



**UNIVERSITI PUTRA MALAYSIA**

***THE ERGONOMICS OF SEATING DESIGN IN LECTURE HALL AT  
FACULTY OF MEDICINE AND HEALTH SCIENCES (FMHS),  
UNIVERSITI PUTRA MALAYSIA (UPM)***

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FPSK4 2016 6**

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FACULTY OF MEDICINE AND HEALTH SCIENCES (FMHS),  
UNIVERSITI PUTRA MALAYSIA (UPM)**

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

1000719348

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## ABSTRACT

### THE ERGONOMICS OF SEAT DESIGN IN LECTURE HALLS AT FACULTY OF MEDICINE AND HEALTH SCIENCES (FMHS), UNIVERSITI PUTRA MALAYSIA (UPM)

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This is a cross-sectional study with the objective to determine the association between complaints Musculoskeletal Discomfort (MSDs) and mismatch of the seats in lecture hall of FMHS, UPM. A total of 132 respondents whom were undergraduate students were involved in this study consist of 47 male and 85 female. Eight anthropometric parameters (height, weight, popliteal height, buttock-popliteal height, shoulder height, subscapular height, elbow height and hip width while sitting) as well as five (5) seats dimensions (seat height, seat depth, seat width, upper edge backrest height and desk height) were measuring Martyn anthropometer and measuring tape. Instruments used were questionnaire modified from Nordic Musculoskeletal Questionnaire, Martyn anthropometer set, measuring tape, height scale and weighing scale. Compared to the anthropometric dimension of the respondents, there were 51.5% mismatch for seat height, 5.3% mismatch for seat depth, 100% match for seat width, 94.7% mismatch for desk height and 18.2% mismatch for upper edge of back rest. For the prevalence of MSDs in the past seven (7) days, 61.4% reported low back pain followed by neck pain (50%) and upper back pain (43.9%). There was significant difference between genders in anthropometric body measurement. There was also have significant association between MSDs and mismatch  $\chi^2 = 5.406$ ,  $p < 0.05$ . In conclusion, there was association between MSDs and ergonomic seats of lecture halls in FMHS, UPM. It is recommended for user to physically active and take break from every 1 hours of seating. For future study, improve the study by including more variables that can lead to MSDs and improve the study design.

**Keyword: Mismatch, anthropometry, MSDs, university student**

## ABSTRAK

### ERGONOMIK REKA BENTUK TEMPAT DUDUK DI DALAM DEWAN KULIAH, FAKULTI PERUBATAN DAN SAINS KESIHATAN (FPSK), UNIVERSITI PUTRA MALAYSIA (UPM)

Nur Aisyah binti Alias dan Ng Yee Guan

Kajian ini merupakan kajian keratan rentas dengan objektif untuk menentukan hubungkait antara aduan gangguan muskuloskeletal (MSDs) dan ketidakpadanan kerusi di dalam dewan kuliah. Sebanyak 132 orang responden yang terdiri daripada pelajar prasiswazah yang terdiri daripada 47 orang lelaki dan 85 orang perempuan telah mengambil bahagian dalam kajian ini. Lapan (8) parameter antropometri telah diambil (tinggi, berat, ketinggian popliteal, panjang punggung-popliteal, ketinggian bahu, ketinggian subscapular, ketinggian siku dan kelebaran punggung ketika duduk) serta lima (5) parameter dimensi perabot (ketinggian kerusi, kedalaman kerusi, kelebaran kerusi, ketinggian tempat bersandar dan ketinggian meja) telah diambil. Instrumen yang digunakan adalah borang soal selidik yang telah diadaptasi daripada Borang Soal selidik Gangguan Muskuloskeletal Nordic, set antropometer Martyn, pita pengukur dan penimbang berat. Berdasarkan perbandingan antara adimensi antropometri responden, 51.5% ketidakpadanan bagi tinggi kerusi, 5.3% ketidakpadanan bagi kedalaman kerusi, 100% kepadanan bagi kelebaran kerusi, 94.7% ketidakpadanan bagi tinggi meja dan 18.2% ketidakpadanan bagi ketinggian tempat bersandar. Bagi kelaziman gangguan muskuloskeletal untuk 7 hari, 61.4% melaporkan mengalami kesakitan di bahagian belakang diikuti 50% bagi kesakitan di bahagian leher dan 43.9% kesakitan di bahagian bahu. Selain itu, terdapat perbezaan antara jantina berkenaan ukuran antropometri badan, terdapat juga hubungan antara MSDs dan ketidakpadanan  $\chi^2 = 5.406$ ,  $p < 0.05$ . Konklusinya, terdapat hubungan antara MSDs dan perabot di dalam dewan kuliah. Bagi penambahbaikan kepada responden, responden dinasihatkan supaya sentiasa aktif dan mengambil rehat setelah satu jam kuliah. Bagi menambahbaik kajian ini pada masa hadapan ialah dengan memasukkan lebih banyak faktor yang boleh mengakibatkan MSDs dan menambah baik reka bentuk kajian.

Kata Kunci: Ketidakpadanan, antropometri, MSDs, pelajar universiti.

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## LIST OF ABBREVIATIONS

BPL	Buttock-popliteal length
CTD	Cumulative trauma disorder
DH	Desk height
EHS	Elbow height sitting
HW	Hip width
IEA	International Ergonomics Association
MSDs	Musculoskeletal discomfort
OOS	Overuse syndrome
PH	Popliteal height
RSI	Repetitive strain injury
SD	Seat depth
SH	Seat height
SHS	Shoulder height sitting
SUH	Subscapular height
SW	Sea width
UEB	Upper edge of backrest
WMSD	Work-related musculoskeletal disorder

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1. Background**

Furniture is an essential physical element in classroom where the learning process takes place. Without furniture which are adapted to the users body dimension the learning process will be distracted. Furniture which fits the physical anthropometry of students will boost their learning performance. While the incompatibility furniture with the student's anthropometry body dimension may cause poor sitting posture and distracted their learning performance (Geldhof et al., 2007; Koskelo et al., 2007). The study from Odunaiya et al. (2014) found that there is mismatch between seats and anthropometry body dimension and it concluded that the design of furniture being used in the classroom should be improved to enhance conducive learning progress.

Gouvali and Boudolos (2006) in their study found that most of the students having difficulties to find the chairs and table that were fits with them. To be extend, it cause high prevalence of back pain among high-school students and increases with age whereby the lifetime prevalence of back pain will exceed 50% by 15 years of age (Murphy et al., 2004; Van Gent et al., 2003; Hakala et al., 2002; Wedderkopp et al., 2001; Grimmer and William, 2000; Burton et al., 1996).

Although studies investigated prolonged sitting in the workplace proposed well-design for seats and desk but the compatibility of the furniture dimensions to students' body dimension remain questionable as the students in a study by Schlossberg (2004) were still reporting discomfort.

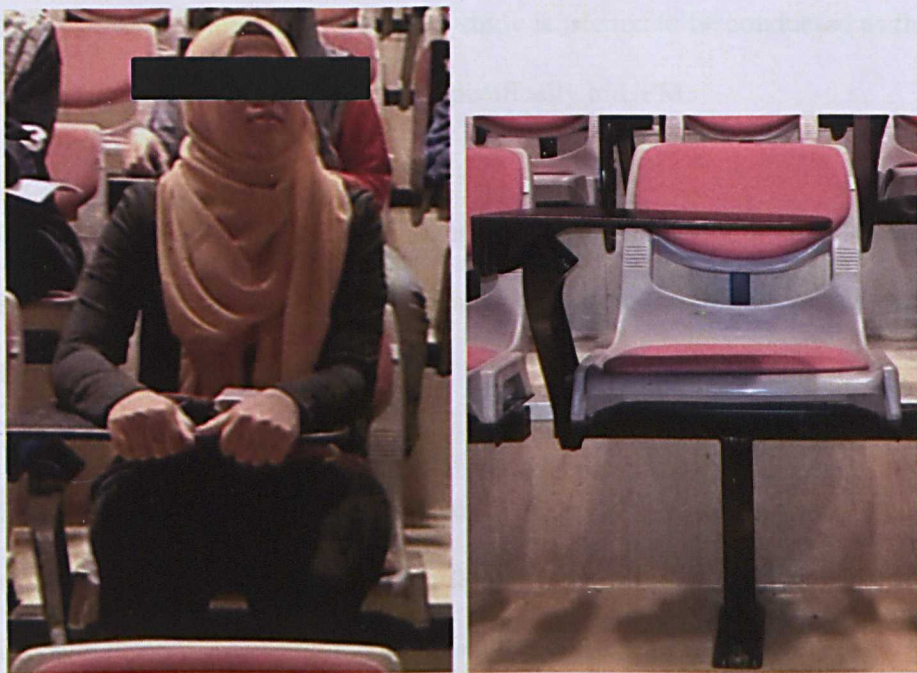
## 1.2.Problem statement

The seat in the lecture hall is a fixed type chairs with side (foldable) table as the price and maintenance is low as compared to the adjustable chair (Straker et al., 1999; Gouvali and Boudolos, 2006). However, studying in fixed-chair may caused constrain postures (Parcells et al., 1999; Gouvali and Boudolos; 2006), which limit the student's body movement. Hence, promote static loads, a risk factor for musculoskeletal discomfort and soon will develop to musculoskeletal disorders (Cascioli et al., 2011).

Many studies have investigated ergonomics problem associated with the design of school furniture and its function (Parcells et al. 1999; Milanese and Grimmer, 2004; Murphy et al, 2004; Panagiotopoulou et al., 2004; Gouvali and Boudolus, 2006). Improper design of furniture will result in the lack of focus or concentrate which will reduce efficiency and may cause musculoskeletal disorders (MSDs) (Mohd Asif et al., 2012).

The study from Farahani and Shakib (2009) showed that students spend about 84% to 88% of their time in sitting position. The study conducted from Troussier (1999) found out that about 41.6% of the students experienced pain while sitting in the classroom and 69.5% experienced back pain that occurred after 1 hour sitting and the pain increases with time. The study from Adejuyigbe and Ali, (2004) found that the static position while sitting by leaning forward have been confirmed to be one of major cause of back pain which is not limited to adults (Troussier, 1994; Niemi et al., 1997).

This showed that the incompatibility of student's body dimension and chair may develop MSDs and in addition of prolonged sitting it will enhance the probability of the lecture hall user to develop MSDs in such a young age. This can be a problem as students were only in their early adulthood and if they developed MSDs this will trouble them in the future.



**Figure 1.1: Current chairs and table at lecture hall**

### 1.3. Study justification

The study about the mismatch of anthropometric body dimension and furniture for the student in university is not as much as a primary and secondary student. As far as concern, there is a few study about anthropometric body dimension and furniture in Malaysia at the university level. This study is needed to be conducted as there is still no study conducted for lecture halls specifically to UPM.

Currently, the lecture halls is not standardise among faculty at UPM in term of sizes and types. Hopefully this study can help in term in designing new furniture for the furniture of future lecture halls.

Besides that, this study is also expected to be able to create awareness among the students. The results of this study will also benefit the organizational stakeholder in consideration of the ergonomics risk factors in the university environment.

#### 1.4.Objective

i. General objective

To determine the association between complaints of Musculoskeletal Discomfort (MSDs) and mismatch of the seats in lecture hall of FMHS, UPM.

ii. Specific objectives

- i. To determine the demographic information of the student who using lecture hall.
- ii. To measure and determine the seat dimension of chairs in the lecture hall.
- iii. To measure and determine anthropometric dimension of students in sitting position.
- iv. To determine the prevalence of MSDs among students in FMHS.
- v. To determine the mismatch between sitting anthropometric measurement of student with the chair dimension in the lecture hall.
- vi. To determine the association between prevalence of MSDs and anthropometry- chair mismatch.
- vii. To recommend the suitable furniture dimension based on anthropometry body dimension.

## 1.5.Hypothesis

- i. There was significant difference between male and female anthropometry body dimension.
- ii. There was mismatch between anthropometric body dimension and chairs in lecture hall.
- iii. There was association between 7 days prevalence of MSDs and mismatch.

## 1.6.Definition of term

- i. Conceptual definition
  - i. Popliteal height (PH)

The vertical distance from the posterior surface of the knee (popliteal surface) and floor or footrest measured with 90° knee flexion (Castellucci, 2015).
  - ii. Buttock-popliteal length (BPL)

Horizontal distance between the most posterior point on the buttock and the back of the knees ass measured in the seating position with 90° knee flexion (Castellucci, 2015).

iii. Hip width (HW)

The horizontal distance measured in the widest point of the hip in the sitting position (Castellucci, 2015).

iv. Elbow height sitting (EHS)

Vertical distance from a horizontal sitting surface to the lowest bony point of the elbow bent at the right angle with their forearm horizontal (Castellucci, 2015).

v. Shoulder height sitting (SHS).

The vertical distance from a horizontal sitting surface to the acromion (Castellucci, 2015)

vi. Subscapular height (SUH)

Vertical distance from the lowest point (inferior angle) of the scapula to the subject's seated measure (Castellucci, 2015).

vii. Seat height (SH)

Vertical distance from the floor to the middle point of the front edge of the seat (Castellucci, 2015).

viii. Seat depth (SD)

The distance from the front to the back of the sitting surface (Castellucci, 2015).

- ix. Seat width (SW)  
Horizontal distance between the lateral edges of the seat (Castellucci, 2015).
- x. Upper edge of backrest (UEB)  
The vertical distance between the middle points of the upper edge of the backrest and the top of the sitting surface (Castellucci, 2015).
- xi. Desk height (DH).  
The horizontal distance from upper desk surface to the seat surface (Castellucci, 2015).
- xii. Mismatch  
A failure to correspond or match; a discrepancy (Oxford students' dictionary in English, 2001).
- xiii. Total of seven (7) days prevalence of MSDs  
The feeling of pain, aches or discomfort at certain body part for 7 days (Kuorinka et al., 1987)

ii. Operational definition

i. Popliteal height (PH)

The distance of the back of the knees from the floor in the sitting position measured by using Martyn's type anthropometer.

ii. Buttock-popliteal length (BPL)

The horizontal distance from the buttocks to the back of the knee in sitting position by using Martyn's type anthropometer.

iii. Hip width (HW)

Horizontal distance of the widest point of the hip in the sitting position by using Martyn's type anthropometer.

iv. Elbow height sitting (EHS)

The vertical distance from the bottom of the tip of the elbow to the seated surface by using Martyn's type anthropometer.

xiv. Shoulder height (SHS).

The vertical distance from a horizontal sitting surface to the acromion by using Martyn's type anthropometer.

- v. Subscapular height (SUH)  
The vertical distance of the scapular to the seat surface by using Martyn's type anthropometer.
- vi. Seat height (SH)  
The vertical distance from the floor to the front edge of the seat surface by using measuring tape.
- vii. Seat depth (SD)  
The distance from front to back of the sitting surface by using measuring tape.
- viii. Seat width (SW)  
The vertical distance of the seal surface by using measuring tape.
- ix. Upper edge backrest  
Vertical distance between middle points of the upper edge of the backrest and the top of the seat.
- xv. Desk height (DH).  
The horizontal distance from upper desk surface to the seat surface by using measuring tape.

x. Mismatch

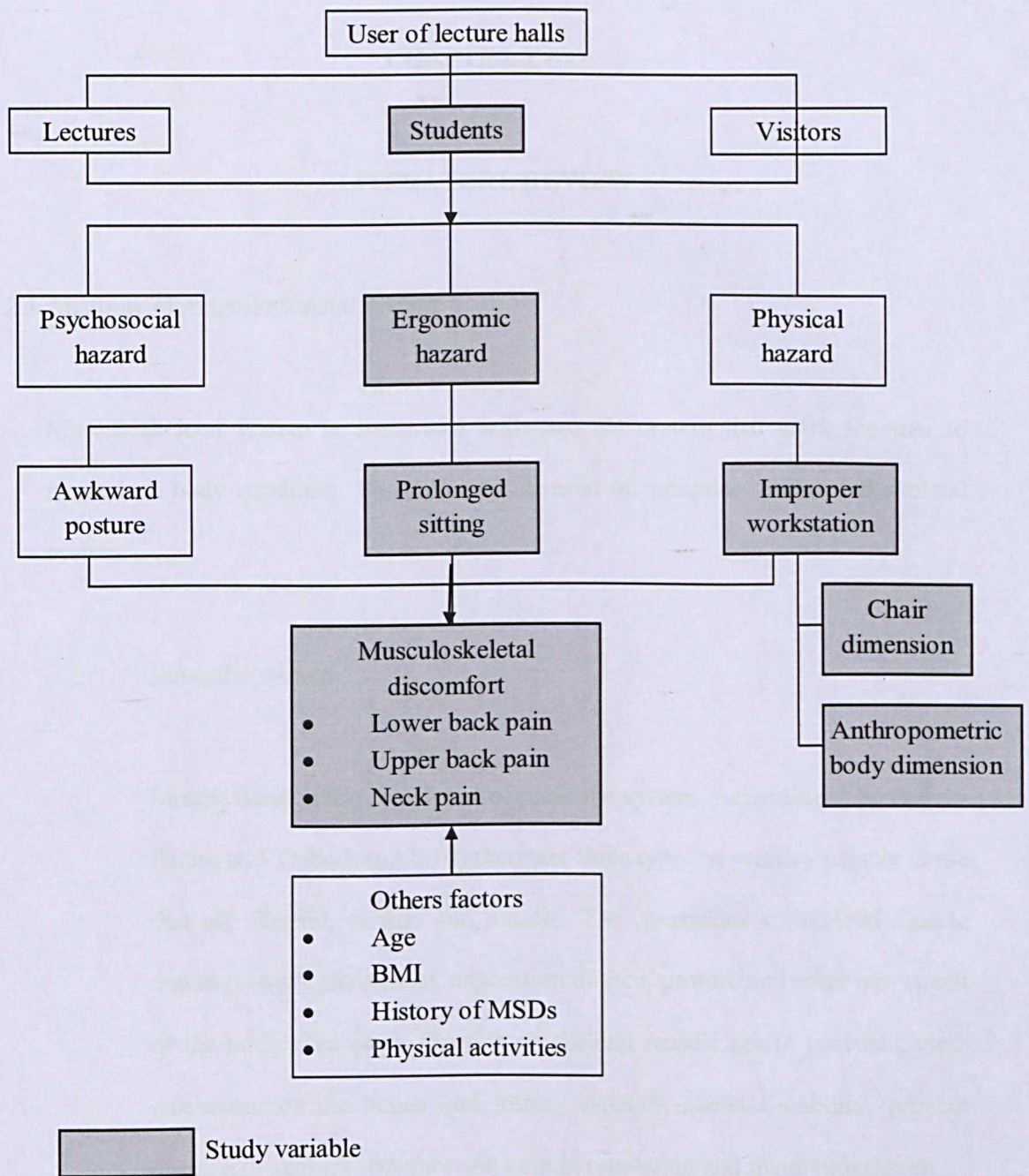
Incompatibility between body dimension of lecture hall user and furniture dimension.

xvi. The total prevalence of MSDs

Having discomfort or pain in any of the body parts; low back, upper back and neck

## 1.7. Conceptual framework

Figure 1.2 shows the summary of the conceptual framework of this study. In this study that involving user of lecture halls consist of lecturers, students and visitors. The users whom used the lecture halls were exposed to three type of hazard which were psychosocial hazard, ergonomic hazard and physical hazard. For ergonomic hazard was due to prolonged sitting and awkward posture and improper workstation (Health and safety executive (HSE), 2013). In this study, the main focused were on prolonged sitting and improper workstation that consists of chairs and table with anthropometry body measurement. Due to the ergonomics hazards due to some extend it will the musculoskeletal discomfort (MSDs) may be developed. Besides the ergonomics factors, MSDs can be cause from other factors such as age, BMI, history of MSDs and physical activities (Hooftman et al., 2004). In this research it focused on prolonged sitting, improper work station and MSDs.



**Figure 1.2: Conceptual framework**

## CHAPTER TWO

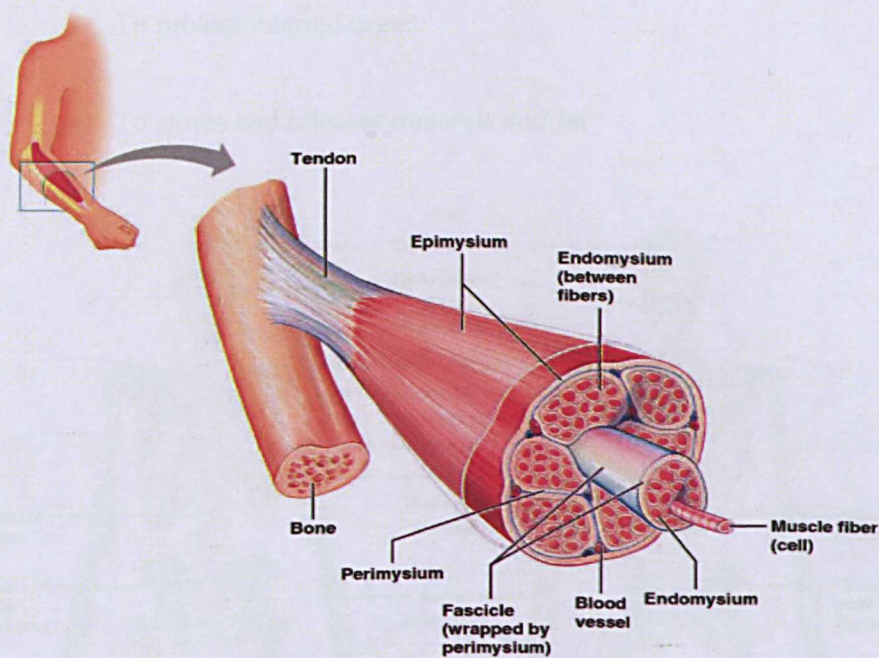
### LITERATURE REVIEW

#### 2.1. Anatomy of musculoskeletal system.

Musculoskeletal system is comprised with two (2) system that work together to maintain a body condition. This system is consist of muscular system and skeletal system.

##### i. Muscular system

Muscle tissue is the component of muscular system. According to book from Patton and Thibodeau,(2010) there are three types of primary muscle tissue that are skeletal, cardiac and muscle. The contraction of skeletal muscle makes possible movement, expression of face, posture and other movement of the body. The other function of skeletal muscle are to prevent excess movement of the bones and joints, maintain skeletal stability, prevent damage to skeletal structure and help in regulating and maintaining heat.



**Figure 2.1: The muscular system**

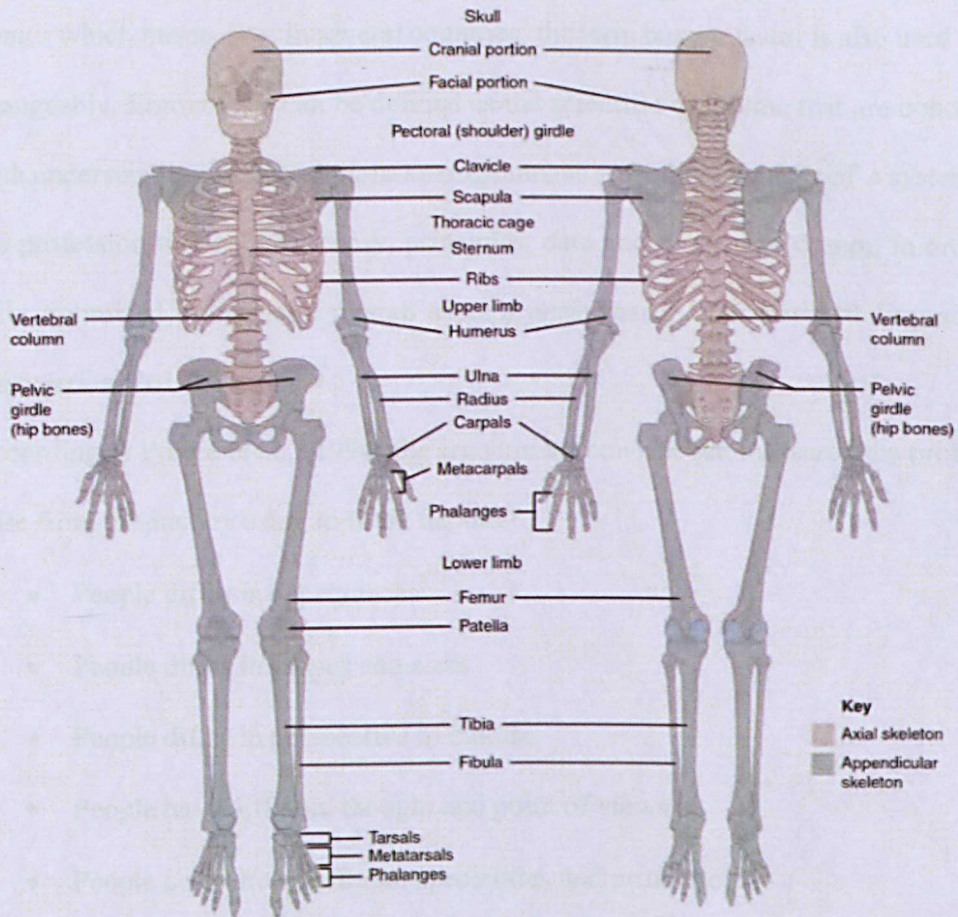
(Source: Patton and Thibodeau, (2010))

ii. Skeletal system

Skeletal system consist of bone and cartilage. Bone is hard, dense connective tissue that form most of the adult skeleton while cartilage is a semi-rigid form of connective tissue that provide smooth and flexibility surface for movement. The function of skeletal system is not limited to movement but there are a few other functions such as:

- To support the body
- To produce blood cells (hematopoiesis)
- To facilitate movement

- To protect internal organ
- To stores and releases minerals and fat



**Figure 2.2: Human skeletal system**

(Source: Patton and Thibodeau, (2010))

## 2.2. Ergonomics

Ergonomics is derived from the Greek words that is *ergon* which means work and *nomos* which means law. In several countries, the term human factor is also used interchangeably. Ergonomics can be defined as the scientific discipline that are concerned with understanding the interactions among humans and other elements of a system and the profession that applies theory, principles, data and method to design, in order to fully optimized human and overall system performance (International Ergonomics Association, 2016).

According to Preece et al., (1994) the ergonomics concept can measured the problem arise from product by using to these factors:

- People differ in appearances
- People differ in shapes and sizes
- People differ in perspective of culture
- People have different thought and point of views
- People come from different specialities and professions

According to Openshaw and Taylor (2006), ergonomics is a science that focussed in the study of human fit, and decreased fatigue and discomfort through product design. To design office furniture, the ergonomic should be taken into account so, the product will fit to the users. Besides that, ergonomics also be defined as multidisciplinary activity striving to assemble the information about people capabilities and capacity for designing job,

products, workplace and equipment (Chenghalur et al., 2006). Musculoskeletal disorder (MSDs)

### 2.2.1. Musculoskeletal disorder

According to Occupational Health and Safety Council of Ontario (OHSCO), (2007), musculoskeletal disorders (MSDs) are the injuries or disorders of the musculoskeletal system. These system includes:

- Muscle, tendons and tendons sheathes
- Nerves
- Bursa
- Blood vessels
- Joints/spinal discs and
- Ligaments.

Other than that, MSDs is also known as repetitive strain injury (RSI), cumulative trauma disorder (CTD), work-related musculoskeletal disorder (WMSD), musculoskeletal injury (MSI), occupational overuse syndrome (OOS) and sprain and strain.

MSDs develop when the body recovery system is being overwhelmed by hazard and risk factors associated to MSDs. When the body is being exposed to stressors, the body regulatory system will attempt to cope with the stress. However, if the stressors

are too much to handle, fatigue will set in as the recovery mechanism is being outrun. Over time, as fatigue remains outrun recovery and the musculoskeletal imbalance persists, the MSDs will develop. The risk factors of MSDs can be divided into two categories, ergo (work-related) risk factor and individual-related risk factors (Middlesworth, 2015). The cause of MSDs is not easily identified with complete accuracy.

#### 2.2.1.1. Ergonomics risk factors

The primary ergonomics risk factors that lead to MSDs include (Armstrong and Lifshitz, 1987; Gerwadowski et al., 1992; Carayon, 1999; ANSI, 1993):

- Repetitive motion
- Forceful exertion
- Awkward posture
- Vibration
- Extreme temperature
- Lifting
- Contact stress

The causes of MSDs do not necessarily depend on one risk factor but the degree to which the risk factor is expressed that may lead to MSDs

(Bramson et al., 1998; Guay, 1998). MSDs is a result of combination of multiple risk factors.

#### 2.2.1.2. Other risk factors of MSDS

There are other risk factors related to MSDs. It can be further categorized into three; psychosocial, health related-lifestyle and individual factors.

##### i. Psychosocial factors

There has been various research evidence which show that many psychosocial factors are found to be linked with MSDs occurrence. The example psychosocial factors are (Kerasek, 1979; Davis and Heaney, 2000; Hoogendoorn et al., 2000; Ariëns et al., 2001; Linton, 2001; Bongers et al., 2002; Bongers et al., 2006):

- Rapid work pace
- Monotonous work
- Low job satisfaction
- Low workplace social support
- High job demand
- Low job control
- Work-stress
- Non-work related stress

- High and low skill discretion

However, the evidence from research findings is insufficient because most of the study is cross-sectional study and the researchers only considered a few of the variables (Derek et al., 2006; Mohd Azuan et al., 2010; Mohd Nordin et al., 2014). The study from Macfarlane et al. (2009) used published research to find the evidence that shows the association between psychosocial factors at works and MSDs.

ii. Health- related lifestyle factors

According to Shiri et al. (2010) the findings shows that there is an association between overweight, obesity and smoking with MSDs. Besides that, the study from Côté et al., (2008) shows that the low moderate physical activity of neck and shoulder was associated with MSDs. As a conclusion, the health related lifestyle can summary into three components that are:

- Obesity
- Smoking
- Physical activity

### iii. Individual factors

According to Hooftman et al., (2004) and Strazdins and Bammer (2004) the women tends to complaint and report more MSDs compared to men. The prevalence of MSDs generally increases with age (Bingefors and Isacson, 2004). The study from Leboueuf-Yde et al., (2009) shows that neck pain and low back pain was common at the age of 20 years old and the prevalence slowly increases until it reach its peak around middle age. The authors also commented that pain was reportedly last longer in older group compared to young one. Genetic factors also may also be associated with MSDs (Zubieta et al., 2003). A study from Danish who involves twins as respondents shows that there are high chance of having pain in three spinal regions (cervical, thoracic and lumbar) (Hartvisgen et al., 2009).

The three individual factors that are related to MSDs are:

- Gender
- Age
- Genetic

### 2.3. Prevalence of MSDs

MSDs are very common and can affect all several of age groups, and socio-demographic background in society (Woolf et al., 2010). A study from McBeth and Jones, (2007) reported that almost one fifth reported widespread pain, one third

shoulder pain, up to half low back pain in a one (1) month period has reported among adults. MSDs is also a major cause of severe long-term pain and disability (Woolf et al., 2010; Woolf et al., 2010), loss of productivity (Martimo et al., 2009) and reduce the quality of life to the person (Roux et al., 2005; Carmona et al., 2001). MSDs have become one of the public health problem among college students, with estimated prevalence rate varying between 32.9% and 89.3% in different parts of the world (Smith and Leggat, 2004; Ekspenyong et al, 2013).

#### 2.4. Anthropometry

Anthropometry is one of the branch of the physical ergonomics. Anthropometry is the study of measurement of the human body in term of dimension of bone, muscle and fat tissue (CDC, 2007). According to Ulijaszek (1994), anthropometric is derived from Greek word *antropo* (human) and *metron* (measure). It can be simplified that anthropometric is the study to measure human body dimension.

There are several factors that must be considered before designing any classroom furniture. According to Daneshmandi et al., (2014), he pointed out the anthropometric measurement such as popliteal height, knee height, buttock-popliteal length and elbow height are the parameters that must be considered before designing any classroom furniture. From this measurement, the proper and suitable furniture dimension will be produced (Knight and Noyes, 1999).

## 2.5. Ergonomics in lecture halls

Lecture halls is a place where the education interaction between students and lecturers take place. It also can be consider as actively accompanied but if it is not ergonomic it will become the risk factors for the development of MSDs (Ismail et al., 2009). According to Manaf (2009) the ergonomics is more actively adapted to the workplace compared to the classroom or lecture halls.

### 2.5.1. Chairs and table

Based on Keegan (1953) and Mandal (1981), prolonged sitting in forward position can give rise to undesirable tension on muscles, ligament and particularly on the discs. Sitting with straight back is generally accepted as healthy but only a few of individuals can maintain in this postures over time. This is due to ischial tuberosities that give relatively little support and the back muscles that cannot support the trunk for a very long period when there is insufficient back rest provided (Knight and Noyes, 1999). To tackle this problem Bendix et al., (1983), Bendix (1984, 1987) suggested that the chair should have an approximately 5° forward inclination, while the table's height should normally correspond to elbow height plus 3-5 cm. Besides, the table should have a tilted desk with 35-45° inclination. The forward-inclining chair and sloping desk has been shown to give positive effect to lumbar spine and this also improve other spine's posture.

It is common that the chairs and furniture at school and universities are fixed-type. This is because of the higher price for adjustable chairs compared to the fixed-type chair (Straker et al., 2006). However, the adjustable seat for workstation are more preferred and it given that each individual differ in postural and size preference (Koskelo et al., 2007, Thariq et al., 2010). From studies by Parcells et al., (1999) and Gouvali and Boudolos (2006), fixed-type furniture may induce constrained postures, which will expose students' body to static loads, commonly reported risk factor for the development of musculoskeletal symptoms and discomfort (Cascioli et al., 2011).

#### 2.5.2. Classroom and body dimension

It is essential to know the body dimension when designing the furniture. This is because, accidents may happen due to incompatible dimension and size of the users' requirement (Steenbekkers and Molenbroek,1990) and health problem such as musculoskeletal, visual and circulatory may arise ( Kayis and Ozok,1991).

Parcell et al. (1999) had given comments on design of school furniture in USA after having personal conversation with two school manufactures in 1996. They found that the dimension of the classroom furniture is unable to fit with the user dimension. Besides that, study from Lane and Richardson (1993) find that the manufacturer did not relied to any research but design based on specification from American Furniture Manufactures Association and National Standard Board. Without a proper design, sitting may incur high muscular force and control to

maintain stability and equilibrium. As a result, fatigue and discomfort may cause poor postural habits and neck or back complaint. This musculoskeletal stress comes from effort to maintain their stability and comfort while seating may cause fidgety individual, a condition which is not conducive to focussed in learning (Parcell et al., 1999).

## 2.6. Summary of study

Title	Author(s)	Year/ Country	Findings
Mismatch between anthropometric body dimensions and classroom furniture in Malaysian Universities	Negin Ozve Aminian & Fairuz I. Romli	2012/ Malaysia	<ul style="list-style-type: none"> <li>• 10 anthropometric dimension were measured.</li> <li>• 500 students from five different universities were involved in this study</li> <li>• There were mismatch between anthropometric body dimensions with furniture.</li> </ul>
An assessment of the anthropometric data of Iranian university students	Mirmohammadi et al.,	2011/ Iran	<ul style="list-style-type: none"> <li>• 20 anthropometric dimension were measured.</li> <li>• 911 university students aged 18025 years old.</li> <li>• Significant difference: gender, different nationality (Iran vs Turkey; China and Portugal)</li> </ul>
Anthropometric dimension of furniture for use in tertiary institutions in Abeokuta, South Western Nigeria	Ismaila et al.,	2013/ Somalia	<ul style="list-style-type: none"> <li>• 7 anthropometric body dimension were taken.</li> <li>• 720 respondents from three selected institutions age 17 to 27 years old participated.</li> <li>• The study found that there were mismatch between anthropometric body dimensions with furniture.</li> </ul>
Analysis of FEUP of school furniture's suitability	Sousa et al.,	2014/ Brazil	<ul style="list-style-type: none"> <li>• 6 anthropometric dimension were taken.</li> </ul>

- 206 consist of 131 male and 75 female with ages ranging from 18–35 years old were the respondents.
- Significant mismatch between the dimension if the school furniture and students' anthropometric dimension.
- 7 anthropometric body dimension were taken.
- 240 students consist of 120 males and 120 females were the respondents.
- Found out that there were mismatch between anthropometric body dimensions with furniture.
- Significant difference: gender
- 6 anthropometric body dimension were taken.
- 194 students aged from 18 to 30 years were the respondents.
- High mismatch percentages were found between furniture and students' anthropometry.
- 7 anthropometric measurements were taken.
- 74 sixth to eighth grade students in Michigan school district participated in this study.

Ergonomic suitability of educational furniture and possible health implications in a university setting

Odunaiya et al., 2014/

Nigeria

Student's body dimensions in relation to classroom furniture

Baharampour et al., 2013/

Iran

Mismatch of classroom furniture and students body dimension: empirical findings and health implications

Parcells et al., 1999/

Michigan

- Substantial degree of mismatch between the students' body anthropometric body dimension with mismatch.
- Girls are less likely to find the suitable chair.
- 60 anthropometric body dimension were taken.
- 125 students age between 18-23 years old were the respondents.
- Significant difference: gender and nationality (Indonesia vs Asian; European).
- 33 anthropometric body dimensions were taken.
- Involving polytechnic students with total 1032 students (595 males & 437 females).
- Male is significantly have larger anthropometric body dimension compared to female.

Anthropometric study of  
Indonesian University students in  
Jakarta

Yanto, et al.,  
2015/  
Indonesia

Development of anthropometry  
database for young adult

Karmegam et al.,  
2013/  
Malaysia

## CHAPTER THREE

### METHODOLOGY

#### 3.1. Study design

This study was a cross-sectional study. The advantage of cross sectional study was it relatively inexpensive and less time consuming. This study had been carried out from January until February, 2016 to determine the mismatch between anthropometric measurement of students in a university and furniture and seat of lecture hall used.

#### 3.2. Study location

This study was conducted at Faculty of Medical and Health Sciences (FMHS), Universiti Putra Malaysia (UPM) Serdang, Selangor. The exact location site was shown in Figure 3.1.



Figure 3.1: Location of the study location

### 3.3. Sampling method

#### 3.3.1. Sampling strategy

Based on the inclusion and exclusion criteria assigned the respondent were purposively from the class name list that have at least one hour lecture at lecture halls. This sampling was used as selection of respondents based on a set of inclusion criteria, which will be explained further in the following sub-chapter

#### 3.3.2. Sampling population

The users of using lecture halls (Dewan Kuliah 1- 6) in FMHS were the sampling population in this study.

#### 3.3.3. Sampling frame

The list of the students who used the lecture halls in FMHS was obtained from Academic Division, Faculty of Medicine and Health Sciences.

#### 3.3.4. Sampling unit

The sampling unit for this study was the student who the inclusion and exclusion criteria of this study as follow:

#### 3.3.4.1. Inclusion criteria

- Undergraduate student who have a minimum of one hour per week lecture in the lecture hall.

#### 3.3.4.2. Exclusion criteria

- Post-graduate student
- FMHS administration and academic staff
- FMHS visitor

#### 3.3.5. Sample size – Calculation

The sampling size calculation was based on 95% confidence interval with probability  $\alpha \leq 0.05$  by Kirkwood and Sterne (2003). Using the prevalence of MSDs among undergraduate students in Ireland (52.8%)  $\alpha \leq 0.05$  by Kirkwood and Sterne (2003) (Dockrell et al., 2015), the sample size for this study were:

$$n = \frac{p(1-p)}{e^2}$$

Where:

- n = sample size for estimating a prevalence
- p = expected proportion (prevalence) = 0.528
- e = desired size of the standard error (0.05)

Minimum sample size calculation:

$$\begin{aligned}n &= \frac{0.528(1-0.528)}{0.05^2} \\ &= 99.6 \\ &\approx 100\end{aligned}$$

However, after taking into consideration of low response rate or missing data, an additional 20% respondent was added to the original sample size. (Aday and Cornelius, 2006).

Response rate =  $\frac{\text{No. of completed interviews}}{\text{No. of eligible unit}}$

No. of eligible unit

$$\begin{aligned}80\% &= 100 \\ 100\% &= N \\ N &= 1000 / 80 \\ N &= 125\end{aligned}$$

An additional 20% of minimum sample size, 15 students were included in order to overcome problem of extreme value, data missing and lower response rate.

### 3.4. Instruments and materials

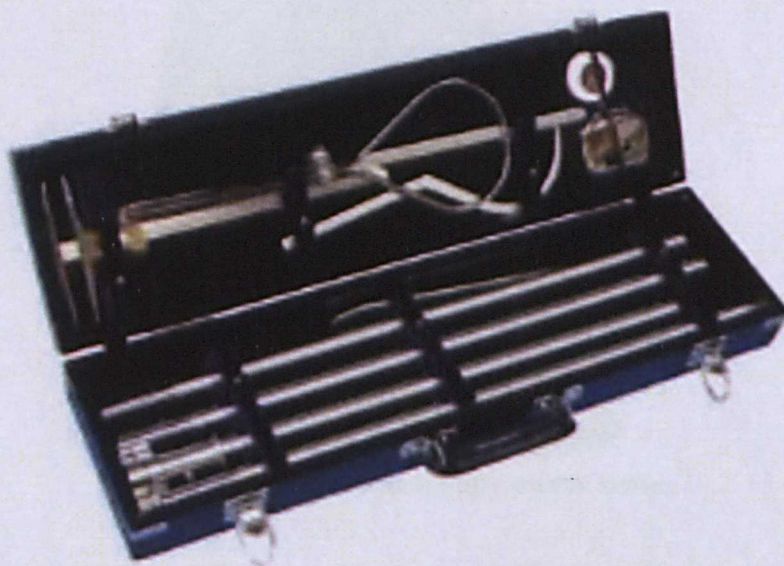
#### 3.4.1. Questionnaire

Questionnaire used in this study consists of three sections. The questionnaire is attached as Appendix 1. The age and gender of the respondent was determined in the first section. In the second section, the

respondents were required to indicate if they experienced MSDs in the past seven (7) days. Besides that, the other risk factor of MSDs such as hours of lecture was also being determine in this section. To determine the prevalence of MSDs, modified Nordic Musculoskeletal Questionnaire (Kuorinka et al., 1987) was used. The respondents were asked to indicate if they experienced pain or discomfort in low back, upper back and neck. The questions used simple phrases such as “Do you have aches, pain or discomfort during the last 7 days in these area?”.

#### 3.4.2. Anthropometry equipment

The Martyn’s type anthropometer was used in determining the anthropometric design for portable anthropometric purposes, indeed this instrument will be also used to measure distance between straight or curved and thickness.



**Figure 3.3: The Martyn’s type anthropometer**

The body dimension of the student was assessed using standard anthropometric measurement technique, based on study that conducted by Parcels et al (1990) and MS ISO 7250-1; 2008 (2013). The subject's posture and definition of each anthropometric parameters were based on the standard procedure that are recommended by Castellucci (2015) and Pheasant and Haslegrave, (2006). The stature that is standing posture also be taken as it is an important reference dimension for comparing population (Pheasant, 1996).

#### 3.4.3. SECA body meter scale

SECA body meter scale was used to measure the stature of the respondent. The respondent was asked to stand erect, heels together, the body weight evenly distributed between both feet, arm at the side, palms against the thigh and fingers extended vertically downward.



**Figure 3.4: The SECA body meter scale**

#### 3.4.4. SECA body weighing scale

Body weight was measured by using SECA body weighing scale. Each measurement was twice in order to get consistence reading.

During measurement, the respondent was asked to remove their belonging and stand erect at the centre of weighing scale with their body weight evenly distributed between both feet and looking straight.



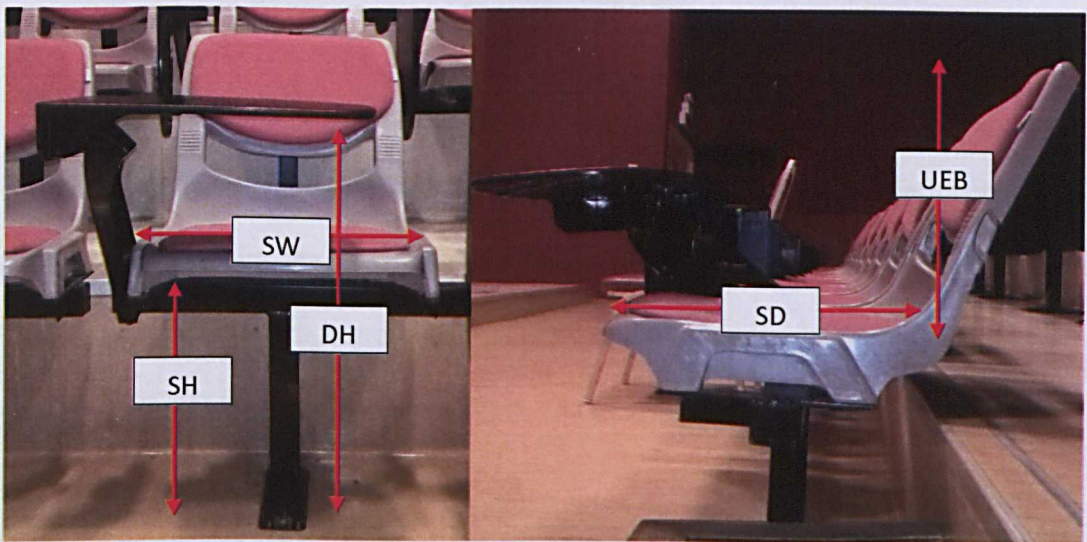
**Figure 3.5: SECA body weighing scale**

#### 3.4.5. DIMENSION OF SEAT

The furniture dimensions were measured by measuring tape. The parameters that were measured as follows:

**Table 3.1: The parameter and measurement method**

Parameter	Measurement method
Seat height (SH).	Vertical distance from the floor to the front edge of the seat surface.
Seat depth (SD).	The distance from front to back of the sitting surface.
Seat width (SW).	Vertical distance of the seal surface.
Desk height (SDH).	The horizontal distance from surface to the upper desk surface.
Upper edge of backrest (UEB)	Vertical distance between middle points of the upper edge of the backrest and the top of the seat.



**Figure 3.6: The parameter of the measurement**

### 3.5. Data collection procedure

#### 3.5.1. Phase 1 – Preliminary and preparatory work

A formal application letter was prepared by Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, UPM were submitted to the Ethic Committee of UPM. Upon approval from the committee, the classes that used lecture hall were obtained and questionnaire

was developed. A pre-test was conducted for the questionnaire. The pre-test will be explained in sub-chapter 3.6.1.

The respondent were gathered and brief about the purpose of the study. Before the questionnaire distributed, the respondent was given a consent form of this study.

### 3.5.2. Phase 2- Questionnaire survey

The questionnaire was distributed to the respondent where they were given 15 minutes to complete the questionnaire. After the completion of the questionnaire, the researcher personally collected the questionnaire from each respondents. The researcher was there to assist, answer any confusion and a brief statement to the respondents. Data key in for analysis.

### 3.5.3. Phase 3 – Anthropometric measurement

The sitting anthropometry dimension of respondents was measured and recorded for each respondent according to the Malaysian Standard (2013). The anthropometric measurement was taken on the same day with the questionnaire survey. The anthropometric measurements were taken in a Tutorial Room, FMHS. To assure the reliability of the measurement, the intra-tester reliability test was conducted and that will be discussed on subchapter 3.6.2.3. Data key in for analysis.

### 3.6. Quality control

#### 3.6.1. Questionnaire

A total of 10% of the population similar to the respondents were used for the pre-test. Cronbach alpha was used to test the internal reliability and consistency of the question. The respondent who took part in this pilot study was not included in the full scale study.

The result of Cronbach's alpha coefficient was 0.78 which was more than 0.6 indicating it was within acceptable range (George and Mallery (2003)).

#### 3.6.2. Anthropometric measurement

##### 3.6.2.1. SECA body weighing scale

The weighing scale was put on the stable surface and the reading taken twice so that the average could be used as the precise reading. The SECA body weighing scale was used according to SECA 750 Manual (2009).

##### 3.6.2.2. Anthropometric data collection

The anthropometric data collection were collected by the researcher to assure the consistency. Before the collection of data, a training

including theoretical, practical and mock situation were conducted to help the researcher during the measurement.

### 3.6.2.3. Intra-reliability test

Intra-reliability test was conducted to make sure that there were no significance difference between the first and second measurement of the tester.

The intra-reliability tester was done by using paired t-test. Since  $p > 0.05$ , so there is no significant difference between first and second measurements of the tester.

**Table 3.2: The intra reliability test**

Variable	t-value	p-value
Elbow height	- 1.754	0.140
Shoulder height	0.832	0.443
Subscapular height	-2.076	0.093
Hip width	0.204	0.846
Buttock-popliteal height	- 0.707	0.511
Popliteal height	0.222	0.833

\*Significant at  $p < 0.05$

### 3.7. Data analysis

Data collected were analysed by using Statistical Package for Social Science Version 21 (SPSS). Table 1 shows matching of seat dimension to respondents' sitting anthropometric measurements in the study by adapting from Castellucci (2015) study:

**Table 3.1: Application of measure**

Parameter	Application of measures equation
Seat height against popliteal height	$(PH + SC) \cos 30^\circ \leq SH \leq (PH + SC) \cos 5^\circ$
Seat depth against buttock popliteal	$0.80BPL \leq SD \leq 0.95BPL$
Seat width against hip width	$HW < SW$
Desk height against Elbow Height Sitting and Shoulder height	$SH - \sin 5^\circ SD + EHS \leq DH \leq (SH - (\sin 5^\circ SD)) + EHS \times 0.8517 + SHS \times 0.1483$
Upper edge of backrest against subscapular height	$SUH \geq UEB$

Univariate analysis were used to describe the data on the respondent's distribution such as socio-demographic data and anthropometric body dimension of the respondents. All data were analyses using descriptive test to obtain frequency, mean, median, standard deviation and percentage.

For Bivariate analysis, T-test was used to compare the mean between male and female anthropometric body dimension. Besides that, Chi-square test was used to determine the association between anthropometry mismatch and prevalence of MSDs.

### 3.8. Ethical consideration

The approval of Ethic Committee of the Universiti Putra was obtained before the study started. The ethic's approval letter was attached in Appendix 2.

## CHAPTER FOUR

### RESULTS

#### 4.1. Demographic information of the respondent

The first objective was to determine the demographic information of the respondents. Five (5) variables on subject background were collected: age, gender, height, weight and body mass index which were reported in Table 4.1. The mean age of the respondents were  $21.18 \pm 0.86$  where the minimum was 20 and maximum was 24. Most of the respondents took part in the study where (64.4%) were female compared to (35.6%) male. The mean height of the respondent were  $160.19 \pm 7.46$  where the minimum was 147 cm and maximum was 177 cm. While for the weight were  $56.01 \pm 9.04$  with minimum was 35 kg and maximum of 80 kg. Majority of the respondent have normal (77.3%) category BMI while the rest was underweight (10.6%), overweight (10.6%) and obese (1.5%).

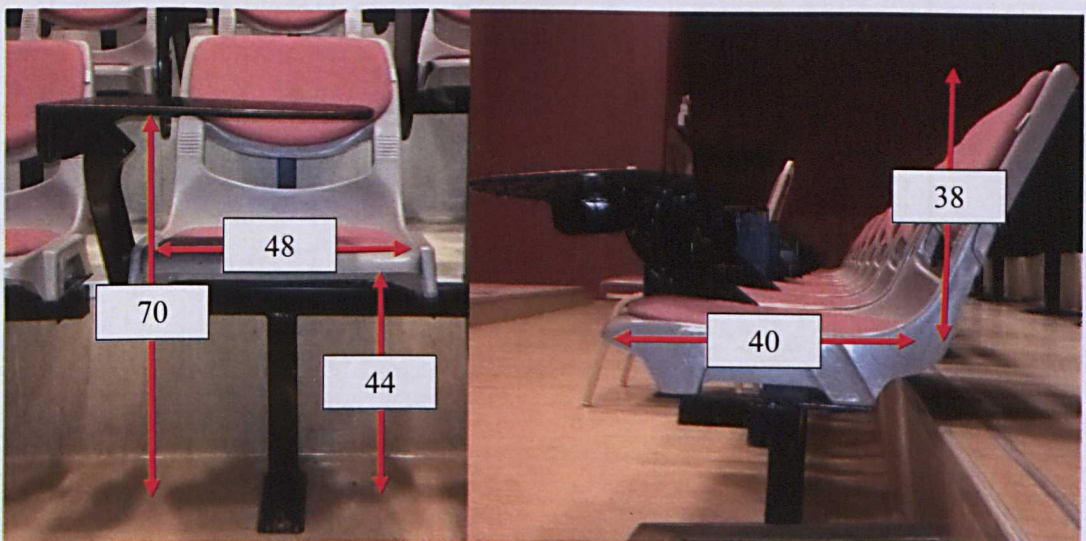
**Table 4.1: Socio-demographic background**

Variable(s)	Mean $\pm$ SD	Frequency (%)
Age	21.18 $\pm$ 0.86	
Height	160.19 $\pm$ 7.46	
Weight	56.01 $\pm$ 9.04	
Gender		
Male		47 (35.6)
Female		85 (64.4)
BMI		
Underweight		14 (10.6)
Normal		102 (77.3)
Overweight		14 (10.6)
Obese		2 (1.5)

N = 132

#### 4.2. Dimension of seats in the lecture hall.

The second objective of this study was to measure and determine the sitting design dimension of furniture in the lecture hall. The upper edge backrest (UEB) was 38 cm, Seat width (SW) was 48 cm, Seat height (SH) was 44 cm, Seat depth (SD) was 40 cm and Desk Height (DH) was 70 cm.



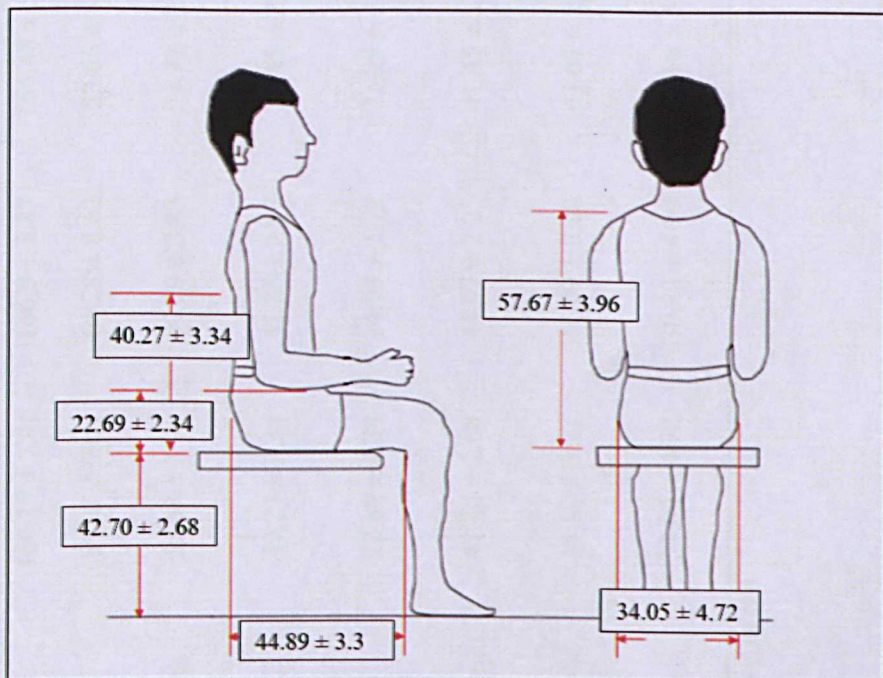
\*All measurements are in cm

**Figure 4.1: The dimension of the lecture hall furniture**

### 4.3. Anthropometric data of respondents in sitting position

The third objective was to measure and determine the mean of anthropometric data for respondents. Based on Table 4.2, the Shoulder Height Sitting (SHS) was  $57.67 \pm 3.96$ , Subscapular Height (SUH) was  $40.27 \pm 3.34$ , Elbow height (EH) was  $22.69 \pm 2.34$ , Popliteal height (PL) was  $42.70 \pm 2.68$ , Buttock Popliteal Length (BPL) was  $44.89 \pm 3.3$  and Hip width (HW) was  $34.05 \pm 4.72$ .

A paired sample T-test showed that the anthropometry dimension of male was significantly different from female.



\*All measurements in cm

**Figure 4.2: The anthropometric body dimension**

**Table 4.2. Anthropometric data of students in sitting position**

Variable(s)	Mean $\pm$ SD		Mean difference (95%CI)	T-statistics (df)	p-value*
	Overall	Male (N = 47)			
Height	160.19 $\pm$ 7.46	166.9 $\pm$ 5.87	156.48 $\pm$ 5.36 10.422 (8.427, 12.417)	10.335 (130)	.000
Weight	56.01 $\pm$ 9.04	60.28 $\pm$ 8.62	53.66 $\pm$ 8.42 6.620 (3.567, 9.673)	4.289 (130)	.000
Shoulder Height Sitting	57.67 $\pm$ 3.96	59.29 $\pm$ 3.83	54.72 $\pm$ 2.05 4.571 (5.760, 3.382)	7.605 (130)	.000
Subscapular Height	40.27 $\pm$ 3.34	42.85 $\pm$ 2.97	38.85 $\pm$ 2.62 4.004 (3.017, 4.991)	8.025 (130)	.000
Elbow height	22.69 $\pm$ 2.34	24.03 $\pm$ 1.72	21.94 $\pm$ 2.31 2.091 (1.328, 2.854)	5.422 (130)	.000
Popliteal height	42.70 $\pm$ 2.68	44.97 $\pm$ 2.25	41.45 $\pm$ 2.00 3.521 (2.769, 4.273)	8.950 (130)	.000
Buttock Popliteal height	44.89 $\pm$ 3.31	46.09 $\pm$ 3.88	44.68 $\pm$ 2.93 1.403 (0.218, 2.589)	2.342 (130)	.021
Hip width	34.05 $\pm$ 4.72	30.22 $\pm$ 4.50	36.16 $\pm$ 3.31 -5.941 (-7.298, -4.585)	-8.667(130)	.000

\*All measurements are in cm

N = 13

4.4. Seven (7) days prevalence of MSDs among lecture halls user in FMHS.

The fourth objective was to determine the seven (7) days prevalence of MSDs among lecture halls user in FMHS. Based on Table 4.3, the total prevalence of MSDs (having discomfort or pain in any of the body parts: low back, upper back and neck pain) was 51.77%. The highest prevalence of MSDs was low back pain (LBP) (61.4 %), followed by neck pain (50.0%) and upper back pain (UBP) (43.9%). In term of gender, female has higher prevalence of UBP and neck pain but male has higher LBP.

**Table 4.3: Prevalence of MSDs in the past seven (7) days among lecture halls user in FMHS.**

	Frequency (%)	%		Total MSDS
		Male	Female	
LBP	81(61.4)	64.1	35.9	
UBP	58(43.9)	41.4	58.6	51.77
Neck pain	66(50.0)	40.9	59.1	

N=132

4.5. Mismatch between sitting anthropometric measurement with furniture at the lecture halls.

The fifth objective was to determine the mismatch between sitting anthropometric measurement of the student with furniture at the lecture halls.

- i. Seat height against popliteal height

$$(PH + SC) \cos 30^\circ \leq SH \leq (PH + SC) \cos 5^\circ$$

According to Table 4.5, the mismatch between seat heights against popliteal height was 51.5%.

- ii. Seat depth against buttock popliteal

$$0.80BPL \leq SD \leq 0.95BPL$$

Based on Table 4.5, the mismatch between seat depths against buttock popliteal height was 5.3%.

- iii. Seat width against hip width mismatch

$$HW < SW$$

Based on Table 4.5, there was no mismatch between seat width against hip width. The result was 100% match.

- iv. Desk height against Elbow Height Sitting and Shoulder height

$$SH - \sin 5^\circ SD + EHS \leq DH \leq (SH - (\sin 5^\circ SD)) + EHS \times 0.8517 + SHS \times 0.1483$$

According to Table 4.5, there was a mismatch between desk height against elbow height sitting and shoulder height which was 94.7%.

- v. Upper edge of backrest against subscapular height mismatch

$$SUH \geq UEB$$

Based on Table 4.5, the mismatch between upper edge backrest against subscapular height was 18.2%.

**Table 4.4: Mismatch between sitting anthropometric measurement with furniture at the lecture halls**

Variable(s)	Frequency (%)		
	Overall	Male	Female
Seat height against popliteal height	68 (51.5)	6 (8.8)	62 (91.2)
Seat depth against buttock popliteal	7 (5.3)	3 (42.8)	4 (57.2)
Seat width against hip width	0 (0)	0 (0)	0 (0)
Desk height against Elbow Height Sitting and Shoulder height	125 (94.7)	43 (34.4)	82 (65.6)
Upper edge of backrest against subscapular height	24 (18.2)	3 (8.3)	22 (91.7)

N= 132

#### 4.6. Association between total MSDs, anthropometry mismatch and other individual risk factors.

The seventh objective was to determine the association between the total MSDs and anthropometry mismatch. The association between total MSDs and anthropometry mismatch was determined by performing chi-square statistical analysis and shown in Table 4.6.

The result was significant association between the total MSDs and anthropometry mismatch with  $\chi^2 = 5.406$ ,  $p < 0.05$  and phi of 0.02. Based on Cohen's Rule of thumb, the Phi value reported showed that the strength between this two variable are small to medium range. Thus, the null hypothesis is accepted.

**Table 4.5: The association between total MSDs and anthropometry mismatch.**

Prevalence of MSDs	Match	Mismatch	$\chi^2$	<i>p</i> value
Yes	25	14	5.406	0.02
No	39	54		

Phi ( $\phi$ ) = 0.02 (small to medium strength according to Cohen's Rule of Thumb)

Further analysis using the individual risk factors were carried out. There were two (2) variables which were significantly associated with MSDs; gender and hours of lecture as ( $p < 0.05$ ). Being male appear to have lower risk of MSDs compared to female while each of the increasing hours of lecture increases the risk of MSDs by almost twice (OR= 1.8; 95%CI= 0.66, 0.98).

**Table 4.6: Factors associated with MSDs**

Variables	Crude OR (95% CI) <sup>a</sup>	Wald statistics (df) <sup>a</sup>	<i>p</i> value	
Age	0.867(0.56,1.34)	0.415 (1)	0.519	
Gender	Male	0.174 (0.77,0.39)	17.94 (1)	0.000
	Female	1		
BMI	Underweight	1		
	Normal	2.5 (0.24, 50.55)	0.86 (1)	0.550
	Overweight	2.29(0.14, 37.81)	0.34 (1)	0.562
	Obese	3.67 (0.17,77.55)	1.56 (1)	0.404
Hours of class at lecture hall	1.8 (0.66, 0.98)	4.51 (1)	0.034	
History of MSDs	Yes	1		
	No	0.47 (0.19, 1.19)	2.528 (1)	0.112

<sup>a</sup> Simple logistic regression

#### 4.7.Recommendation of new suitable furniture based on user anthropometry body dimension.

The sixth objective was to recommend the new furniture based on anthropometry body dimension. The recommendation of the furniture was based on the calculation by Pheasant (2006).

i. Seat height

5<sup>th</sup> percentile of female popliteal height or whichever is lower.

The seat height was recommended to 44 cm taking shoe correction into account.

ii. Seat depth

5<sup>th</sup> percentile of female buttock-popliteal length or whichever is lower.

The seat depth was recommended at 38 cm based on 5<sup>th</sup> percentile of female buttock-popliteal length.

iii. Seat width

95<sup>th</sup> percentile of male hip width or whichever is higher.

It is recommended the seat width is maintained.

iv. Desk height

50<sup>th</sup> percentile (female or female)

[Elbow height sitting + 75 + (Popliteal height – 50)]

The desk height is recommended to 83 cm after taking into consideration the shoe correction.

**Table 4.7: The proposed new furniture based on anthropometry measurement.**

<b>Parameters</b>	<b>Existing furniture</b>	<b>Proposed furniture</b>
*Seat height	44	38
Seat depth	40	38
Seat width	48	48
*Desk height	70	83

All measurement in cm

\*shoes correction 2.5cm

## CHAPTER FIVE

### DISCUSSIONS

The data from this study were only based on measurements that were taken at FMHS, and not representative to the whole population. However, from this current study findings it is in line with the previous researches that showed that there were significant difference between male and female anthropometry (Md. Dawal et al., 2012; Baharampour et al., 2013; Karmegam et al., 2011, Mirmohammadi et al., 2011 and Md Dawal et al., 2012). To match both male and female anthropometry body dimension with chairs and desk, there was study that conducted by Pheasant (2006) that recommended the suitable furniture dimension according to certain parameter to closed the gap between male and female. Thus, this recommendation can be used to recommend the new design that will fit with both genders.

The MSDs is more prone to female compared to male. This could be due to the differences in term of physiological and physical characteristic between male and female (Mohd Azuan et al., 2010). According to Katzmaryk et al. (1998), one of the reason female is prone to get MSDs compared to male is because the male tends to have more muscle strength particularly in upper limb. Besides that, female has also greater body awareness and lower pain threshold (Breitchecker et al., 2004) and this is why female tend to complaint more than male.

In combination with mismatch, prolonged sitting has been identified as one of the risk factors for MSDs and supported by several studies (Lis et al. 2007; Mohd Nordin et al., 2014; Nyland and Grimmer, 2003). Prolonged sitting will cause in increasing of spinal compression load (Callaghan & McGill, 2001) and increasing the activity of paraspinal muscles (Harrison et al., 1999) and happen due tissue micro damage and paraspinal muscle dysfunction (Solomonow et al, 2003).

No significant association was shown between BMI and MSDs which was similarly found in previous study (Mohd Nordin et al, 2014; Chung et al, 2005; Grimmer & Williams, 2000; Levangie, 1999) with a systematic review from Leboeuf-Yde (2000) that conclude that was only weak association between BMI and MSDs. It is believed that, the rapid changes of weight within a short period of time may not have an effect on the low back of younger adult (Grimmer & Williams, 2000) and it concluded that generally, BMI has little effect the MSDs.

Various research has similarly found mismatch between the anthropometry of users with the dimension of the seats as was shown in this study (Syed Asif et al., 2012; Samira et al, 2013; Aminian and Romli, 2012). The importance of matching seat has also been described by various research from the perspective of biomechanics and physiological mechanism leading to potential musculoskeletal disorders. Specifically, Castellucci (2015) has elaborated that the importance of seat height to be lower than popliteal height in order to enable the feet being placed entirely on the floor at 5 – 30 degree angle. This was further supported by Mokdad and Al-Ansari (2009), Parcels et al., (1999) and Ramerkers (1996) whom described vascular and neural structure

along popliteal space being compressed if the seat were too high causing their leg to hang mid-air.

In another example, the mismatch of the seat depth against buttock popliteal length which were similarly found in various other research (Samira et al., 2013; Aminian and Fairuz, 2013; Syed Asif et al., 2012). If the seat pan is too long, the back rest became useless as the user were unable to rest to support their back or lumbar (Milanese and Grimmer, 2004). If the seat pan is too short, the thigh were not fully supported where extra pressure is being put on the back of the thigh resulting in discomfort over a long period of time (Pheasant, 2006). The ideal seat depth (buttock to popliteal length) which was found in this study should range from 80% of buttock-popliteal length to 95% of buttock-popliteal length.

Besides that, the mismatch of desk height in this study were also corresponding with various other studies (Samira et al., 2013; Qutubuddin et al., 2013; Ismaila et al., 2013; Syed Asif et al, 2012; Aminian and Romli, 2012). Hedge et al., (1999) has described that the neck or shoulder can be in great discomfort or even injured if the weight of the head not properly supported. There were various study showed that if the desk height is too height it will make the user to bend forward and their arms need to support their weight as well as maintaining their neck muscle. As a result this can lead to Kyphotic posture and round neck and increases the fatigue's episode (Maras and Karwowski, 2006; Mandal, 1984; Keegan, 1953).

Other than that, the mismatch between upper edge backrest in this study were also found in various research (). As the edge of backrest is not supported the subscapular,

the lumbar and spine will be affected and this will result increasing force to the lower back (Bendix et al., 1988; Aagard- Hansen and Storr-Paulsen, 1995). In addition, the study from Garcia-Acosta and Lange-Morales (2007) and Orborne (1996) stated that higher upper edge backrest will cause the compression of scapula and reduction in arm and mobility. This will lead to awkward posture as the student is having difficulties to complete their task performance.

## CHAPTER SIX

### CONCLUSION, LIMITATION AND RECOMMENDATION

#### 6.1. Conclusion

Based on the data obtained it can be concluded that the furniture at the lecture hall does not entirely fit the user based on their anthropometric body measurement. As students spend most of their time in sitting position during lecture, they are more vulnerable to develop MSDs due to prolonged sitting. To a certain extent, it has been shown that MSDs among respondents were associated with mismatch beside BMI and lecture hours. Thus, the suitable furniture that fit with the user anthropometric should be used in the lecture halls to decrease the likelihood for students to develop MSDs.

#### 6.1. Limitation

Among the study limitation were:

- i. The study was only applicable to the population studied which were students of FMHS, UPM
- ii. The study have specific focus that were only for those who using FMHS lecture halls only.
- iii. The questionnaire may have recalled bias because the respondents need to recall to answer the questionnaire.

- iv. Time constrains

## 6.2.Recommendation

For the current population:

- i. The time table should not exceed than one hours but if it cannot be avoided it should have time break every one hour.
- ii. Do some physically movement for the body to recovery.
- iii. The management can put foot rest for the student who their legs does not touch the floor.

For improvement of research:

- i. Take into account larger sample size so it will be more representative.
- ii. Include more variables that will leads to MSDs.
- iii. Improving the study design.

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## FORM B1: RESPONDENT'S INFORMATION SHEET AND CONSENT

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

### 1. STUDY TITLE :

The ergonomics of seat design in lecture hall at Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM).

### 2. INTRODUCTION:

Furniture is an essential physical element in the classroom where the learning process takes place. Without a proper ergonomic furniture, the learning process will be affected. Furniture which fits to the physical anthropometry of the students will help enhance their performance and learning process whereas furniture which are too large or too small to the students may promote or cause poor sitting postures in the classroom. As the anthropometric body dimension is having mismatch with the furniture, this will result in the decreasing in efficiency and productivity of the student and it also may cause musculoskeletal discomfort (MSDs). Besides that, there have been confirmed that prolonged sitting in the static leaning forward have been confirmed as a major cause of (MSDs). This study is aimed to determine the prevalence of MSDs among the user of lecture in Faculty Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM).

### 3. WHAT WILL YOU HAVE TO DO?

1. You are required to answer a set of questionnaire after being briefed by the researcher within 10-20 minutes.
2. Then, the researcher will brief about the anthropometric measurement that will be taken within 15-20 minutes. First, you need to remove your belonging and stand erect on the centre of weighing scale with your body weight evenly distributed between both feet

and looking straight. Then, you need to stand erects, heels together with your body weight evenly distributed between both feet, arm at the side, palms against the thigh and fingers vertically downward at the wall. After that, you need to sit at the designated chair fully erect with the thighs fully supported and the foot are resting on the surface. The researcher will take the anthropometric of body dimension based on these parameter:

No.	Parameter	Measurement method
1.	Elbow height sitting	Vertical distance from the bottom of the tip of your elbow to the seated surface
2.	Buttock-popliteal length	Horizontal distance from the back of the knee to the surface of the buttock
3.	Popliteal height	Vertical distance from the seated surface to the surface of the foot surface
4.	Thigh thickness	Vertical distance from the seated surface to the upper thigh
5.	Subscapular height	Vertical distance form scapular to the seated surface
6.	Hip width	Horizontal distance between the widest points of the hip in sitting position.
7.	Shoulder height sitting	Vertical distance from a horizontal sitting surface to the acromion

#### 4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

The post-graduate student, administration staff of Faculty Medicine and Health Sciences (FMHS) and the visitors who used the lecture halls in FMHS will be excluded in this study.

#### 5. WHAT WILL BE THE BENEFITS OF THE STUDY:

##### (a) TO YOU AS THE SUBJECT?

The respondents are able to know whether they have experienced or experiencing MSDs due to the furniture design and the factors that might contribute to MSDs.

##### (b) TO THE INVESTIGATOR?

Researcher can identify the prevalence of MSDs among lecture hall user in FMHS. Besides that, the factors that associate to this MSDs can be determined and indirectly the control measure to reduce MSDs can be proposed to the

Please initial here if you have read and understood the contents of this page \_\_\_\_\_

9. CONSENT

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

.....hereby voluntarily agree to  
take part in the research stated above \*(clinical /drug trial/video recording/ focus  
group/interview-based/ questionnaire-based).

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

I\* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be  
used in any form of publication or presentation (if applicable)

\* 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 research.

Date .....

Signature .....

(Researcher)



**THE ERGONOMICS OF SEAT DESIGN IN LECTURE HALLS AT FACULTY OF MEDICINE AND HEALTH SCIENCES (FMHS), UNIVERSITI PUTRA MALAYSIA (UPM)**

The purpose of this survey is to get opinion from you regarding ergonomics of sitting design in lecture hall at Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM). All information given will be processed using the computer and will be kept confidential. The individual answer will not be presented in any presentation. Hence, I would like to ask you to fill in this questionnaire honestly and correctly. Your cooperation is highly cooperated.

I have read the introduction of this questionnaire form and agree to answer according to the terms and conditions.	Yes / No
--	----------

Signature:

Date:

.....

**Confidential**

The information given is for the research purpose only and will be kept confidential.  
 Instruction: Please answer all of the questions below and tick (√) in the given boxes.

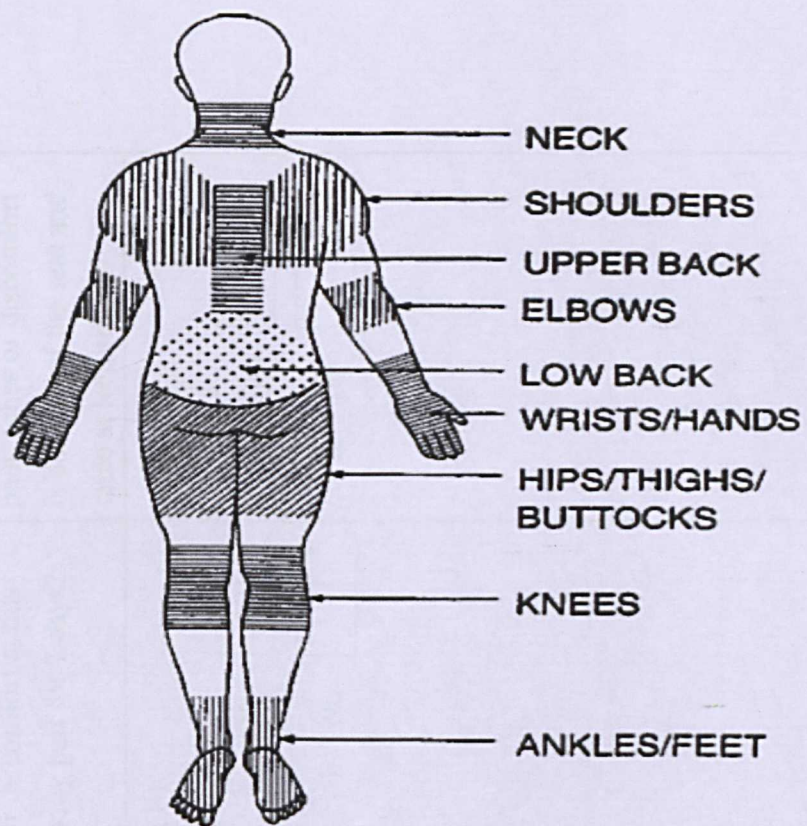
ID NO

SECTION A- (BACKGROUND, DEMOGRAPHIC INFORMATION)

1. Age :  years old
2. Gender :  Male  Female
3. How many hours of class do you need to attend at the lecture hall in one day?  
\_\_\_\_\_ hours.

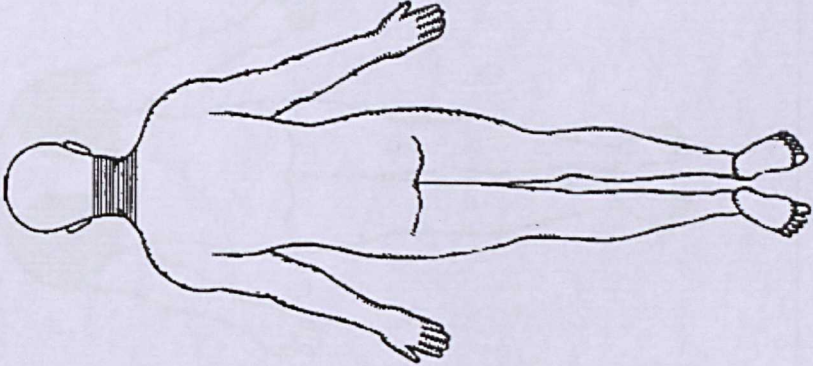
SECTION B- (HISTORY OF MSDs)

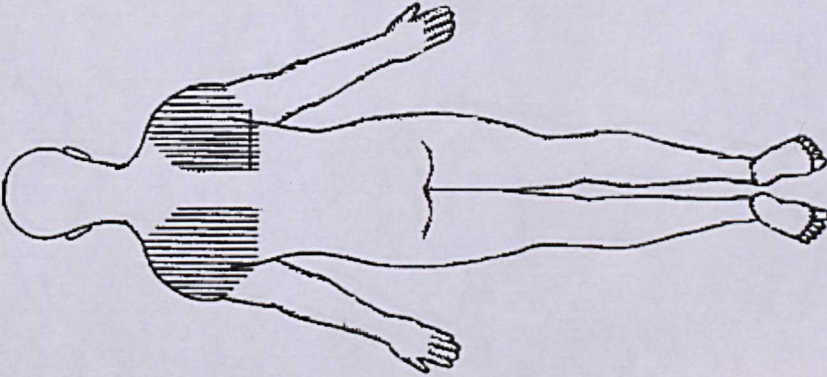
4. In the last month, have you been absent from lecture because of aches, pains or discomfort?  
 Yes  No
5. If Yes, what is the causes of your absenteeism? Please state  
\_\_\_\_\_
6. Have you been seen by doctor, physiotherapist, physician or other such person because the aches, pain or discomfort at your body during the last 12 months?  
 Yes  No
7. Have you been in accident before?  
 Yes  No
8. If Yes, which part of your body that having impact from the accident? Please circle from the body part (from body map) below.

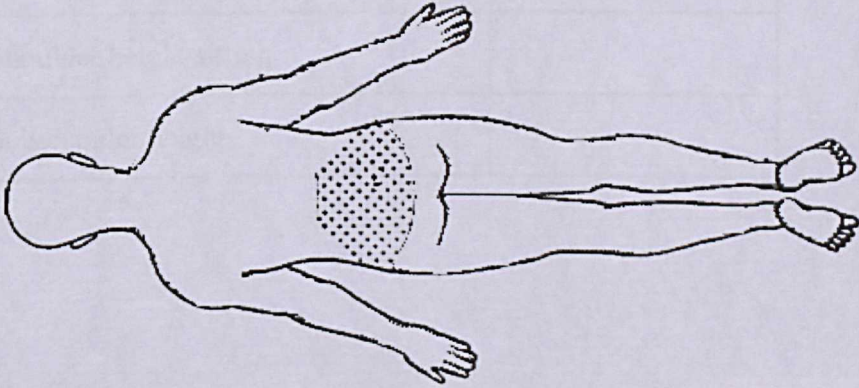


SECTION C - (PREVALENCE OF MSDS)

Please answer by (✓) in the most related to you. You may be in doubt as to how to answer, but please do your best.

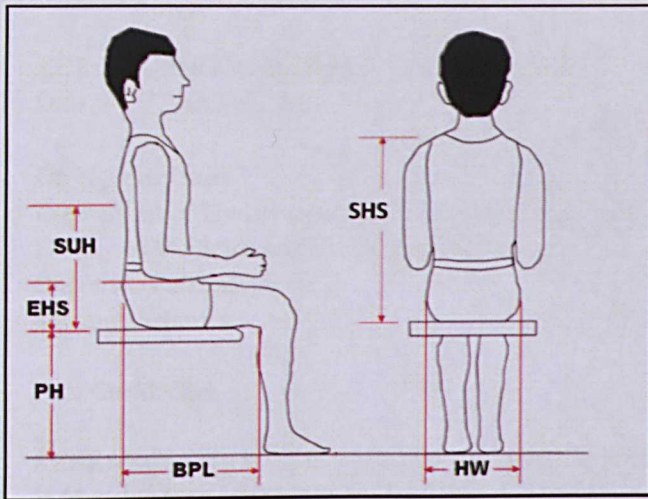
<p>Body part (Neck)</p>	<p>Did you ever feel pain, aches or discomfort at this body part?</p>	<p>Did you feel pain, aches or discomfort at this body part for 7 days?</p>	<p>Did you think that the pain, aches or discomfort is because of the seat and table at lecture hall?</p>
<p>i.</p>  <p>                     i. Yes <input type="checkbox"/>                      ii. No <input type="checkbox"/>                      If yes, proceed to question                      ii, iii and iv.                      If no, proceed to the next                      question.                 </p>	<p>ii.</p> <p>                     i. Yes <input type="checkbox"/>                      ii. No <input type="checkbox"/> </p>	<p>iii.</p> <p>                     i. Yes <input type="checkbox"/>                      ii. No <input type="checkbox"/> </p>	

<p>Body part (Shoulder)</p> 	<p>Did you ever feel pain, aches or discomfort at this body part?</p> <p>i.            i. Yes <input type="checkbox"/>            ii. No <input type="checkbox"/></p> <p>If yes, proceed to question ii, iii and iv. If no, proceed to the next question.</p>	<p>Did you feel pain, aches or discomfort at this body part for 7 days?</p> <p>ii.            i. Yes <input type="checkbox"/>            ii. No <input type="checkbox"/></p>	<p>Did you think that the pain, aches or discomfort is because of the seat and table at lecture hall?</p> <p>iii.            i. Yes <input type="checkbox"/>            ii. No <input type="checkbox"/></p>
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<p>Body part (Lower Back)</p> 	<p>Did you ever feel pain, aches or discomfort at this body part?</p> <p>ii.</p> <p>i. Yes <input type="checkbox"/></p> <p>ii. No <input type="checkbox"/></p> <p>If yes, proceed to question ii, iii and iv. If no, proceed to the next question.</p>	<p>Did you feel pain, aches or discomfort at this body part for 7 days?</p> <p>ii.</p> <p>i. Yes <input type="checkbox"/></p> <p>ii. No <input type="checkbox"/></p>	<p>Did you think that the pain, aches or discomfort is because of the seat and table at lecture hall?</p> <p>iii.</p> <p>i. Yes <input type="checkbox"/></p> <p>ii. No <input type="checkbox"/></p>
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FOR RESEARCHER TO FILL IN

SECTION D- ANTHROPOMETRIC BODY DIMENSION



a) ANTHROPOMETRIC MEASUREMENT OF THE STUDENT

No	Anthropometric Measurement	Measurement (cm)
1	Weight	
2	Height	
3	Popliteal height	
4	Buttock popliteal length	
5	Hip width	
6	Elbow height sitting	
7	Shoulder height sitting	
8	Subscapular height	

JKEUPM Ref No. : FPSK(EXP15-OSH)U039

- a) Members of the JKEUPM who reviewed the documents:  
Prof Dr Zamberi Sekawi
- b) Date of approval: 31/12/2015

Endorsed at JKEUPM Meeting on 8/1/2016, attended by:

NAME	DESIGNATION	GENDER	TICK IF PRESENT
Prof. Dato' Dr. Abdul Jalil Nordin	Nuclear Radiologist & Dean, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr Zamberi Sekawi	Medical Microbiologist & Deputy Dean of Research and Internationalization, Faculty of Medicine and Health Sciences	Male	√
Prof. Dato' Dr. Lye Munn Sann	Medical Statistician, Dept of Community Health, Faculty of Medicine and Health Sciences	Male	
Prof. Dr. Tengku Aizan Abd Hamid	Gerontologist & Director, Institute of Gerontology	Female	
Prof. Dr. Lekhraj Rampal	Medical Statistician, Dept of Community Health, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr. Lim Thiam Aun	Anesthesiologist, Dept of Surgery, Faculty of Medicine and Health Sciences	Male	√
Prof. Dr. Patimah Ismail	Professor of Biomedicine, Dept of Biomedical Sciences, Faculty of Medicine and Health Sciences	Female	√
Prof. Dr. Johnson Stanslas	Pharmacologist, Dept of Medicine, Faculty of Medicine and Health Sciences	Male	
Prof. Dr. Sherina Mohd.Sidik	Professor of Medical, Department of Psychiatry, Faculty of Medicine and Health Sciences	Female	√
Prof Dr. M. Iqbal Saripan	Professor of Department of Computer and Communication Systems Engineering	Male	
Assoc. Prof. Dr. Mansor Abu Talib	Assoc. Professor of Guidance and Counselling, Dept of Human Development and Family Studies, Faculty of Human Ecology	Male	
Assoc. Prof. Dr. Hejar Abd.Rahman	Assoc. Professor of Public Health / Head Of Unit, Department of Community Health, Faculty of Medicine and Health Sciences	Female	√
Assoc. Prof. Dr. Normala Ibrahim	Assoc. Professor of Psychiatry, Department of Psychiatry, Faculty of Medicine and Health Sciences	Female	√

Assoc Prof Dr Sharmala Paramasivam	Assoc Prof of Department English, Faculty of Modern Languages and Communication	Female	
Assoc Prof Dr Arshad Abdul Samad	Assoc Prof of Department Language and Humanities Education, Faculty of Educational Studies	Male	√
Assoc Prof Dr Muhamamd Najib Mohamad Alwi (Independent Member)	Psychiatric Consultant, Cyberjaya University College of Medical Sciences (CUCMS)	Male	√
Dr. Salmiah Md. Said	Lecturer of Epidemiology, Medical Statistics, Department of Community Health, Faculty of Medicine and Health Sciences	Female	√
Assoc. Prof. Dr. Noritah Omar (Lay Person)	Assoc. Professor of English Language, Dept of English Language, Faculty of Communication and Modern Languages	Female	√
Dr. Rojanah Kahar (Lay Person)	Senior Lecturer of Dept of Human Development and Family Studies, Faculty of Human Ecology	Female	
Tan Sri Dato' Napsiah Omar (Independent Member)	Chairman, National Population and Family Development Board	Female	√
En John Posko Anthony (Lay Person)	Headmaster of Sekolah Jenis Kebangsaan (Tamil) Kajang	Male	√