSIA

JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN

FAKULTI PERUBATAN DAN SAINS KESIHATAN

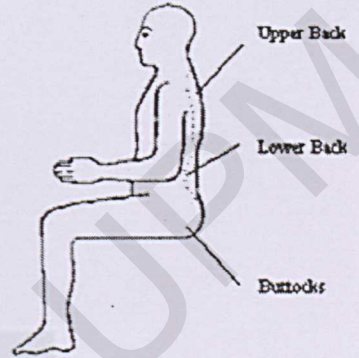
BORANG KAJIAN KEBERKESANAN KERUSI ERGONOMIK PADA TAHAP  
KETIDAKSELESAAN DAN AKTIVITI OTOT DI KALANGAN ORANG DEWASA

SEMUA MAKLUMAT DIJAMIN SULIT

Sila isikan maklumat dan tandakan pada ruang yang berkenaan

**DOES YOUR BODY HURT NOW?**

Parts of Body	OCR Scale Rating
Head or Neck	
Shoulder	
Upper Back	
Arms and Hands	
Lower Back	
Buttocks	
Thighs	
Knees	
Lower Legs/ Calves	
Ankles and Feet	



Total Sector Length	<input type="text"/>
Hours Elapsed	<input type="text"/>
Date	<input type="text"/>
Subject	<input type="text"/>
Signature	<input type="text"/>

UPM

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## General Comfort Rating

Please rate the chair on your feelings now, by choosing a ranking of the most comfortable and the least comfortable.

- 1 I feel completely relaxed (Saya merasa benar-benar santai)
- 2 I feel perfectly comfortable (Saya merasa sangat selesa)
- 3 I feel quite comfortable (Saya merasa agak selesa)
- 4 I feel barely comfortable (Saya merasa hampir tidak selesa)
- 5 I feel uncomfortable (Saya merasa tidak selesa)
- 6 I feel restless and fidgety (Saya merasa resah)
- 7 I feel cramped (Saya merasa kejang)
- 8 I feel stiff (Saya merasa kaku)
- 9 I feel numb (or pins and needles) (Saya merasa kebas (seperti dicucuk pin atau jarum))
- 10 I feel sore and tender (Saya merasa sakit)
- 11 I feel unbearable pain (Saya merasa sangat sakit)

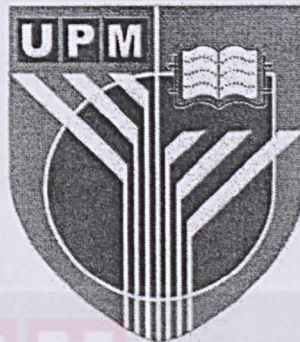
The logo of Universiti Putra Malaysia (UPM) is centered on the page. It features a shield with a red and white design, including a book and a torch. The letters 'UPM' are prominently displayed in a red box at the top left of the shield.

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## APPENDIX 6

Ergonomic Seating Evaluation

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JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN

FAKULTI PERUBATAN DAN SAINS KESIHATAN

BORANG KAJIAN KEBERKESANAN KERUSI ERGONOMIK PADA TAHAP  
KETIDAKSELESAAN DAN AKTIVITI OTOT DI KALANGAN ORANG DEWASA

SEMUA MAKLUMAT DIJAMIN SULIT

Sila isikan maklumat dan bulatkan pada ruang yang berkenaan

## Ergonomic Sitting Evaluation

Type of Chair: \_\_\_\_\_

Date: \_\_\_\_\_

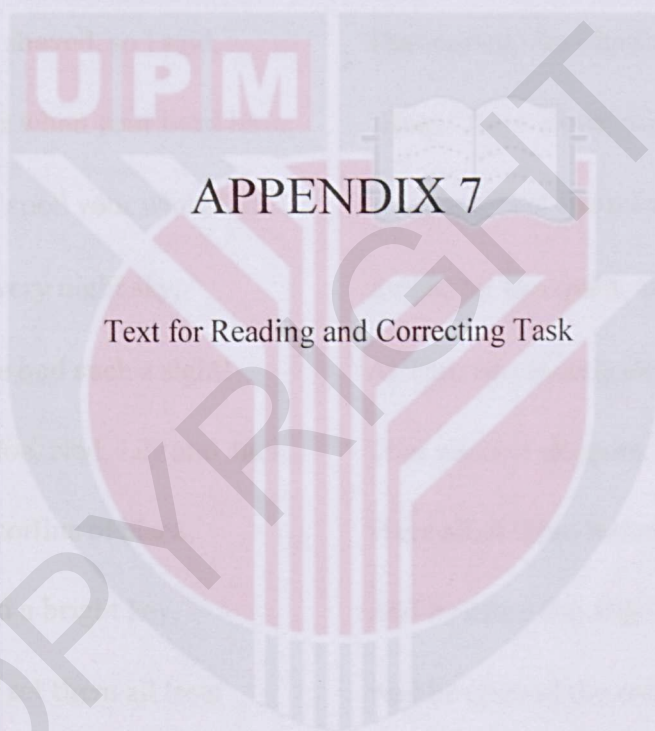
Evaluation Criteria	Marks out of 10
<b>A: Chair Adjustments (are these available and how usable are they?)</b>	<b>Unacceptable(0) -- Average(5) -- Excellent(10)</b>
1. Usability and range of seat pan depth adjustment	0-1-2-3-4-5-6-7-8-9-10
2. Usability and range of back height adjustment while sitting	0-1-2-3-4-5-6-7-8-9-10
3. Usability and range of backrest recline adjustment while sitting	0-1-2-3-4-5-6-7-8-9-10
4. Arm support range of adjustability	0-1-2-3-4-5-6-7-8-9-10
5. Chair seat, back and arms adjust independently to allow comfortable sitting	0-1-2-3-4-5-6-7-8-9-10
	<b>A: Chair Adjustments Score =</b>
<b>B: Seat Comfort</b>	<b>Unacceptable(0) -- Average(5) --Excellent(10)</b>
6. Seat pan/cushion comfort (evaluate after at least 90 min. of sitting)	0-1-2-3-4-5-6-7-8-9-10
7. Seat edge contour comfort (no pressure points under buttocks, thighs, knees)	0-1-2-3-4-5-6-7-8-9-10
8. Backrest cushion comfort (evaluate at various recline positions)	0-1-2-3-4-5-6-7-8-9-10
9. Armrest comfort (when sitting back and resting arms)	0-1-2-3-4-5-6-7-8-9-10
	<b>B: Seat Comfort Score =</b>

<b>C: Ease of Use</b>	<b>Unacceptable(0) -- Average(5) -- Excellent(10)</b>
10. Ease of chair seat height adjustment while sitting	0-1-2-3-4-5-6-7-8-9-10
11. Ease of seat pan depth adjustment while sitting	0-1-2-3-4-5-6-7-8-9-10
12. Ease of armrest height adjustment while sitting	0-1-2-3-4-5-6-7-8-9-10
13. Ease of backrest recline adjustment while sitting	0-1-2-3-4-5-6-7-8-9-10
14. Ease of cleaning chair parts and materials	0-1-2-3-4-5-6-7-8-9-10
	<b>C: Ease-of-use Score =</b>
<b>D: Body Support</b>	<b>Unacceptable(0) -- Average(5) -- Excellent(10)</b>
15. Mid/Upper back support at various recline positions (no forward push or fall back)	0-1-2-3-4-5-6-7-8-9-10
16. Lumbar (low back) support (evaluate at various recline positions)	0-1-2-3-4-5-6-7-8-9-10
17. Seat pan support at various backrest recline positions	0-1-2-3-4-5-6-7-8-9-10
18. Armrest height support range (below thigh level to above seated elbow height)	0-1-2-3-4-5-6-7-8-9-10
	<b>D: Body Support Score =</b>

E: Overall Chair Experience	Unacceptable(0) -- Average(5) -- Excellent(10)
19. Overall ease of use of the chair and controls (include training & adjustment time, # movements)	0-1-2-3-4-5-6-7-8-9-10
20. Overall appearance of the chair	0-1-2-3-4-5-6-7-8-9-10
21. Overall comfort of the chair	0-1-2-3-4-5-6-7-8-9-10
	E: Overall Chair Experience Score =
<b>TOTAL % ERGONOMIC DESIGN SCORE (%EDS) = ((A+B+C+D+E)/210) x 100 =</b>	

© Professor Alan Hedge, Cornell University, Oct 07

Set A




## APPENDIX 7

Text for Reading and Correcting Task

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## Proofreading Text.

SET A contains the original 10-character string while SET B is either identical or different by few characters. Identify the difference between SET A and SET B under 100%. Highlight the difference by using the "Highlight text"  in this pdf file. Time given for this task is 10 minutes.

### Set A

#### The Chimney Sweeper

By William Blake

There's little Tom Dacre, who cried when his head hit.

That curled like a lamb's back, shaved, so I said,

"Hush, Tom! Never mind it, for when your head bare,

You know that the soot cannot spoil your white hair."

And so he was quiet, and that very night sky,

As Tom was quietly sleeping he had such a sight!

That 1000 of sweepers, Dick, Joe, Ned, Lily and Jack,

Were all of them locked up in coffins of black;

And by came an Angel who had a bright key,

And he opened the coffins and set them all free;

Then down a green plain, leaping, laugh & run away,

And wash in a river and shine in the Sun.

Then naked and white, all their bags left behind them,

They rise upon clouds, and sport in the blowing wind.

The Angel told Tom, if he would be good boy,

He would have his beloved father and never want joy.

### Set A

#### The Chimney Sweeper

By William Blake

There's little tom Dacre, who cried when his head hit.

That curled like a lamb's black, shave, so I said,

"Hush, Tom! Never mind it, for when your head bare,

You know that the soon cannot spoilt your white hair."

And so he was quiet, and that very night sky,

As Tom was quietly sleeping he had such a right!

That 1000 of sleepers, Nick, Joe, Ned, Lily and jack,

Were all of them locked up in coffins of back;

And by came the Angel who had a bright key,

And he opened the coffins and set them all free;

Then down a grey plain, leaping, laugh & ran away,

And wash in a river and whine in the Sun.

Then naked and white, all their bugs left behind them,

They ride upon clouds, nad spot in the blowing wind.

The Angel told tom, if he would be god boy,

He would have his beloved father and never want joy.

## Set A

### **Broken Promises**

By David Kirby

I have met them in dark alleys, limping and one-armed;  
I have seen them playing cards under a single light-bulb  
and tried to join in, but they refused me rudely,  
knowing I would only let them win without any fight.  
I have seen them in the foyers of that theatres,  
coming back late from the interval long after the others  
taken their seats, and in deserted shopping malls late at  
night, peering at things they can never buy and I've  
found them wandering in a wood where I too have.  
This morning I caught one; small and stupid, too slow  
to get away, it was only a promise I had  
made to myself once and then forgot, but it screamed  
and kicked at me and ran to join the others,  
who looked at me with reproach in their sad faces.  
I drew near them, they scurried away even though they  
will sleep in my yard tonight. I hate them for  
their ingratitude, that is making me sick & annoyed to.  
I who have kept countless promises, as dead now as  
Shakespeare's child. "You cowards," I scream, loudly &  
Said "you have to love me—I gave you life!"

## SET B

### **Broken Promises**

By David Kirby

I have met them in dark alleys, limping and one-armed;  
I have see them playing cards under a single light-pulb  
and tried to join in, but they refused me rudely,  
knowing I would only lot them win without any flight.  
I have seen them in the fovers of that theatre,  
coming back late from the interval long after the others  
taken their seas, and in deserted shopping mails late at  
right, peering at things they can never bug and I've  
found them wondering in a wool where I to have.  
This morning I caught on; small and stupid, too show  
to got away, it was only a promise I had  
mad to myself once and then forgot, but it screamed  
and kicked at me and run to join the others,  
who looked at me with reproach in their sad faces.  
I draw near them, their scurried away even though they  
will sleep in my yard tonight. I hate them four  
their ingratitude, that is taking me sick & annoyed to.  
I who have kept countless promise, as dead now as  
Shakespeare's child. "You cowards," I scream, loudly &  
Said "you have to leave me—I gave you live!"

SET A

**The Animals**

By Josephine Jacobsen

At night alone, all of the animals came and shone.  
The full darkness whirled but silent shone all the animals:  
The mighty lion the man the calf the eagle saying  
Sanctus which was and is and is to come again.  
The sleeper watch the people at the water wilderness edge  
The wilderness was made of granite, of thorn, of death,  
It was the goat which lightened the people for praying.  
The goat went out with sin on its sunken head.  
On the sleeper's midnight & the smaller after hours then  
From over below away there shone the animals & crickets  
Through the circular dark the cock appear in bright light  
Crying three times, for tears for tears and for tears.  
High in the frozen tree the sparrow sat. At 3 o'clock  
The luminous thunder of its fall fractured the earth down.  
The sombre serpent looped its coils to write with love  
In scales the slow snake-music of the red globe.  
To all the sleeper, alone, the animals came and shone,  
The darkness whirled but silent shone all of the animals.  
Just before dawn the dove flew out of the dark  
Flying with green in her beak the dove also come.


SET B

**The Animals**

By Josephine Jacobsen

At night lone, all of the animals come and shone.  
The full darkness whirled but silent shine all the animals:  
The mighty lion the mean the calf the eagle laying  
Sanctus which was and is and is to came again.  
The sleepers watch the people at the water wilderness edge  
The wilderness was mode of granite, of thorn, of death,  
It was the goat which lightened the people four praying.  
The goat went out with sun on its sunken head.  
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The sombre serpent looped its boils to write with live  
In scales the show snake-music of the red globe.  
To all the sleaper, alone, the animals came and shone,  
The darkness swirled but silent shone tall of the animals.  
Just before-dawn the dive flew out of the park  
Flying with green in her peak the dove also come.

## Proofreading Text.

SET A contains the original 10-character string while SET B is either identical or different by few characters. Identify the difference between SET A and SET B under 100%. Highlight the difference by using the "Highlight text"  in this pdf file. Time given for this task is 10 minutes.

### Set A

#### Abandoned Farmhouse

By Ted Kooser

He was a big man, says the size of his  
Shoes on a pile of broken dishes by the house;  
A tall man too, says the length of the bed  
In an upstairs room; and a good, God-fearing man, says  
The Bible with a broken back on the floor below  
The window, dusty with sun; but not a man for  
Farming, say the field clutter with boulder and the leaky  
Barn. A woman lived with him, says the bedroom wall  
Papered with lilacs & the kitchen shelves covered with oilcloth,  
and they had a child, says the sandbox made from  
a tractor tire. Money was scarce, say the jars of  
plum preserves and canned tomatoes sealed in the cellar hole.  
And the winters cold, say the rags in the window  
frames. It was lonely here, says the narrow country road.  
Something went wrong, says the empty house in the yard.  
Stones in the fields say he was not a farmer;  
the still-sealed jars in the cellar say she left in  
a nervous haste. And the child? Its toys are strewn  
in the yard like branches after a storm--a rubber  
cow, a rusty tractor with a broken plow, a doll.

### Set B

#### Abandoned Farmhouse

By Ted Kooser

He was a bug man, say the sizes of his  
Shoes in a pole of broken dishe by the house;  
A tall men too, says the length of the bed  
In an upstairs room; and a god, Good-fearing man, says  
The Bible with a broken book on the floor below  
The windows, dusty with sun; but not a man for  
Farming, says the field cluter with boulder and the leak  
Barn. A woman live with him, say the bedroom wall  
Paper with lilacs & the kitchen shelve covered with oilcloth,  
and they had a child, say the sandbox made from  
a tractors tire. Money was scarce, say the jar of  
plum preserve and canned tomatoes seal in the cellar hole.  
And the winter cold, say the rag in the windows  
frame. It was lonely here, says the narrow country roads.  
Something went wrong, say the empty houses in the yard.  
Stone in the fields says she was not a harmer;  
the still-sealed jar in the cellar say she left in  
a nervous hastes. And the child? Its toy are strewn  
in the yard like branch after a storms--a rubbers  
cow, a rusty tractor with a broken low, a doll.

**Set A**

**Ah! Why, Because the Dazzling Sun**

By Emily Brontë

Ah! why, because the dazzling sun Restored my earth to  
Joy Have you departed, every one, And left a desert  
Sky? All through the night, your glorious eyes Were gazing  
Down in mine, And with a full heart's thankful sighs  
I blessed that watch divine! I was at peace, and  
Drank your beams As they were life to me And  
Reveled in my changeful dreams Like petrel on the sea.  
Thought follow thought star to star Why did the morning  
Rise to break So great, so pure a spell, And  
Scorch with fire the tranquil cheek Were you cool radiance  
Fell? Blood-red he rose, & arrow, His fierce beams struck  
My brow; The soul of Nature sprang elate, But mine  
Sank sad and low! My lids closed down—yet through  
Their veil I saw him blazing still; And bathe in  
Gold the misty dale, And flash upon the hill. I  
Turned me to the pillow then To call back Night,  
And see Your worlds of solemn light, again Throb with  
My heart and me! It would not do—the pillow  
Glowed And glowed both roof and floor, And birds sang  
Loudly in the wood, And fresh winds shook the door.

**Set B**

**Ah! Why, Because the Dazzling Sun**

By Emily Brontë

Ah! why, because the dazling sun Restored my earth to  
Joy Have you depart, every one, And left a deserted  
Sky? All through the knight, your glory eye We gazing  
Down in mine, And with a full heart thankful sigh  
I bless that watch divine! I was at peace, and  
Drink your beam As they were life to me And  
Revel in my change dreams Like petrol on the see.  
Thought follows thought stars to star Why did the moning  
Rise to breaking So great, so pure a spill, And  
Scorch with fire the tranquil check We you cool radiance  
Fell? Blood-red he roses, & arrow, His fierce beams struck  
My brow; The soul of Natural sprang elate, But mines  
Sank sadness and low! My lid closing down—yet through  
They veil I saw him blaze still; And bathe in  
Gold the mist doll, And flash upon the hell. I  
Turn me to the pillows then To call back Knight,  
And saw Your world of solemn slight, again Throw with  
My heart and you! It would not to—the pillows  
Glow and glowed both roof and floors, And birds sing  
Loud in the wood, And freshes winds shock the door.

SET A

**Himself**

By Thomas P. Lynch

He'll have been the last of his kind here then.

The flagstone, dry wall the slumping thatch, offices & cow  
cabins, the patch of haggard he sowed spuds and onions  
in—all of it a century out of fashion—all  
giving way to the quiet rising damp of hush and  
vacancy once he is gone. Those long contemplation at the  
fire, cats curling at the door, the dog's lame waltzing,  
the kettle, the candle and the lamp—all still, all  
quenche, all darken, the votive & rosaries & novenas, the  
pipe & Kennedy & Sacred Heart, the bucket, the basket,  
the latch and lock, the tractor that took him into  
town and back for the pension cheque and messages and  
pub, the chair, the bedstead and the chamber pot, Thing  
will amount to not much. Thing will slowly disappear.  
and some niece, a sister's daughter's daughter, 1 blue Aug  
in ten or fifteen years will marry well and will inherit  
it: the cottage ruins, the brown abandon land. They'll  
come to see it in a hired car. The kindly Liverpudlian  
she's wed, in concert with a local auctioneer, will post  
a sign to offer Site for Sale. Into the sea.

SET B


**Himself**

By Thomas P. Lynch

He'll have been the lastest of his kind here then.

The flagstone, dry will the slump thatch, office & cow  
cabin, the patches of hoggard he sowed spuds and onion  
in—all of is a century out of fashion—all  
gave way to the quiet rise damp of hush &  
vacancy one he is gone. These song contemplation at the  
fire, cat curly at the door, the dog's lame waltzings,  
the kittle, the candles and the lamp—all stall, all  
quenche, all dark, the votives & rosaries & novena, the  
pipe & Kennedy & Sacred heart, the bucket, the basket,  
the latch and look, the tractor that take him into  
town and book for the pension cheque and message and  
pub, the chair, the bedstread and the chamber put, Thing  
will amount too not much. Things will slowly disappear.  
and some nice, a sister's daughters daughter, 1 blues Aug  
in ten or fiften years wall marry will and mill inheritance  
it: the cottoge ruin, the brown abandon lands. They'll  
come to saw it in a tired car. The kind Riverpudlian  
she's weed, in concert with a local auctioner, will post  
a sign to offered Site for Sale. Into the saw.

## Proofreading Text.

SET A contains the original 10-character string while SET B is either identical or different by few characters. Identify the difference between SET A and SET B under 100%. Highlight the difference by using the "Highlight text"  in this pdf file. Time given for this task is 10 minutes.

### Set A

### Set B

#### Old Men Playing Basketball

#### Old Men Playing Basketball

By B. H. Fairchild

By B. H. Fairchild

The heavy bodies lunge, the broken language of fake and	The heary bodies lunge, the broken language of take and
Drive, glamorous jump shot slow to a stutter. Their gesture,	Drive, glamorous jump shit slow to a shutter. their gesture,
In love again with the pure geometry of curves, rise	In move again with the sure geometry of curve, rise
Toward the ball, falter, and fall away. On the boards	Toward the ball, farter, and fall away. On the beards
Their hands and fingertips tremble in tense little prayers of	Their hands and fingertip tremble in sense little prayers if
Reach and balance. Then, the grind of bone and socket,	Reach dan balance. Then, the ground of bone and socket,
The caught breath, the sigh, the grunt of the body	The caught breath, the tight, the stunt of the body
Labouring to give birth to itself. In their toiling and	Labouring to give birth to itself. In their boiling and
Grand sweeps, I wonder, do they still make love to	Grand sleeps, I wonders, do they still sake love to
Their wives, kissing the underside of their wrists, dance the	Their wives, missing the undersize of their wrist, dance the
Old soft-shoe of desire? And on the long walk home	Old soft-shoe of desire! And on the song walk home
From the VFW, do they still sing to the drunken	From the TFW, do they still king to the drunken
Moon? Stands full, clock moving, the one in army fatigues	Soon? Stands full, clock loving, the son in army fatigues
And house-shoes says to himself, pick and roll, and the	And horse-shoes slays to himself, pick and toll, and the
Phrase sound musical as ever, radio crooning songs of love	Phrase round musical as ever, radio crowning songs of live
After the game, the girl leaning back in the Chevy's	After the same, the girl learning back in the Cherry's
Front seat as her raven hair flames in the shuddering	Bront seat as his raven hair frames in the shudering
Light of the outdoor movie, and now he drives, gliding	Right of the outdoor mové, and now he drives, sliding
Toward the net. A glass wand of autumn light breaks	Towards the net. A class wand of autumn right breaks
Over the backboard. Boys rise up in old men, wings.	Over the blackboard. Boys rise up in old man, wings.

## Set A

### **The Redeemer**

By Siegfried Sassoon

Darkness: the rain sluiced down; the mire was deep; It  
Was past 12 on a mid-winter night, When peaceful folk  
In beds lay snug asleep; There, with much work to  
Do before the light, We lugged our clay-sucked boots as  
Best we might Along the trench; sometimes a bullet sang,  
And droning shells burst with a hollow bang; We were  
Soak, chill & wretch, every one; Darkness; the distant wink  
Of a huge gun. I turned in the black ditch,  
Loathing the storm; A rocket fizz & burn with blanching  
flare, And lit the face of what had been a  
Form floundering in mirk. He stood before me there; I  
Say that He was Christ; stiff in the glare, And  
Lean forward from His burden task, Both arms support it;  
His eyes on mine Stared from the woeful head that  
Seemed a mask Of mortal pain in Hell's unholy shine.  
No thorny crown, only a woollen cap He wore—an  
English soldier, white and strong, Who loved his time like  
Any simple chap, Good days of work and sport and  
Homely song; Now he has learned that nights are very  
Long, & dawn a watching of the windowed sky, unjudging.

## Set B

### **The Redeemer**

By Siegfried Sassoon

Darkness: the main sluiced down; the wire was peep; It  
Was past 21 on a mid-winter night, When peaceful yolk  
In beds slay snug sleep; There, with much pork to  
Do before the night, We lugged our cay-sucked bots as  
Best we mighty along the trench; sometimes a bullet song,  
And drowning shells burst with a shallow bag; We were  
Soak, chill & wretch, every lone; Darkness; the distant ink  
Or a huge run. I turned in the slack ditch,  
Loathing the storms; A rocket fizz & burn with branching  
flame, And lite the face of what had been as  
Form floundering in milk. He stood before me thee; I  
Say that he was Christ; stiff on the glared, And  
Lean foward from His burden task, Both harms support it  
His eye on mine Starred from the woreful head tart  
Seemed a mask if mortal plain in Hell's unholy shame.  
No thorny clown, only a swollen cap He sore—an  
English soldeer, write and strong, Who love his lime like  
Any simple chop, Good days of work and spurt and  
Homey song; now he was learned that slights are very  
Long, & dawn a watching of the windowed sky, judging.

SET A

**The Way It Sometimes Is**

By Henry Taylor

At times it is like watching a face you have  
Just met, trying to decide who it reminds you of—  
No one, surely, whom you ever hated or loved, but  
Yes, somebody, somebody. You watch the face as it turns  
and nods, showing you, at certain angles, a curve of  
The lips or a lift of the eyebrow that is  
Exactly right, and still the lost face eludes you. Now  
This face is talking, and you hear a sound in  
The voice, the accent on certain words—yes! A phrase . . .  
You barely recall sitting outside, by a pool or a  
Fire, mark a peculiar, recure express. 2 syllables, wasn't it?  
Knob? Bathroom? Shawcross? What the hell kind of word is  
Shawcross? A name; not the right one. A couple of  
Syllables that could possibly be a little like something you  
may once have heard. So the talk drifts, and you  
Drift, sneak glances, pounding your brain. Days later a face  
Occurs to you, and yes, there is a resemblance. That  
Odd word, though, or phrase, is gone. It must have  
Been somebody else. Yes, it's like that, at times; something  
is; maybe; when you can almost say what it is.


SET B

**The Way It Sometimes Is**

By Henry Taylor

At time it is like watching a fake you have  
Just meet, trying to decide who it reminds your of—  
No none, surely, whom you ever hate or love, but  
Yes, somebody, somebony. You catch the face as it turns  
and nods, showing your, at certain angles, a curves of  
The lips or as lift of the eyebrow that is  
Exactly might, and still the loss face eludes you. Now  
This faces is talking, and you heard a sound in  
The voice, the acent on certain words—nos! A phrase . . .  
You barely recall sitting inside, by a pool on a  
Fire, marks a peculiar, recure express. 3 syllables, wasn't it?  
Knob? Bathroom? Shaw cross? What the hell kind of word is  
Shawcross? A tame; not the right on. A couple if  
Syllable that could possibly be i little luke something you  
May once have heard. So the talk drift, & you  
Drift, sneap glances, rounding your brain. Days late a face  
Occurs to u, and yes, there in a resemblance. That  
Old word, though, on phrase, is pone. It must have  
Been someone else. Yes, its like that, at time; something  
is; maybe; when you cant almost lay what it if.

## Numeric Verification Test (NVT)

SET A contains the original 10-digit strings while SET B is either identical or different by few characters. Identify the difference between SET A and SET B. Highlight the difference by using the "Highlight text"  in this pdf file. Time given for this task is 10 minutes.

<u>SET A</u>	<u>SET B</u>
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8923664135	8923694135
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7742633909	7748638909
-----	-----
0019919278	0119919278
-----	-----
2843145663	2843145683
-----	-----
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-----	-----
4107312034	4167312034
-----	-----
9761457789	9761457789
-----	-----
9516870356	9516970355
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7227626721	7272629721
-----	-----
4988255115	4988255715
-----	-----
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-----	-----
0845789876	0842789976
-----	-----
0678302007	0638303007
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4585811643	4582811663
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9466004391	9269904361
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8516057065	8418053065

2218324378

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2085160571

1833437833

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2768758263

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1845353117

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1964606040

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2058160371

## Adventures Of Huckleberry Finn – Chapter 1

You don't know about me without you have read a book by the name of The Adventures of Tom Sawyer, but that ain't no matter. That book was made by Mr. Mark Twain, and he told the truth, mainly. There was things which he stretched, but mainly he told the truth. That is nothing. I never seen anybody but lied one time or another, without it was Aunt Polly, or the widow, or maybe Mary. Aunt Polly—Tom's Aunt Polly, she is—and Mary, and the Widow Douglas is all told about in that book, which is mostly a true book, with some stretchers, as I said before.

Now the way that the book winds up is this: Tom and me found the money that was hid in the cave, and it made us rich. We got six thousand dollars' worth—all gold—was a awful sight of money when it was first counted. Tom he took it and put it in a box, and he fetched us a dollar a piece for the box, and he made us take it. What to do with The Widow Douglas she took me for her son, and she called me Tom, but it was rough living in the cave all the time, and the widow she sent the widow was in all her ways, and she wanted me to be a regular boy, and she had a party with sugar-bread and molasses, and she had me up and said she was going to start a school in my honor, and she was going to be the widow and be respectable. So I went back

## APPENDIX 8

### Articles used in Typing Task

The widow she cried over me, and she called me a lot of other names, too, but she never meant no harm. Tom Sawyer that was a bad boy, and I couldn't do nothing but what she wanted me to do. Well, then the old thing commenced again. The widow she wanted me to be a regular boy, and she had a party with sugar-bread and molasses, and she had me up and said she was going to start a school in my honor, and she was going to be the widow and be respectable. So I went back

After she had got out her book, and began to read about Moses and the Holiness, and I was in a hurry to find out all about him, but she wouldn't let me. She let it out that Moses had been dead a long time, so I didn't see no more about him, because I don't take no stock in people.

Praxy soon I wanted to smoke, and I asked the widow to let me, but she wouldn't. She said it was against practice and wasn't right, and I had to be good for the Lord's sake. That is just the way with

## Adventures Of Huckleberry Finn – Chapter 1

You don't know about me without you have read a book by the name of The Adventures of Tom Sawyer; but that ain't no matter. That book was made by Mr. Mark Twain, and he told the truth, mainly. There was things which he stretched, but mainly he told the truth. That is nothing. I never seen anybody but lied one time or another, without it was Aunt Polly, or the widow, or maybe Mary. Aunt Polly--Tom's Aunt Polly, she is--and Mary, and the Widow Douglas is all told about in that book, which is mostly a true book, with some stretchers, as I said before.

Now the way that the book winds up is this: Tom and me found the money that the robbers hid in the cave, and it made us rich. We got six thousand dollars apiece--all gold. It was an awful sight of money when it was piled up. Well, Judge Thatcher he took it and put it out at interest, and it fetched us a dollar a day apiece all the year round--more than a body could tell what to do with. The Widow Douglas she took me for her son, and allowed she would sivilize me; but it was rough living in the house all the time, considering how dismal regular and decent the widow was in all her ways; and so when I couldn't stand it no longer I lit out. I got into my old rags and my sugar-hogshead again, and was free and satisfied. But Tom Sawyer he hunted me up and said he was going to start a band of robbers, and I might join if I would go back to the widow and be respectable. So I went back.

The widow she cried over me, and called me a poor lost lamb, and she called me a lot of other names, too, but she never meant no harm by it. She put me in them new clothes again, and I couldn't do nothing but sweat and sweat, and feel all cramped up. Well, then, the old thing commenced again. The widow rung a bell for supper, and you had to come to time. When you got to the table you couldn't go right to eating, but you had to wait for the widow to tuck down her head and grumble a little over the victuals, though there warn't really anything the matter with them,--that is, nothing only everything was cooked by itself. In a barrel of odds and ends it is different; things get mixed up, and the juice kind of swaps around, and the things go better.

After supper she got out her book and learned me about Moses and the Bulrushers, and I was in a sweat to find out all about him; but by and by she let it out that Moses had been dead a considerable long time; so then I didn't care no more about him, because I don't take no stock in dead people.

Pretty soon I wanted to smoke, and asked the widow to let me. But she wouldn't. She said it was a mean practice and wasn't clean, and I must try to not do it any more. That is just the way with

some people. They get down on a thing when they don't know nothing about it. Here she was a-bothering about Moses, which was no kin to her, and no use to anybody, being gone, you see, yet finding a power of fault with me for doing a thing that had some good in it. And she took snuff, too; of course that was all right, because she done it herself.

Her sister, Miss Watson, a tolerable slim old maid, with goggles on, had just come to live with her, and took a set at me now with a spelling book. She worked me middling hard for about an hour, and then the widow made her ease up. I couldn't stood it much longer. Then for an hour it was deadly dull, and I was fidgety. Miss Watson would say, "Don't put your feet up there, Huckleberry;" and "Don't scrunch up like that, Huckleberry--set up straight;" and pretty soon she would say, "Don't gap and stretch like that, Huckleberry--why don't you try to behave?" Then she told me all about the bad place, and I said I wished I was there. She got mad then, but I didn't mean no harm. All I wanted was to go somewheres; all I wanted was a change, I warn't particular. She said it was wicked to say what I said; said she wouldn't say it for the whole world; she was going to live so as to go to the good place. Well, I couldn't see no advantage in going where she was going, so I made up my mind I wouldn't try for it. But I never said so, because it would only make trouble, and wouldn't do no good.

Now she had got a start, and she went on and told me all about the good place. She said all a body would have to do there was to go around all day long with a harp and sing, forever and ever. So I didn't think much of it. But I never said so. I asked her if she reckoned Tom Sawyer would go there, and she said not by a considerable sight. I was glad about that, because I wanted him and me to be together.

Miss Watson she kept pecking at me, and it got tiresome and lonesome. By and by they fetched the niggers in and had prayers, and then everybody was off to bed. I went up to my room with a piece of candle, and put it on the table. Then I set down in a chair by the window and tried to think of something cheerful, but it warn't no use. I felt so lonesome I most wished I was dead. The stars were shining, and the leaves rustled in the woods ever so mournful; and I heard an owl, away off, who-whooping about somebody that was dead, and a whippowill and a dog crying about somebody that was going to die; and the wind was trying to whisper something to me, and I couldn't make out what it was, and so it made the cold shivers run over me. Then away out in the woods I heard that kind of a sound that a ghost makes when it wants to tell about something that's on its mind and can't make itself understood, and so can't rest easy in its grave, and has to go about that way every night grieving. I got so down-hearted and scared I did wish I had some company. Pretty soon a spider went crawling up my shoulder, and I flipped it off and it lit in the candle; and before I could budge it was all shriveled up. I didn't need anybody to tell me that that

was an awful bad sign and would fetch me some bad luck, so I was scared and most shook the clothes off of me. I got up and turned around in my tracks three times and crossed my breast every time; and then I tied up a little lock of my hair with a thread to keep witches away. But I hadn't no confidence. You do that when you've lost a horseshoe that you've found, instead of nailing it up over the door, but I hadn't ever heard anybody say it was any way to keep off bad luck when you'd killed a spider.

I set down again, a-shaking all over, and got out my pipe for a smoke; for the house was all as still as death now, and so the widow wouldn't know. Well, after a long time I heard the clock away off in the town go boom--boom--boom--twelve licks; and all still again--stiller than ever. Pretty soon I heard a twig snap down in the dark amongst the trees-- something was a stirring. I set still and listened. Directly I could just barely hear a "me-yow! me-yow!" down there. That was good! Says I, "me-yow! me-yow!" as soft as I could, and then I put out the light and scrambled out of the window on to the shed. Then I slipped down to the ground and crawled in among the trees, and, sure enough, there was Tom Sawyer waiting for me.

## A Tale Of Two Cities – Chapter 1

It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct to Heaven, we were all going direct the other way--in short, the period was so far like the present period, that some of its noisiest authorities insisted on its being received, for good or for evil, in the superlative degree of comparison only.

There were a king with a large jaw and a queen with a plain face, on the throne of England; there were a king with a large jaw and a queen with a fair face, on the throne of France. In both countries it was clearer than crystal to the lords of the State preserves of loaves and fishes, that things in general were settled for ever.

It was the year of Our Lord one thousand seven hundred and seventy-five. Spiritual revelations were conceded to England at that favoured period, as at this. Mrs. Southcott had recently attained her five-and-twentieth blessed birthday, of whom a prophetic private in the Life Guards had heralded the sublime appearance by announcing that arrangements were made for the swallowing up of London and Westminster. Even the Cock-lane ghost had been laid only a round dozen of years, after rapping out its messages, as the spirits of this very year last past (supernaturally deficient in originality) rapped out theirs. Mere messages in the earthly order of events had lately come to the English Crown and People, from a congress of British subjects in America: which, strange to relate, have proved more important to the human race than any communications yet received through any of the chickens of the Cock-lane brood.

France, less favoured on the whole as to matters spiritual than her sister of the shield and trident, rolled with exceeding smoothness down hill, making paper money and spending it. Under the guidance of her Christian pastors, she entertained herself, besides, with such humane achievements as sentencing a youth to have his hands cut off, his tongue torn out with pincers, and his body burned alive, because he had not kneeled down in the rain to do honour to a dirty procession of monks which passed within his view, at a distance of some fifty or sixty yards. It is likely enough that, rooted in the woods of France and Norway, there were growing trees, when that sufferer was put to death, already marked by the Woodman, Fate, to come down and be sawn into boards, to make a certain movable framework with a sack and a knife in it, terrible in history. It is likely enough that in the rough outhouses of some tillers of the heavy lands adjacent to Paris, there were sheltered from the weather that very day, rude carts, bespattered with rustic

mire, snuffed about by pigs, and roosted in by poultry, which the Farmer, Death, had already set apart to be his tumbrils of the Revolution. But that Woodman and that Farmer, though they work unceasingly, work silently, and no one heard them as they went about with muffled tread: the rather, forasmuch as to entertain any suspicion that they were awake, was to be atheistical and traitorous.

In England, there was scarcely an amount of order and protection to justify much national boasting. Daring burglaries by armed men, and highway robberies, took place in the capital itself every night; families were publicly cautioned not to go out of town without removing their furniture to upholsterers' warehouses for security; the highwayman in the dark was a City tradesman in the light, and, being recognised and challenged by his fellow-tradesman whom he stopped in his character of "the Captain," gallantly shot him through the head and rode away; the mall was waylaid by seven robbers, and the guard shot three dead, and then got shot dead himself by the other four, "in consequence of the failure of his ammunition:" after which the mall was robbed in peace; that magnificent potentate, the Lord Mayor of London, was made to stand and deliver on Turnham Green, by one highwayman, who despoiled the illustrious creature in sight of all his retinue; prisoners in London gaols fought battles with their turnkeys, and the majesty of the law fired blunderbusses in among them, loaded with rounds of shot and ball; thieves snipped off diamond crosses from the necks of noble lords at Court drawing-rooms; musketeers went into St. Giles's, to search for contraband goods, and the mob fired on the musketeers, and the musketeers fired on the mob, and nobody thought any of these occurrences much out of the common way. In the midst of them, the hangman, ever busy and ever worse than useless, was in constant requisition; now, stringing up long rows of miscellaneous criminals; now, hanging a housebreaker on Saturday who had been taken on Tuesday; now, burning people in the hand at Newgate by the dozen, and now burning pamphlets at the door of Westminster Hall; to-day, taking the life of an atrocious murderer, and to-morrow of a wretched pilferer who had robbed a farmer's boy of sixpence.

All these things, and a thousand like them, came to pass in and close upon the dear old year one thousand seven hundred and seventy-five. Environed by them, while the Woodman and the Farmer worked unheeded, those two of the large jaws, and those other two of the plain and the fair faces, trod with stir enough, and carried their divine rights with a high hand. Thus did the year one thousand seven hundred and seventy-five conduct their Greatnesses, and myriads of small creatures--the creatures of this chronicle among the rest--along the roads that lay before them.

## A Clergyman's Daughter – Chapter 1

As the alarm clock on the chest of drawers exploded like a horrid little bomb of bell metal, Dorothy, wrenched from the depths of some complex, troubling dream, awoke with a start and lay on her back looking into the darkness in extreme exhaustion.

The alarm clock continued its nagging, feminine clamour, which would go on for five minutes or thereabouts if you did not stop it. Dorothy was aching from head to foot, and an insidious and contemptible self-pity, which usually seized upon her when it was time to get up in the morning, caused her to bury her head under the bedclothes and try to shut the hateful noise out of her ears. She struggled against her fatigue, however, and, according to her custom, exhorted herself sharply in the second person plural. Come on, Dorothy, up you get! No snoozing, please! Proverbs vi, 9. Then she remembered that if the noise went on any longer it would wake her father, and with a hurried movement she bounded out of bed, seized the clock from the chest of drawers, and turned off the alarm. It was kept on the chest of drawers precisely in order that she should have to get out of bed to silence it. Still in darkness, she knelt down at her bedside and repeated the Lord's Prayer, but rather distractedly, her feet being troubled by the cold.

It was just half past five, and coldish for an August morning. Dorothy (her name was Dorothy Hare, and she was the only child of the Reverend Charles Hare, Rector of St Athelstan's, Knype Hill, Suffolk) put on her aged flannelette dressing-gown and felt her way downstairs. There was a chill morning smell of dust, damp plaster, and the fried dabs from yesterday's supper, and from either side of the passage on the second floor she could hear the antiphonal snoring of her father and of Ellen, the maid of all work. With care--for the kitchen table had a nasty trick of reaching out of the darkness and banging you on the hip-bone--Dorothy felt her way into the kitchen, lighted the candle on the mantelpiece, and, still aching with fatigue, knelt down and raked the ashes out of the range.

The kitchen fire was a 'beast' to light. The chimney was crooked and therefore perpetually half choked, and the fire, before it would light, expected to be dosed with a cupful of kerosene, like a drunkard's morning nip of gin. Having set the kettle to boil for her father's shaving-water, Dorothy went upstairs and turned on her bath. Ellen was still snoring, with heavy youthful snores. She was a good hard-working servant once she was awake, but she was one of those girls whom the Devil and all his angels cannot get out of bed before seven in the morning.

Dorothy filled the bath as slowly as possible--the splashing always woke her father if she turned on the tap too fast--and stood for a moment regarding the pale, unappetizing pool of water. Her body had gone goose-flesh all over. She detested cold baths; it was for that very reason that she made it a rule to take all her baths cold from April to November. Putting a tentative hand into the water-- and it was horribly cold--she drove herself forward with her usual exhortations. Come on, Dorothy! In you go! No funking, please! Then she stepped resolutely into the bath, sat down and let the icy girdle of water slide up her body and immerse her all except her hair, which she had twisted up behind her head. The next moment she came to the surface gasping and wriggling, and had no sooner got her breath back than she remembered her 'memo list', which she had brought down in her dressing-gown pocket and intended to read. She reached out for it, and, leaning over the side of the bath, waist deep in icy water, read through the 'memo list' by the light of the candle on the chair.

It ran:

7 oc. H.C.

Mrs T baby? Must visit.

BREAKFAST. Bacon. MUST ask father money. (P)

Ask Ellen what stuff kitchen father's tonic NB. to ask about stuff for curtains at Solepipe's.

Visiting call on Mrs P cutting from Daily M angelica tea good for rheumatism Mrs L's cornplaster.

12 oc. Rehearsal Charles I. NB. to order 1/2 lb glue 1 pot aluminium paint.

DINNER (crossed out) LUNCHEON . . . ?

Take round Parish Mag NB. Mrs F owes 3/6d.

4.30 pm Mothers' U tea don't forget 2 1/2 yards casement cloth.

Flowers for church NB. 1 tin Brasso.

SUPPER. Scrambled eggs.

Type Father's sermon what about new ribbon typewriter?

NB. to fork between peas bindweed awful.

Dorothy got out of her bath, and as she dried herself with a towel hardly bigger than a table napkin--they could never afford decent- sized towels at the Rectory--her hair came unpinned and fell down over her collar-bones in two heavy strands. It was thick, fine, exceedingly pale hair, and it was perhaps as well that her father had forbidden her to bob it, for it was her only positive beauty. For the rest, she was a girl of middle height, rather thin, but strong and shapely, and her face was her weak point. It was a thin, blonde, unremarkable kind of face, with pale eyes and a nose just a shade too long; if you looked closely you could see crow's feet round the eyes, and the mouth, when it was in repose, looked tired. Not definitely a spinsterish face as yet, but it certainly would be so in a few years' time. Nevertheless, strangers commonly took her to be several years younger than her real age (she was not quite twenty-eight) because of the expression of almost childish earnestness in her eyes. Her left forearm was spotted with tiny red marks like insect bites.

