EVALUATION OF ERGONOMICS WORKSTATION IN

UTeM LAMAN HIKMAH LIBRARY

MUHAMMAD ANWAR BIN ABDUL AZIZ

A report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering (Hons.)

Faculty of Mechanical Engineering
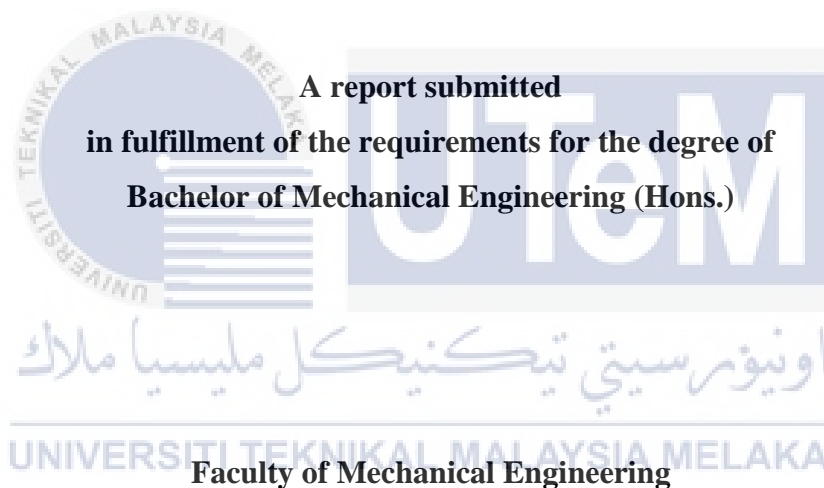
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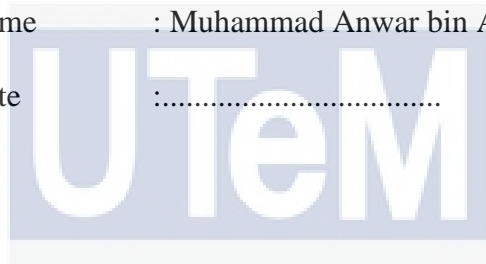
2021

DECLARATION

I declare that this project report entitled "Evaluation of Ergonomics Workstation in UTeM

Laman Hikmah Library" is the result of my own work except as cited in the references

Signature   :...................................

Name   : Muhammad Anwar bin Abdul Aziz

Date   :...............................

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APPROVAL

I hereby declare that I have read this project and in my opinion this report is sufficient in terms of scope and quality for the quality for the award of the degree of Bachelor of Mechanical Engineering (Hons).

Signature   :………………………….

Supervisor's Name   : Dr. Shafizal Bin Mat

Date   :………………………….

DEDICATION

For my beloved parents who are always supported me:

Abdul Aziz Bin Hj Mohd Yusof

Zaharah Binti Omar

For My Supervisor,

Dr. Shafizal Bin Mat

For my families and my friends thank for their caring

ABSRACT

Ergonomic is defined as the application of science concerned with the design and arrangement of objects that people use for people and things to interact more efficiently and safely. The learning environment, including lighting, temperature, workstation design, and others, can also affect users' comfort and health. Poor workstation design can result in injuries or related problems like musculoskeletal disorder (MSDs). The main objective of this project is to apply the ergonomic assessments (Temperature, illuminance, humidity and space) in the Laman Hikmah Library. The questionnaire is chosen method for gathering the information Laman Hikmah. The researcher also focused on evaluating the pattern and its compatibility with existed designs with ergonomic guidelines. Rapid Upper Limb Assessment (RULA) was also applied in this project to evaluate the computer workstation in Laman Hikmah Library. This assessment was conducted by using CATIA software. Some assessments (temperature assessment, humidity assessment, and illuminance assessment) indicate that the library and furniture were comfortable for Laman Hikmah users. However, ergonomic awareness among the Laman Hikmah Library needs further improvement. Evaluation ergonomic in the workstation library can improve awareness about ergonomic among Laman Hikmah Library.

ABSTRAK

Ergonomik ditakrifkan sebagai aplikasi sains yang berkaitan dengan reka bentuk dan susunan objek yang digunakan orang untuk orang dan perkara untuk berinteraksi dengan lebih cekap dan selamat. Persekitaran pembelajaran, termasuk pencahayaan, suhu, reka bentuk stesen kerja, dan lain-lain, juga dapat mempengaruhi keselesaan dan kesihatan pengguna. Reka bentuk stesen kerja yang buruk boleh mengakibatkan kecederaan atau masalah yang berkaitan seperti gangguan muskuloskeletal (MSD). Objektif utama makalah ini adalah untuk menerapkan penilaian ergonomik (Suhu, pencahayaan, kelembapan dan ruang) di Perpustakaan Laman Hikmah. Soal selidik dipilih kaedah untuk mengumpulkan maklumat Laman Hikmah. Pengkaji juga memberi tumpuan untuk menilai corak dan kesesuaiannya dengan reka bentuk yang ada dengan garis panduan ergonomik. Rapid Upper Limb Assessment (RULA) juga diterapkan dalam makalah ini untuk menilai stesen kerja komputer di Perpustakaan Laman Hikmah. Penilaian ini dilakukan dengan menggunakan perisian CATIA. Beberapa penilaian (penilaian suhu, penilaian kelembapan, dan penilaian pencahayaan) menunjukkan bahawa perpustakaan dan perabotnya selesa untuk pengguna Laman Hikmah. Namun, kesedaran ergonomik di Perpustakaan Laman Hikmah perlu diperbaiki lagi. Penilaian ergonomik di perpustakaan stesen kerja dapat meningkatkan kesedaran mengenai ergonomik di kalangan Perpustakaan Laman Hikmah.

ACKNOWLEDGEMENT

First the foremost, all praise is due to **Allah Subhana-Wa-Taala** for bestowing me with health, knowledge, and patience to finish this project. Without his permission, I would not be able to complete this work.

Thousands of thanks to my supervisor, Dr. Shafizal Bin Mat, for giving me a chance to do my project under his supervise. I would like to show gratitude for his patient assistance and his invaluable support.

Furthermore, I would like to convey my sincere appreciation to my parent for their prayers and for supporting me physically and mentally

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBEREVATIONS

UTeM	Universiti Teknikal Malaysia Melaka
MSDs	Musculoskeletal Disorder
ERF	Ergonomic Risk Factor
SH	Seat Height
SW	Seat Width
SD	Seat Depth
PH	Popliteal height
HB	Hip breadth
BPL	Buttock Popliteal, Length
UEBR	Upper Edge of Bracket
LEBR	Lower Edge of Bracket
HBR	Height of Backrest
WBR	Width of Bracket
SH	Shoulder Height
SSH	Subscapular Height
LH	Lumber Height
DH	Desk Height
DW	Desk Width
RULA	Rapid Upper Limb Assessment
CATIA	Computer Aided Three-Dimensional Interactive Application
FYP	Final year Project

CHAPTER 1

INTRODUCTION

1.1 Background

Laman Hikmah Library is suitable place for the user to study because of the quiet environment and comfortable place. The library is seen as an "informal place for learning," unlike the classroom, a formal place for learning (Montgomery, 2014). There seems to be great problems of ergonomic in the library environment. Since a comprehensive analysis occurs, the literature on ergonomic and libraries contained in books, journal and references from the internet (Bellemare *et al.*, 2006). In order to apply the ergonomic in library workstation, the definition of ergonomic must be understood.

Typically, ergonomics is related to humans and their jobs. However, on a broader scale, Ergonomics analyses humans' behavioural, psychological, and physiological capabilities and limitations (Jaffar *et al.*, 2011). Ergonomics is a comprehensive subject that encompasses a range of aspects that can impact a worker's comfort and health, including lighting, noise, temperature, vibration, heavy lifting, repetitive motion, workstation design, tool design, machine design, chair design, and footwear design, among others (Jaffar *et al.*, 2011). Next, musculoskeletal disorder (MSDs) causing pain in the hands, arms, shoulders, neck, back legs or feet while Musculoskeletal Disorder involving muscles, bones, tendons, nerves or other soft tissues (Santos et al., 2014).

1

1.2 Problem Statement

The incompatibility of furniture dimensions with user's anthropometry is the one of the problems in this paper. It is because of the lack of concern on ergonomic in the workstation. This problem can make some health problem such as musculoskeletal disorder (MSDs). 90% of the older impaired workers have MSDs (Yelin *et al.*, 1999).Therefore, ergonomic research can help detect poorly built furniture that does not suit the user's anthropometric features that have a negative effect on human health.

Laman Hikmah Library provide the computer workstation for the user. A standard computer or laser printer produces nearly the same heat as a person. Overheat and lack moisture can induce drowsiness, irritability, itching of the skin, eruptions and dryness or irritation of the eyes (Thibodeau and Melamut, 1995). Lighting in workstation also contributed the glare problem and need to evaluate.

Finally, ergonomic awareness of Laman Hikmah Library user need to determine. Some user spend a long period in the library to find some resources and information. Lack of ergonomic awareness will result in head position in an awkward posture, neck and upper extremities. Thus, making the pressure on the soft tissues against external workstation increased (Yuan, 2015).

1.3 Objective

The objectives of this project are as follows:

1. To evaluate the design of a workstation that effect on fatigue, safety and performance of user at Laman Hikmah Library.

2. To conduct the ergonomic assessment for library design at Laman Hikmah Library workstation.

3. To analyse user posture using Rapid Upper Limb Assessment (RULA) at computer workstation in Laman Hikmah Library.

4. To investigate the awareness about ergonomic in Laman Hikmah Library.

1.4 Scope of Project

The scopes of this project are:

1. Analysing and evaluate the ergonomics assessments such as temperature assessment, space assessment, arrangement assessment and light assessments.

2. Focus on compatibility of posture by using RULA method at computer workstation.

3. Proposed the ergonomic library environment form assessment for Laman Hikmah Library that meets ergonomic criteria.

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

The literature review is a theoretical background or the foundation of the project. In this chapter, it will discuss the material from the literature review that has used for the study. In order to obtain the crucial information, the review was conducted to achieve the objectives of the study that has been determined.

The review of literature on workers' ergonomic condition in related database such as Google Scholar, Science Direct, etc. There many investigations about ergonomic in the industrial workplace due to work in industrial at high risk of musculoskeletal disorder. However, this report to focus on library workstation which is Laman Hikmah Universiti Teknikal Malaysia Melaka (UTeM). Besides that, this chapter also includes information about Rapid Upper Limb Assessment (RULA). The information about anthropometric measurement will be include in this chapter. Lastly, the conclusion is the last subpart in this chapter that summarizes the whole chapter of literature review in this study.

2.2   Laman Hikmah

Since 10 June 2001, The UTeM Library has been operate in serving 348 pioneer students at the Temporary Campus in Taman Tasik Utama, Ayer Keroh, Melaka. Laman Hikmah Library at the Main Campus with 10,063.68 square meters provides a seating capacity of 500 users at any one time (utem.edu.my, 2015).

Figure 2.1: Location of Laman Hikmah Library

Figure 2.1 shows that Laman Hikmah location is the place to do some research in evaluating the ergonomics. The address of Laman Hikmah is Hang Tuah Jaya, 76100 Durian Tunggal, Melaka.

2.3 Ergonomic

Ergonomic come from the words ergo, a Greek word meaning "work" and nomics, meaning as "study" (Te-Hsin & Kleiner, 2001). From the definition, ergonomics is important to study the capabilities of human relating to work demands. Therefore, there is variety definition of ergonomics used by numerous researchers. Below are the definitions of ergonomics stated by previous researcher. Practicing good ergonomics has many advantage. Based on Middlesworth (2013) the advantages of ergonomics are:

1. Ergonomics improves productivity of workers:

   It will also increase the productivity of the staff by designing the efficient workstation that makes a job for good posture, less effort, less movements and better height and reaches.

2. Ergonomics help to improves quality:

   The quality of the product will reduce if the ergonomics of their workstation is poor. Then, the worker cannot do their best work due to frustrated and

fatigued. Therefore, optimizing an ergonomics workstation is important to workers because it can help to improve the quality of the product produced and increase the performance of the worker.

3. Ergonomics help to improve employee engagement:

    By making the best possible effort to provide their workers with the best health and safety. It can also decrease turnover, decrease absenteeism, enhance productivity and increase employee performance and during their workday the employee does not experience any pain and discomfort.

4. Ergonomics can create a better safety culture:

    To get better human performance in organization by creating and fostering the safety and health culture in the company because healthy employees are most valuable asset.

2.4   Ergonomic risk factor (ERF)

In safety concepts and in applied ergonomics literature, risk and risk factors are common topics. Risk contains an element of how likely or likely an event is and the seriousness of the impact or severity if something occur (Jaffar *et al.*, 2011).The seven types of The Ergonomic Risk Factor (ERF) which are:

a) Awkward posture: Muscles, tendons and ligaments must work harder and might be pressured in an awkward posture. An awkward posture arises when any joint bends or twists significantly outside the comfort of the movement (Jaffar *et al.*, 2011).

b) Force: Can be described as the amount of physical work needed to carry out a task (e.g. lifting) or to maintain control of equipment or instruments. Exerting force on a person or item can cause our muscles and tendons to become overworked.

c) Repetition: The repetition rate of a joint or a body link is indicated as the average number of movements or exertions completed within a unit of time or the repetition of identical motions with the same body part with little rest or recuperation (Jaffar *et al.*, 2011).

d) Vibration: Vibrations occur when an object oscillates or moves rapidly around its fixed point, like a swinging pendulum (Jaffar *et al.*, 2011).

e) Contact stress: Contact stressors occur when you work with forearms or wrists on the edge of a desk or counter (Jaffar *et al.*, 2011).

f) Extreme temperature: Extreme temperatures can be classed into two extremely cold and extremely hot temperatures. Cold temperature can be determined by reducing manual dexterity and emphasizing the nerve end symptoms (Jaffar *et al.*, 2011).

g) Static load: Our body is designed to move, not to keep passive. It is uncomfortable and fatigued to keep any position of the body for longer durations without modification (Jaffar *et al.*, 2011).

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2.5   Ergonomic of library workstation

Adam (2010) found in this study, stretch, pressure, headache are the ergonomic problem happen due to the condition in librarians, library stuffs and system engineers in Logos and Covenant University. Instead, most related ergonomic research either focuses on evaluating ergonomic risks for library users or only looks at how librarians set up their computer workstations. Human factors and ergonomics are often ignored by libraries when designing electronic information services' hardware and software implementations (Thibodeau and Melamut, 1995).

2.6   Library space study

It requires understanding how students learn to facilitate their learning in the space they choose when creating the space. One of the main functions that define library space, according to Anuta Nitecki's article, is the job of the facilitator. The library fulfils this purpose by providing areas that "promote self-directed study." as well as the generation of new knowledge" (Montgomery, 2014).

2.7   Illumination study

Different lighting conditions can affect the scale and precision of visual perception, which can affect task performance. Artificial illumination's primary goal is to allow individuals to complete tasks in a comfortable, simple, and timely manner (Montgomery, 2014).

2.8 Thermal comfort

The influence of external elements and subjective responses towards the reported thermal condition make predicting optimal values of comfort parameters in automobiles problematic, as this particular environment is influenced by a number of additional aspects compared to buildings (Danca *et al.*, 2016).

2.8.1 Current standard of thermal comfort

The current standard that assessing thermal comfort building was The European EN ISO 7730 and is based on the theory of Fanger. During assessment, the person were exposed to various thermal conditions and the subject had standard clothes performing a standard activity (Danca *et al.*, 2016). By using ASHRAE scale with seven values (-3; cold,-2; cool,-1; slightly cool, 0; neutral, 1; slightly warm, 2; warm, 3 hot) the subject has been assessed according to the felt sensation.

2.9 Relationship between library and anthropometric measures
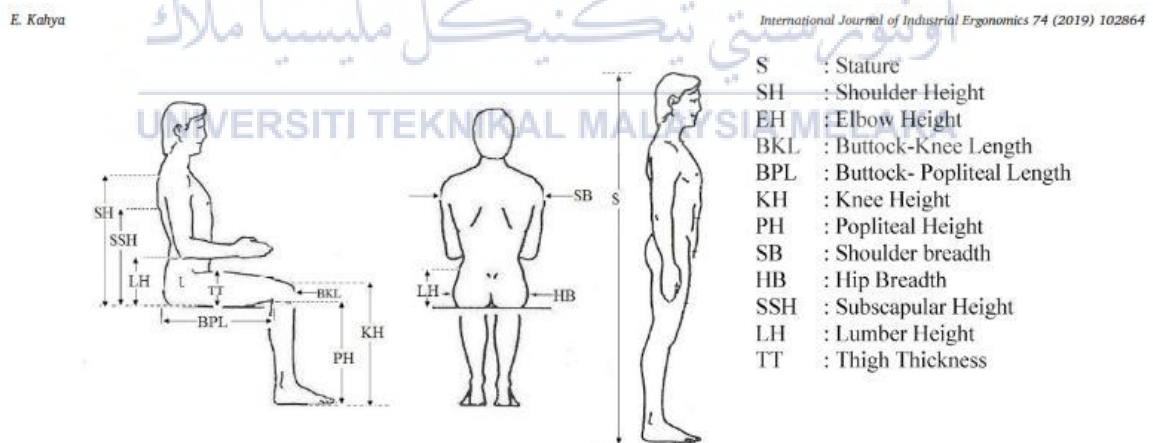
Figure 2.2: Anthropometric measures (Kahya, 2019).

Figure 2.2 shows the anthropometric measures that have to focus on this project. There are 12 anthropometrics measures: stature, shoulder height, elbow height, buttock-knee length, buttock-popliteal length, knee height, popliteal height, shoulder breadth, and hip breadth, subscapular height, lumber height, and thigh thickness.

9
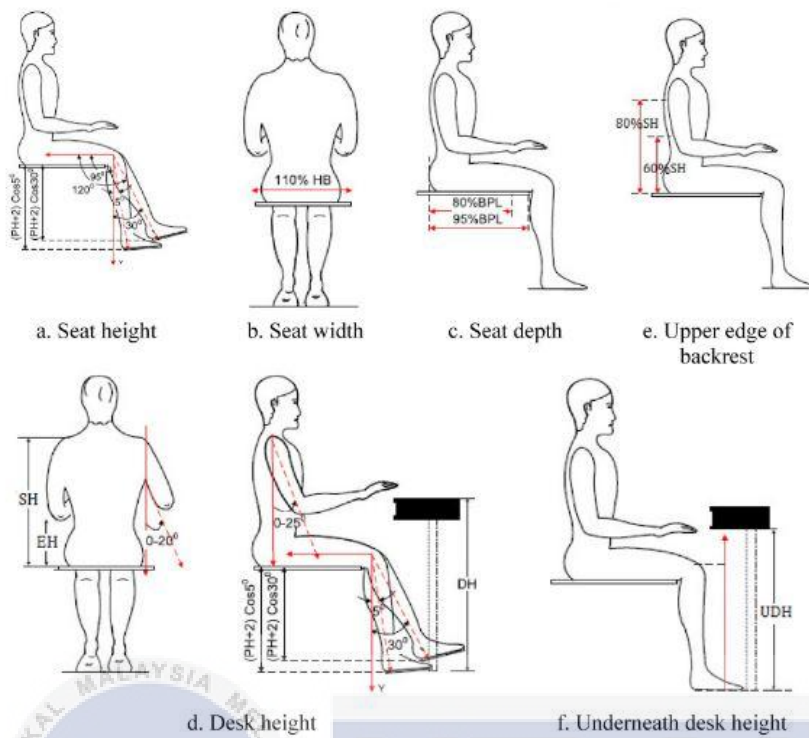
Figure 2.3: Relationship between anthropometry and library furniture dimensions (Yanto, Lu and Lu, 2017).

Figure 2.3 shows the correlation between anthropometry and library furniture, which is the chair and desk. This illustration can be an indicator of the project during the measuring session. In Figure 2.3, all anthropometric measures used in this study are seat height, seat width, seat depth, the upper edge of the backrest, desk height, and underneath desk height.

Table 2.1: Relation between library furniture and anthropometric

Section	University Library furniture dimension	Anthropometric measures
Seat	Seat height (SH)	Popliteal height (PH)
	Seat Width (SW)	Hip breadth (HB)
	Seat Depth (SD)	Buttock- popliteal length (BPL)
Backrest	Upper Edge of Backrest (UEBR)	Shoulder Height (SH)
	Lower Edge of Backrest (LEBR)	Lumber height (LH)
	Height Backrest (HBR)	Lumber height (LH)
	Width Backrest (WBR)	Shoulder breadth (SB)
Desk	Desk Height (DH)	Popliteal height (PH)
		Elbow Height (EH)
		Shoulder Breadth (SH)
	Desk Depth (DD)	Functional Criteria
	Desk Width (DW)	Functional Criteria
		Seat Width (SW)
	Underneath Desk Height (UDH)	Knee Height (KH)
Interaction	Seat to desk clearance (SDC)	Thigh Thickness (TF)
		Knee Thickness (KH)
	Seat to Desk Height (SDH)	Elbow height (EH)

2.10   Equation for mismatch by past researcher

2.10.1 Seat Height (SH)

It shows from Figure 2.3 the height of the seat must be higher than [(PH+2) Cos (30˚)] to make sure the formation of angle of the leg in an angle less than 30˚ relatively to the vertical. From that, student would sit comfortably while the thighs have sufficient support. Then, the seat will less than [(PH+2) Cos (5˚)] for the maximum, the student's feet must have proper contact with floor and in order to prevent pressure from existing in the tissue on the underside area of the thighs (Yanto, Lu and Lu, 2017).

$$(PH + SC)\cos 30° \leq SH \leq (PH + SC)\cos 5° \tag{1}$$

11

2.10.2 Seat width (SW)

SW should be at least 10% (to suit hip breadth) and at most 30% (economy of space) higher than HB in Figure 2.3, recommended by Gouvali and Boudolos (2006) which is determined by equation (2):

$$1.10 \text{ HB} \leq \text{SH} \leq 1.30 \text{ HB} \qquad (2)$$

2.10.3 Seat depth (SD)

Mismatch when SD is either > 95% or < 80% of BPL in Figure 2.3 stated by (Parcells, Stommel and Hubbard, 1999). It can determined in equation (3):

$$0.80 \text{ BPL} \leq \text{SD} \leq 0.95 \text{ BPL} \qquad (3)$$

2.10.4 Upper edge of bracket (UEBR)

Gouvali and Boudolos, (2006) recommend that in order to keep the backrest lower than or at most on the upper edge of scapula which is 60%-80% shoulder height (SH) in Figure 2.5.2.It can show in equation 4:

$$0.60 \text{ SH} \leq \text{UEBR} \leq 0.80 \text{ SH} \qquad (4)$$

2.10.5 Lower edge of bracket (LEBR)

Based on (Gouvali and Boudolos, 2006), that UDH should be at least 2 cm higher than knee height (but not higher than desk height plus its thickness). It will be assumed 2 cm for table thickness and determined in equation 5:

$$(\text{KH} + \text{SC}) + 2 \leq \text{UDH}$$
$$\leq (\text{PH} + \text{SC})\text{Cos } 5° + 0.8517 \text{ EH} \qquad (5)$$
$$+ 0.1483 - 2$$

2.10.6 Desk height (DH)

There are suggestion from Chaffin and Anderson (1991) about the minimum and maximum angles that is suitable for the shoulder during writing which 0-25° for shoulder flexion and 0-20° for shoulder abduction. It can determined by equation 6:

$$(SH + EH) \leq D \leq SH + 0.88517\ EH + 0.1483\ SH \qquad (6)$$

2.11 Anthropometry of Malaysia young adults

Table 2.2 and 2.3 below provides an anthropometric database of male and female adults in Malaysia. There 33 anthropometric dimensions were shown and presented in the form of mean, minimum, and maximum, standard deviation, coefficient of variant,1 percentil,5 percentile,50 percentile,95 percentile and 99 percentile. This database could be used for evaluating the ergonomic design of a workstation or product. The obtained anthropometric data were analysed using the SPSS program and the MS ISO 15535:2008 standard (Malaysian Standard, 2008). Evaluate the irregular and outlier anthropometric data by using The MS ISO standard (Karmegam *et al.*, 2011).

The SPSS program was used for the statistical analysis and investigated the precious entries by checking on the outlier (Kothiyal and Tettey, 2001).

Table 2.2 Anthropometric data for Malaysian Males (Karmegam *et al.*, 2011).

	Measurement [a]	Mean	SD	SEM	CV (%)	Min	1st	5th	50th	95th	99th	Max
1	Age (year)	19,70	1,00	0,04	5,06	18,00	18,00	19,00	19,00	21,00	23,00	24,00
2	Weight (kg)	64,33	15,24	0,62	23,68	41,00	43,00	46,00	60,00	99,00	115,08	120,00
3	Stature	168,01	6,08	0,25	3,62	150,50	152,90	159,38	167,40	178,34	183,50	186,18
4	Eye Height	156,41	6,49	0,27	4,15	137,20	140,12	146,70	156,00	167,60	173,63	175,30
5	Shoulder Height	139,57	6,07	0,25	4,35	122,30	125,26	131,10	138,80	150,00	156,80	157,30
6	Elbow Height	106,02	4,68	0,19	4,41	92,50	94,50	98,48	105,90	113,44	119,30	120,20
7	Fist (grip axis) height	71,70	4,48	0,18	6,25	58,80	60,60	64,88	71,60	79,62	84,10	85,10
8	Vertical Grip Reach, standing	200,93	8,87	0,36	4,42	177,50	182,40	186,48	200,20	217,40	222,92	225,50
9	Shoulder (biacromial) breadth	43,28	2,95	0,12	6,81	35,20	36,40	39,26	42,80	49,30	51,51	52,80
10	Elbow-to-elbow breadth	45,64	4,20	0,17	9,21	36,30	38,10	39,90	44,70	54,18	57,61	58,20
11	Thigh clearance	14,82	2,16	0,09	14,59	9,20	9,90	11,70	14,50	19,30	19,70	19,90
12	Abdominal Depth, sitting	18,70	3,64	0,15	19,48	13,20	13,60	14,60	17,70	27,60	29,50	30,00
13	Hip Breadth, sitting	31,35	3,31	0,14	10,57	22,10	22,50	27,28	30,90	37,62	40,61	40,80
14	Sitting height (erect)	83,52	4,15	0,17	4,98	71,10	71,20	76,90	83,50	89,98	92,82	95,70
15	Eye height, sitting	71,85	4,17	0,17	5,81	59,40	59,50	64,48	72,20	78,42	80,60	82,20
16	Shoulder height, sitting	55,74	3,21	0,13	5,77	46,70	47,28	50,50	55,60	61,42	63,81	65,30
17	Elbow height, sitting	19,20	3,25	0,13	16,91	11,80	12,70	14,50	18,90	25,40	27,42	40,50
18	Elbow Grip Length	33,72	2,60	0,11	7,71	26,20	26,50	29,80	33,50	38,30	41,00	41,50
19	Grip reach; forward reach	73,88	4,74	0,19	6,41	59,70	60,60	65,38	74,20	81,42	84,92	87,90
20	Buttock-popliteal length (seat depth)	49,05	3,52	0,14	7,17	38,60	40,07	42,40	49,30	54,40	56,30	59,40
21	Buttock Knee Length	60,49	3,20	0,13	5,29	51,50	52,09	55,20	60,40	65,82	67,71	69,90
22	Buttock Heel Length	109,48	5,32	0,22	4,86	94,60	97,60	101,18	109,40	118,42	120,50	122,80
23	Lower leg length (popliteal height)	41,44	1,42	0,06	3,44	37,60	38,20	39,30	41,30	44,00	45,30	45,70
24	Hand Length	18,63	0,98	0,04	5,26	16,00	16,20	16,80	18,60	20,20	20,60	20,90
25	Hand breadth at metacarpals	8,33	0,32	0,01	3,85	7,40	7,50	7,90	8,30	8,80	9,10	9,20
26	Hand Thickness	2,62	0,25	0,01	9,49	1,90	2,00	2,30	2,60	3,00	3,10	3,10
27	Thumb breadth	1,99	0,17	0,01	8,40	1,50	1,60	1,80	2,00	2,30	2,40	2,40
28	Index finger breadth, proximal	1,58	0,14	0,01	8,82	1,20	1,20	1,40	1,60	1,80	1,90	1,90
29	Foot Length	25,28	1,18	0,05	4,67	20,20	20,70	23,30	25,40	26,90	27,20	27,20
30	Foot Breadth	9,68	0,56	0,02	5,75	8,20	8,30	8,80	9,70	10,60	10,90	11,00
31	Head Length	18,23	0,66	0,03	3,61	16,80	16,80	17,10	18,30	19,30	20,00	20,20
32	Head Breadth	14,13	0,45	0,02	3,15	12,60	13,10	13,40	14,20	14,90	14,90	15,00
33	Head Height	23,24	1,23	0,05	5,30	19,60	20,40	21,30	23,00	25,40	25,90	26,00
34	Head circumference	55,39	1,70	0,07	3,06	50,90	51,30	52,60	55,30	58,10	59,40	60,20

[a] measured in centimeters

14

Table 2.3 Anthropometric data for Malaysian Females (Karmegam *et al.*, 2011)

	Measurement [a]	Mean	SD	SEM	CV (%)	Min	1st	5th	50th	95th	99th	Max
1	Age (year)	19,98	1,14	0,06	5,71	18,00	19,00	19,00	19,00	22,00	24,00	24,00
2	Weight (kg)	55,88	10,71	0,51	19,17	36,00	38,00	41,00	55,00	76,00	92,24	100,00
3	Stature	156,07	5,32	0,25	3,41	141,50	143,08	146,49	155,90	163,91	170,06	170,70
4	Eye Height	144,80	5,27	0,25	3,64	130,60	131,84	135,29	144,50	152,81	158,76	159,70
5	Shoulder Height	129,36	5,86	0,28	4,53	117,10	117,44	119,70	128,70	140,51	145,62	146,70
6	Elbow Height	98,28	4,93	0,24	5,02	85,90	87,24	89,88	98,30	106,20	111,02	112,40
7	Fist (grip axis) height	66,16	4,53	0,22	6,84	52,50	53,54	57,99	66,40	73,21	75,50	79,80
8	Vertical Grip Reach, standing	184,29	7,82	0,37	4,24	161,00	162,28	169,92	184,40	197,30	199,40	203,90
9	Shoulder (biacromial) breadth	37,51	2,74	0,13	7,32	30,20	30,34	33,29	37,30	42,40	44,42	45,10
10	Elbow-to-elbow breadth	41,83	3,75	0,18	8,95	32,40	33,73	35,59	41,60	48,46	53,22	54,10
11	Thigh clearance	13,56	2,41	0,12	17,77	9,00	9,24	9,99	13,20	17,52	19,46	19,70
12	Abdominal Depth, sitting	18,06	3,59	0,17	19,90	12,20	13,00	13,50	17,30	25,62	28,30	28,70
13	Hip Breadth, sitting	31,75	3,68	0,18	11,61	22,70	23,21	26,49	31,30	39,00	41,90	42,80
14	Sitting height (erect)	78,31	4,36	0,21	5,57	65,30	66,54	71,22	78,40	84,80	89,76	90,10
15	Eye height, sitting	67,66	4,56	0,22	6,74	54,40	54,64	59,40	67,40	74,90	79,55	81,20
16	Shoulder height, sitting	52,32	4,17	0,20	7,97	42,40	42,83	44,49	52,30	60,01	63,30	64,70
17	Elbow height, sitting	19,30	3,21	0,15	16,63	11,40	12,15	14,30	18,90	24,91	26,96	27,80
18	Elbow Grip Length	34,94	4,68	0,22	13,38	25,10	27,59	29,20	33,20	42,31	45,50	47,80
19	Grip reach; forward reach	68,25	5,44	0,26	7,98	54,30	57,58	60,17	67,40	80,30	83,36	84,30
20	Buttock-popliteal length (seat depth)	45,70	3,82	0,18	8,35	35,80	38,44	40,30	45,30	53,22	54,96	55,80
21	Buttock Knee Length	54,48	4,33	0,21	7,94	42,80	46,54	48,30	54,20	62,10	64,56	65,30
22	Buttock Heel Length	99,85	4,89	0,23	4,89	89,30	89,40	90,78	99,30	108,52	112,10	113,10
23	Lower leg length (popliteal height)	39,31	2,46	0,12	6,25	33,10	33,40	34,40	39,90	42,81	43,90	44,50
24	Hand Length	16,95	1,11	0,05	6,53	13,80	14,40	14,70	17,00	18,80	19,46	19,80
25	Hand breadth at metacarpals	7,33	0,50	0,02	6,82	6,50	6,50	6,50	7,40	8,30	8,70	8,80
26	Hand Thickness	2,38	0,27	0,01	11,38	1,60	1,70	1,99	2,40	2,80	3,00	3,00
27	Thumb breadth	1,75	0,18	0,01	10,24	1,30	1,30	1,50	1,80	2,10	2,20	2,20
28	Index finger breadth, proximal	1,53	0,15	0,01	10,14	1,10	1,20	1,30	1,50	1,80	1,90	1,90
29	Foot Length	22,78	1,45	0,07	6,35	18,70	19,30	20,10	23,00	25,20	25,60	25,90
30	Foot Breadth	8,53	0,83	0,04	9,78	7,10	7,10	7,20	8,60	9,70	10,30	10,30
31	Head Length	17,38	0,80	0,04	4,61	15,20	15,34	15,80	17,40	18,70	19,30	19,60
32	Head Breadth	14,08	0,57	0,03	4,05	12,40	12,50	12,80	14,30	14,80	14,90	14,90
33	Head Height	21,98	1,60	0,08	7,26	17,40	17,84	19,08	22,00	24,50	25,36	25,70
34	Head circumference	54,72	2,36	0,11	4,31	47,90	48,10	51,00	55,00	58,62	59,62	60,00

[a] measured in centimeters

2.12 RULA (rapid upper limb assessments)

To investigate the exposure of individual workers toward risk factors associated with work-related upper limb disorder is the main objective the RULA was developing (Mcatamney and Corlett, 1993). RULA was created without the use of any specialised equipment. A number of investigators were able to receive training in conducting the assessments as a result of this without the need for extra equipment.

2.12.1 Development of RULA for body parts (upper arm, lower arm and wrist)

The scoring diagram for the posture of the body components in Group A shows in Figure 2.3: the upper arm, lower arm, and wrist with a section to record the pronation or supination occurring called a wrist twist (Mcatamney and Corlett, 1993).
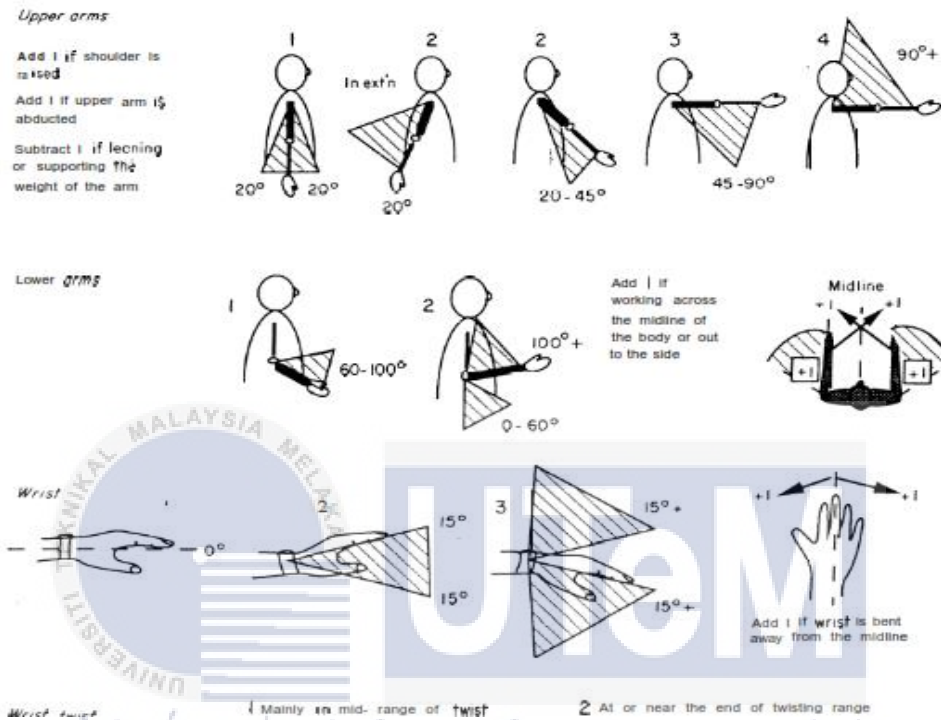
Figure 2.4: Posture scores for body part (Mcatamney and Corlett, 1993).

2.12.1.2   Upper arm

The table 2.2 below shows the scoring and assessed range of movement for the upper arm that Tichauer Chaffin, Herberts, et al., Herberg, Schuldt, et al., and Harms-Ringdahl and Schudt has carried out (Mcatamney and Corlett, 1993).

Table 2.4: Scoring for upper arm using RULA method

Body part	Score	Observation
Upper arm	1	20˚ extension to 20˚ flexion
	2	Extension greater than 20˚ or 20˚-45˚ of flexion
	3	45˚-90˚ of flexion
	4	90˚ of flexion

2.12.1.3   Lower arm

The range for the lower arm in table 2.3 are developed from Grandjean and Tichauer.

Table 2.5: Scoring for lower arm using RULA method

Body part	Score	Observation
Lower arm	1	60°-100° flexion
	2	Less than 60° or more than 100° flexion

2.12.1.4   Wrist

To provide the posture score for wrist issue, the guidelines by Health and Safety Executive has used. Based on Tichauer the pronation and supination of wrist (wrist twist) are determined as neutral posture .The table below show the score for the wrist.

Table 2.6: Scoring for wrist using RULA method

Body part	Score	Observation
Wrist	1	Neutral position
	2	0°-15° in either flexion or extension
	3	15° or more in either flexion or extension
Wrist twist	1	Wrist is in mid-range of twist
	2	Wrist is at or near the end of range of twist.

2.12.2 Development of RULA for body parts (neck and trunk)

The figure below shows the diagram of posture ranges for the neck and trunk. The diagram an indicator for an explanation of detail in neck and trunk posture.
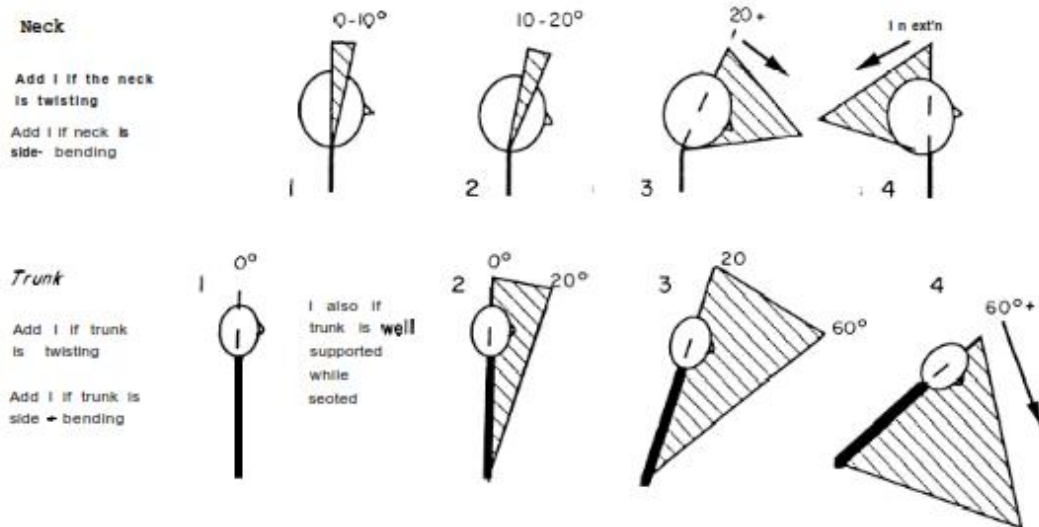
Figure 2.5: The posture score for body parts (neck and trunk) (Mcatamney and Corlett, 1993).

2.12.2.1 Neck

The range for neck in table 2.5 has refer on Chaffin and Kilbom et al. studies. Neck posture will increased by 1 if the neck was twisted (Mcatamney and Corlett, 1993).

Table 2.7: Scoring for neck using RULA method

Body part	Score	Observation
	1	0°-10° flexion
Neck	2	10°-20° flexion
	3	20° or more flexion
	4	extension

2.12.2.2 Trunk

Drury and Grandjean et al. has developed the ranges for the trunk (Mcatamney and Corlett, 1993).

Table 2.8 Scoring for trunk using RULA method

Body part	Score	Observation
	1	Sitting and well supported with a hip-trunk angle of 90° or more
Trunk	2	0°-20° flexion
	3	20°-60° flexion
	4	60° or more flexion

2.13   Summary for chapter 2

Literature review is scientific and experimental findings that start from fundamental theory or the basic concept and then the methodology is developed to find the main purpose. The main objective of literature review is to obtain an understanding of the existing research relevant to a certain study and to present that knowledge in the form of written report.

This chapter explains ergonomic past year study that has been found by past researchers. This chapter also shows aspects that related on ergonomic factors which are thermal comfort, illuminance study, furniture's design and space study. Rapid upper limb assessments also has been discussed in this chapter. The next chapter will discuss the selected approach to project development as it contributed to completing the project.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter discusses the method used in the study. This method aims to identify the compatibility of furniture in Laman Hikmah and the user's body dimension. Every single step that involves carrying out the research will be described in detail.

3.2 Planning project

The Gantt chart for Final Year Project (FYP) 1 and 2 shows in Tables 3.1 and 3.2. The Gantt chat is essential to simplifying the complex project and reference for project management. The tables also show the activities and timeframe. Although the real-time progress is not as exact as the time frame, it keeps track of and systematically organizes the time.

Table 3.1: Gantt chart of Project planning FYP 1(Author)

Activities	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Title selection	█													
Identification of objective, scope and workflow		█												
Literature review			█	█	█									
Methodology						█	█	█	█	█	█			
Report preparation									█	█	█	█		
Report writing and submission												█	█	█
PSM seminar														█

Table 3.2: Gantt chart of Project planning FYP 2(Author)

Activities	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Do ergonomic assessment and survey	▓	▓	▓	▓										
Write progress report			▓	▓	▓	▓								
Make the analysis from data						▓	▓	▓	▓	▓	▓			
Report preparation									▓	▓	▓	▓		
Report writing and submission												▓	▓	▓
PSM seminar														▓

3.3 Flow chart

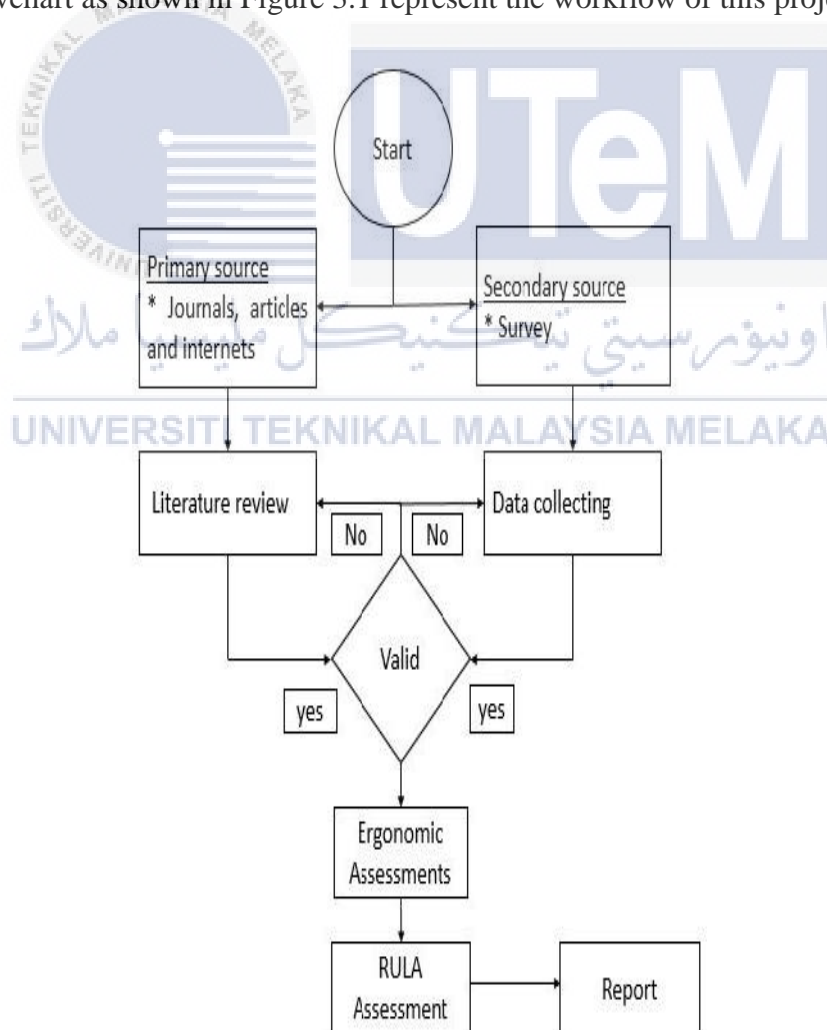Flowchart as shown in Figure 3.1 represent the workflow of this project.

Figure 3.1: Flow chart of the methodology

21

3.4   Questionnaire

The questionnaire is the research instrument that includes questions that collect data or information from Laman Hikmah Library's users. Their feedback use for statistical analysis of user experience while in the library. Forty samples will be taken to evaluate or determine the problem related to ergonomics while staying in the library. This method will be conducted in one way: distribute the questionnaire online using google form. The target participant are student and staff in Universiti Teknikal Malaysia Melaka (UTeM).

3.5   Ergonomic Assessments in library

3.5.1   Light assessments

Table 3.3:Data of recommended illuminance level for level for different building type (Hartigan-Go and Bongat, 2014).

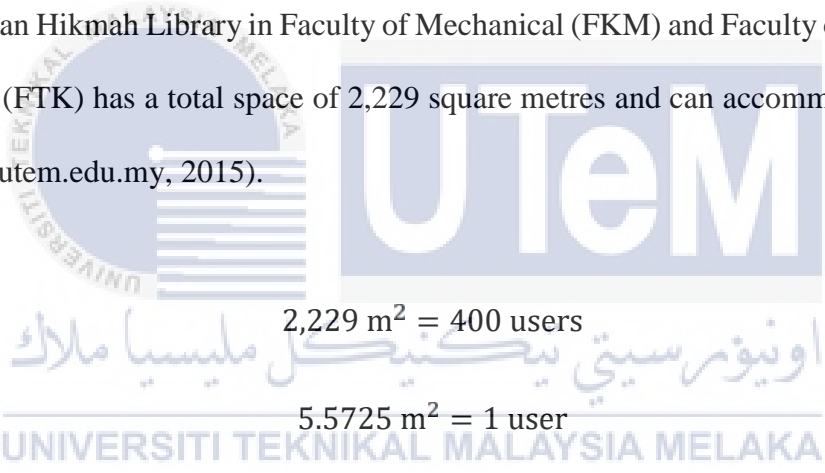| Task and application	Illuminance (Lux)
a) Lighting for infrequently used area:	
• Minimum service illuminance	20
• Interior walkway and car-park	100
• Hotel bedroom	100
• Lift interior	100
• Corridor	100
• Escalator, travellator	150
b) Lighting for working interior:	
• Infrequent reading and writing	200
• General offices, shops and stores,	300-400
• Drawing office	300-400
• Restroom	150
• Kitchen	150-300
• Classroom, library	300-500

This assessment helps to identify the illumination level in the library. Lighting in the workplace is essential to make the user comfortable and accomplish tasks efficiently and safely. The proper light can also allow user to do their task like studying or reading in the library for a longer time.

3.5.2 Temperature and humidity Assessment

The evaluations are measured in two sessions: on a sunny day and cloudy. Therefore, all temperatures are expected to differ as the session are varies in condition. This assessment will be assisted by someone who knows about temperature, a student from the thermal elective. Next, the humidity also focuses because this aspect will affect the comfort of people in the library.

3.5.3 Space Assessment

Evaluation based on the library layout and the furniture spacing. The dimension of between table and another will be taken. From that, it can identify that the space is acceptable or not. . Laman Hikmah Library in Faculty of Mechanical (FKM) and Faculty of Technology Engineering (FTK) has a total space of 2,229 square metres and can accommodate roughly 400 people (utem.edu.my, 2015).

$$2{,}229 \text{ m}^2 = 400 \text{ users} \qquad (7)$$

$$5.5725 \text{ m}^2 = 1 \text{ user} \qquad (8)$$

3.5.4 Chair Assessment

During COVID-19, there is no measurement task for users anthropometric. Instead, the researcher will measure the chair dimension to evaluate by comparing user anthropometric data from past research published in 2011. Figure 3.2 shows the indicator for the researcher to measure the chair dimension and make a minor measurement error. There are numerous ways in the literature review used to measure the chair and dimension which are measuring tape, ruler and bevel protractor.
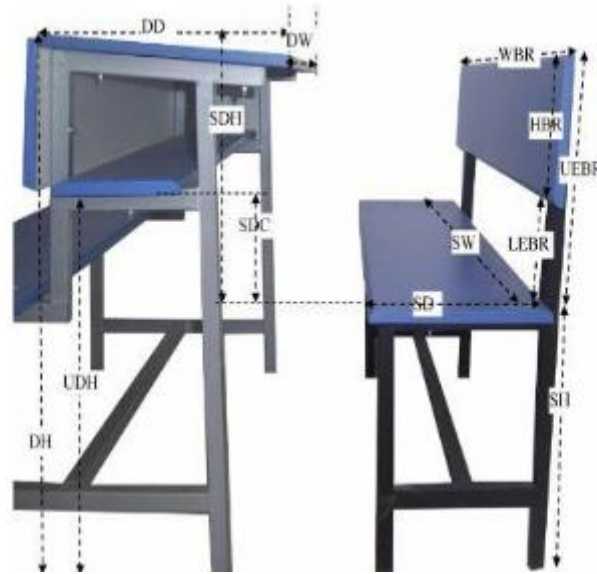
Figure 3.2 Indicator for measurement chair and table (Kahya, 2019).

There are four chair dimensions (Chair seat height, Chair seat width, Chair seat depth and Upper edge of backrest) and one desk dimension (Desk height) will measure. Table 3.2 shows the match and matching level analysis.

Table 3.4: Determine the match and mismatch between user anthropometric measurement and library furniture

Component	School furniture dimension	Existing furniture	Match/Mismatch level		
			Min	Max	Average
Seat	Seat Height (SH)				
	Seat width (SW)				
	Seat Depth (SD)				
Backrest	Upper Edge of Backrest (UEBR)				
	Slope				
Desk	Desk Height (DH)				
	Scoring				

To calculate the match and mismatch level, this section will propose several equations to obtain the result. Table 3.4 shows the table will fill during chair and desk assessment. Based on the literature review, the calculation for match and mismatch analysis are:

24

For seat height,

$$(PH + SC)\cos 30° \leq SH \leq (PH + SC)\cos 5° \qquad (1)$$

Where PH= Popliteal Height, SC= Shoe correction

For seat depth,

$$0.80\ BPL \leq SD \leq 0.95\ BPL \qquad (3)$$

Where BPL= Buttock- Popliteal Length

For seat width,

$$1.10\ HB \leq SH \leq 1.30\ HB \qquad (2)$$

Where HB=Hip Breadth

For upper edge of backrest,

$$0.60\ SH \leq UEBR \leq 0.80\ SH \qquad (4)$$

Where SH= Shoulder Height

For desk height,

$$(SH + EH) \leq D \leq SH + 0.88517\ EH + 0.1483\ SH \qquad (6)$$

Where SH= Seat Height, EH=Elbow Height

3.6 RULA (Rapid Upper Limb Assessment)

This section will conduct by using computer software. The computer workstation in Laman Hikmah Library will design using Computer Aided Three-Dimensional Interactive Application (CATIA) software as shown in Figure 3.3. The position will evaluate are seating posturer, static seating in working position and flexion lumbar angle in seating posture. The selecting the posture by the observation based on RULA guidelines, the worst or the most frequent posture of user were investigate when conducting their task at computer workstation in Laman Hikmah Library.
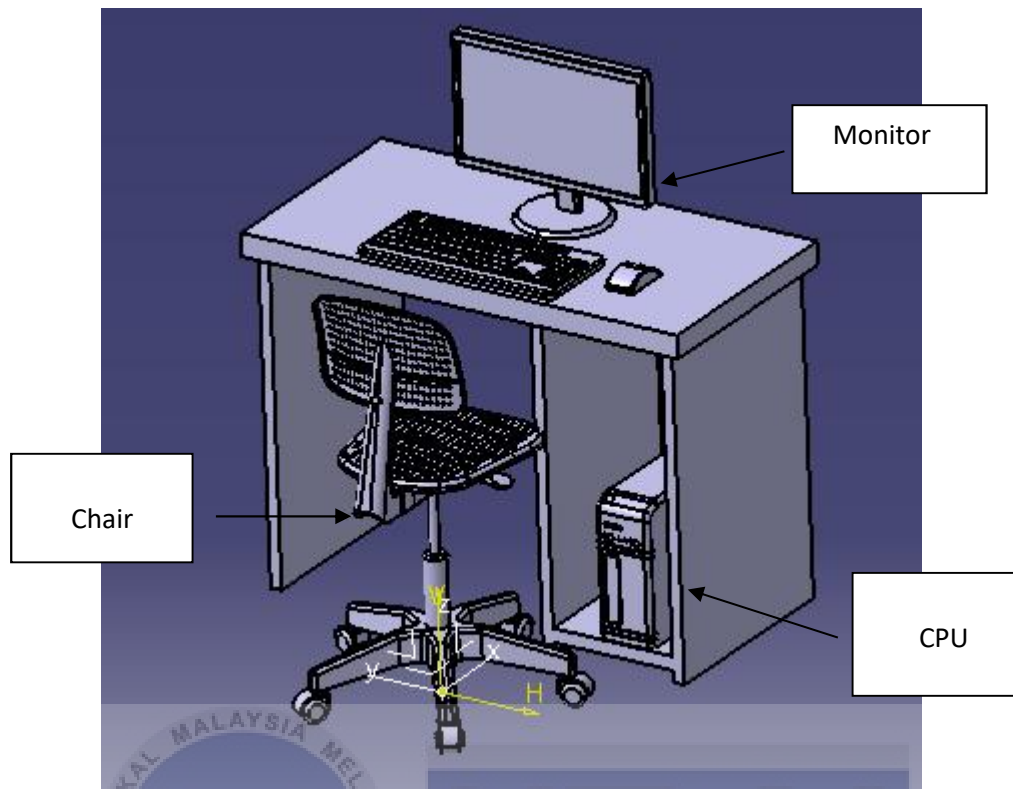
Figure 3.3: Design of computer workstation with labelling in isometric view

3.7   Summary chapter 3

The chapter discusses the method used to gather information from user's Laman Hikmah Library and evaluate the assessment of the Laman Hikmah in reading area for the with existed ergonomic approach that gained from journal research, articles, books and websites. By the comparing result, the ergonomic analysis will be conducted to make the improvement in ergonomic factor. Therefore, the result that has been obtain from the method used will be comparing conclusion.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the data obtained and result from the information gathered throughout Laman Hikmah Library users. Google form is the main platform to proceed with the evaluation session and the data are retrieved from 40 participants .The sample question of this research has shown in Appendix A. This chapter discusses temperature assessment, humidity assessment, lighting assessment, and anything related to ergonomics in the library. Comparison between other library areas (reading zone 1st level, working room, reading zone 2nd level, 24 hours area, and SMART room) also present in this chapter. RULA Assessment result at the computer workstation in reading zone 1st level will discuss in this chapter.

4.2 Data Evaluation

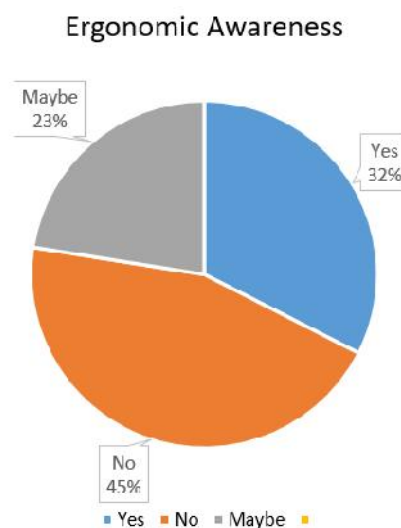### 4.2.1 Ergonomic awareness among Laman Hikmah Library user

Figure 4.1: Ergonomic awareness percentage, n=40

The pie chart as shown in Figure 4.1 reveal that, 45 % of respondents stated that they do not know about ergonomic awareness. On the other hand, 32% of respondents know about ergonomic. Next, 23% have little knowledge about ergonomic awareness. The study showed that Laman Hikmah Library user were lack of knowledge regarding of ergonomic is highest due to no particular safety and health program conducted in Laman Hikmah Library

4.2.2 Reading zone 1st level in Laman Hikmah Library features

The area in reading zone 1st level is 113.4 m². Based on ergonomic guidelines, eight square feet per person depends on the size of the user in Laman Hikmah Library. From equation 8, this calculation suitable in determining the ideal number of people in reading zone 1st level in the same time.

$$5.5725 \text{ m}^2 = 1 \text{ user} \tag{8}$$

$$113.4 \text{m}^2 = \text{x user} \tag{9}$$

$$5.5725 \text{m}^2 \text{x} = 113.4 \text{m}^2 \tag{10}$$

$$\text{x} = \frac{113.4 \text{m}^2}{5.5725 \text{m}^2} = 20.25 \approx 20 \text{ people} \tag{11}$$

From the calculation, the ideal approximately users that can be in the reading zone at the same time was 20 people. Figure 4.2 shows that 60% of respondents feel comfortable with the temperature. 31% of respondents feel slightly cold. Therefore, some factors affect the library's environmental temperature to be slightly cold, such as the technical problem of the air ventilation and the number of users using the library. A small percentage of 8% feel cold, and it can be considered as the individual factor such as metabolic rate.
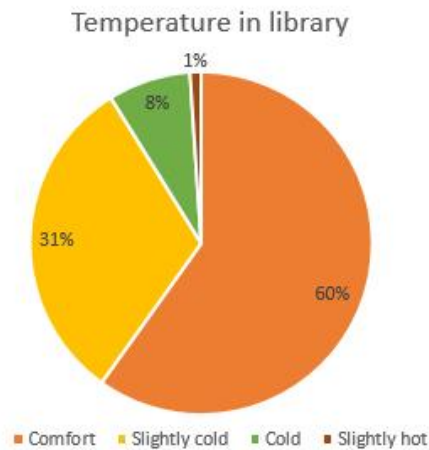
Temperature in library

■ Comfort ■ Slightly cold ■ Cold ■ Slightly hot

Figure 4.2: Distribution of library temperature, n=40

4.2.4 Reading zone 1ˢᵗ level in Laman Hikmah Library furniture

The overall lighting in the reading area 1ˢᵗ level is made up of 36 fluorescent lamps. The power of each lamb is 36 watts, is suitable for the Laman Hikmah Library user to make their task like study and reading. Figure 4.3 below describes the 85% of Laman Hikmah users say that the reading area in the library is good, and the rest (15%) are not satisfied with the lighting. Therefore, the figure shows the satisfaction of the library's users about reading area lighting.
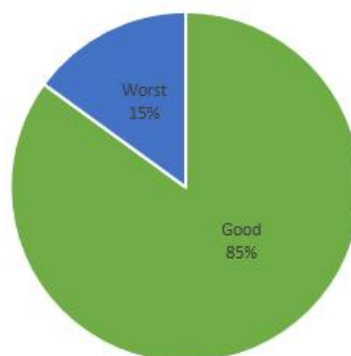

Lighting in Laman Hikmah Library

Figure 4.3: Data on satisfaction on light brightness in the reading zone 1ˢᵗ level

n=40

4.2.5 User Assessment

The graph in Figure 4.4 illustrates that most users (19 out of 40) do not feel fatigued during their task in the library, and 10 users feel little fatigued in the library and the rest feel fatigued. Seven users disagree that the chairs are suitable for them, while 33 users agree that they are suitable for them. Furthermore, 28 out of 40 users stated that the chair is durable. Therefore, it can conclude, the chair design is satisfied with the user's Laman Hikmah Library. Figure 4.4 also shown the result in the percentage value.
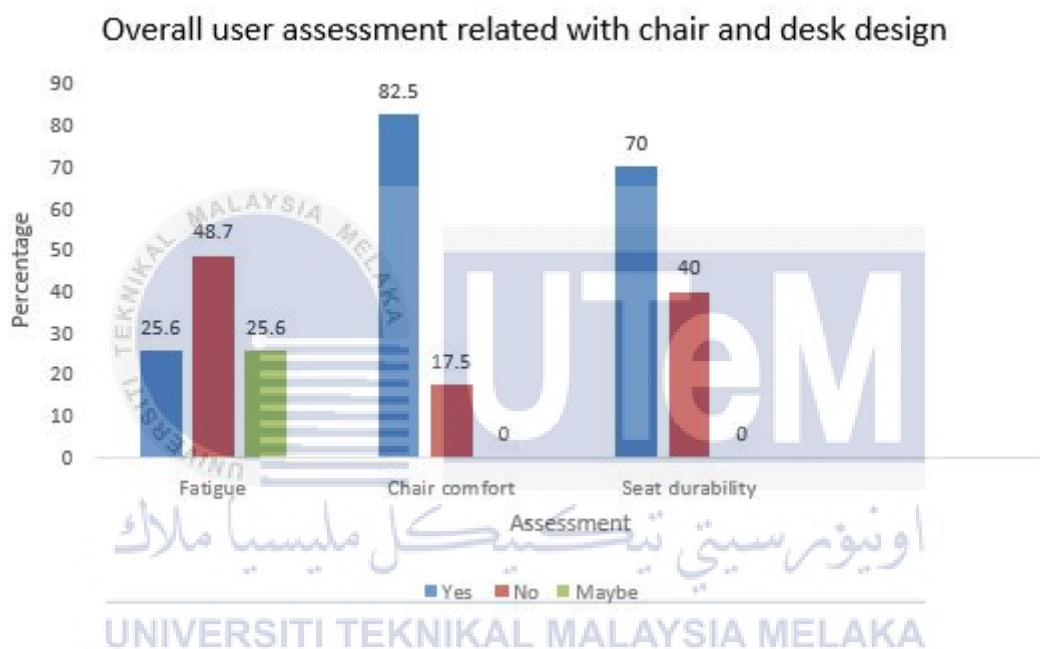
Figure 4.4: Overall User Assessment related to the design of the chair, n=40

4.2.6 Analysis user anthropometric and library furniture in 24 hours area

24 hours area selected place to evaluate the furniture chair and desk by using equation from past research about ergonomic in chair design. From the observation, the 24 hours area has poor ergonomic from the other place in library. Table 4.1 and 4.2 below shows the user anthropometric for male and female. There are three categories which are minimum, maximum, and average. The minimum category is considered a small size user, the maximum category a large size user, and the average category is regarded as a medium-size user.

Table 4.1: Anthropometric data for Malaysia Male, n=595 (Karmegam *et al.*, 2011).

No	Measurement	Min (cm)	Max (cm)	Average (cm)
1	Stature	150.50	186.18	168.01
2	Shoulder Height, sitting	46.70	65.30	55.74
3	Elbow Height, sitting	11.80	40.50	19.20
4	Popliteal Height	37.60	45.70	41.44
5	Hip Breadth, sitting	22.10	40.80	31.35
6	Buttock-popliteal length	38.60	59.40	49.05

Table 4.2: Anthropometric data for Malaysia Female, n=595 (Karmegam *et al.*, 2011)

No	Measurement	Min (cm)	Max (cm)	Average (cm)
1	Stature	141.50	170.70	156.07
2	Shoulder Height, sitting	42.40	64.70	52.32
3	Elbow Height, sitting	11.40	27.80	19.30
4	Popliteal Height	33.10	44.50	39.31
5	Hip Breadth, sitting	22.70	42.80	31.75
6	Buttock-popliteal length	35.80	55.80	45.70

Table 4.3 below describes the furniture dimension for Laman Hikmah Library matching scoring between the male user anthropometric measurement and furniture dimension. The result shows the average size of males getting higher scores compare to the minimum and maximum categories. The suggested slope is 5° (Kahya, 2019). It seems possible that these results are due to the chair and desk are designated based on the average user's size. The minimum and maximum categories have the same score due to two categories consider have minority users.

Table 4.3: Matching and mismatching analysis levels for the male user.

Component	School furniture dimension	Existing furniture	Match/Mismatch level		
			Min	Max	Average
Seat	Seat Height (SH)	42 cm	Mismatch	Match	Match
	Seat width (SW)	35.0 cm	Mismatch	Mismatch	Match
	Seat Depth (SD)	36 cm	Match	Mismatch	Mismatch
Backrest	Upper Edge of Backrest (UEBR)	36.3 cm	Mismatch	Mismatch	Mismatch
	Slope	3	Mismatch	Mismatch	Mismatch
Desk	Desk Height (DH)	75.5cm	Mismatch	Mismatch	Match
	Scoring		1	1	3

As can be seen matching and mismatching analysis levels for females also provide in this research paper. Table 4.4 below shows the maximum and average categories that have the highest score, which is 3. The minimum obtained the lowest score comparing other categories. The result of this analysis indicate that the small size female need something equipment that assisting them while using library's furniture.

Table 4.4: Matching and mismatching analysis level for the female user

Component	School furniture dimension	Existing furniture	Match/Mismatch level		
			Min	Max	Average
Seat	Seat Height (SH)	42 cm	Mismatch	Match	Mismatch
	Seat width (SW)	35.0 cm	Mismatch	Mismatch	Match
	Seat Depth (SD)	36 cm	Mismatch	Mismatch	Match
Backrest	Upper Edge of Backrest (UEBR)	36.3 cm	Mismatch	Match	Match
	Slope	3	Mismatch	Mismatch	Mismatch
Desk	Desk Height (DH)	75.5cm	Mismatch	Match	Mismatch
	Scoring		0	3	3

4.2.7 Overall finding

The results gain from the Laman Hikmah Library evaluation and user assessment are conclude in Table 4.5. From the Table, percentage difference of the room temperature is 13% and temperature consider comfort for the user. However, the further improvement needs to ensure the user will comfort using the library for period of time. The humidity in reading zone in Laman Hikmah Library is in standard condition which is in range 50% - 70%. The light brightness also in standard condition range.

Table 4.5: Ergonomic parameter in reading zone 1st level library

Features	Data	Ergonomic Guideline	Percentage different	Improvable
Temperature	23.8 °C	20°C-22°C	13	Yes
Humidity	63 %	50%-70%	0	No
Light brightness	457.3 lux	300lux-500lux	0	No

4.3   Other selected location in Laman Hikmah Library design

From the observation, the other area in the library has different sizes, layout, and essential components such as a lamp, computer, and air conditioner. The data obtained from observation and estimation by the user himself. The selected location chosen based on the probability user visited was higher. This selection is also based on a survey that has been distributed by google form.

Table 4.6: List of features and its quantity that available in the library

Location	Features
24 hours Area	• 4 Fans • 20 Air Cond funnel • 136 Fluorescent lamp
Reading zone level 2	• 4 Computer • 168 Fluorescent lamp • 14 LED lamp
SMART room level 1	• 24 fluorescent lamp • 4 fan • 12 Computer
Working area level 1	• 74 Fluorescent lamp • 14 LED lamp • 9 Computer • 1 Scanner • 1 Photostat machine
Leisure room	• 6 LED lamp • 2 Fan • 4 air-conditioning funnel
Viewing room level 1	• 12 Fluorescent lamp • 1 Fan • 1 LCD • 1 Computer
Viewing room level 2	• 1 Fan • 1LCD • 1 Computer • 48 Fluorescent lamp
Carrel room (1-10)	• 2 Fluorescent lamp

4.3.1 Overall comparison of selected location

Figure 4.5 shows the simplified overall data that have to evaluate. By referring the Appendix B2, the evaluation has been made by comparing their percentage difference. From the assessment, as shown in Figure 4.5, the Viewing room's 1st level is the lowest score which is 8 for temperature criteria. 24-hours Area and carrel room (1-10) gained nine, and the rest earned a total score for the temperature criteria. Next, the 24-hours Area obtains the lowest score for illuminance, while the leisure room scores 7 for illuminance criteria. However, the student's evaluation result is not 100% due to the requirements (temperature and illuminance) neglected, such as weather and human factors. Next, the different locations are not very obvious, but this data can indicate further improvement. Appendix B1 shows the distribution data from several assessments, which are temperature, humidity, and illuminance.
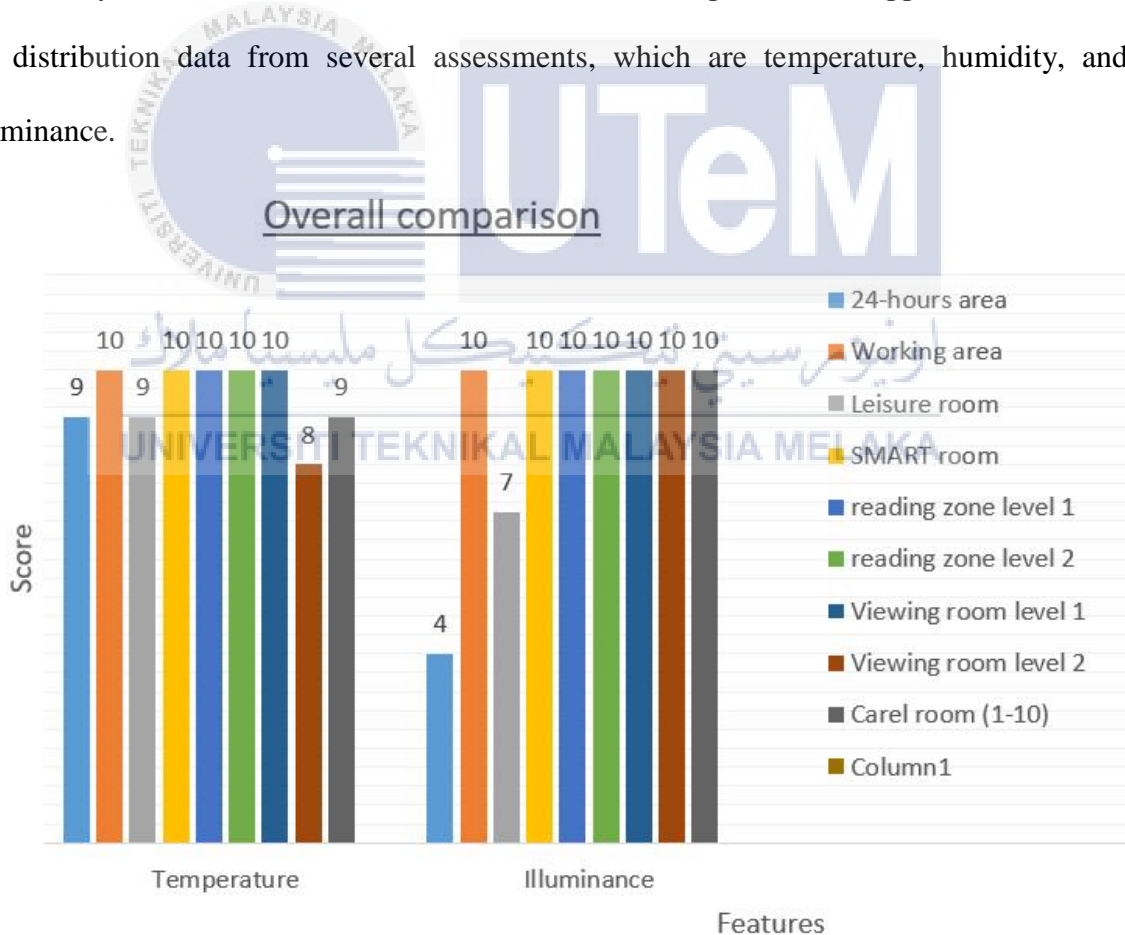

Figure 4.5: Overall comparison of selected locations

4.4. Ergonomics analysis design at computer workstation by using RULA.

The user's anthropometric dimensions are based on average student size and using percentiles 50 (P50) to assume that there is 50% student size are below the average and 50% student size are above the average. Table 4.7 shows the indicator score for evaluation after the result RULA has been appearing or determine.

Table 4.7: Indicator score for evaluation in RULA

Scoring	Colour indication	Response
1-2		Negligible risk, no action required
3-4		Low risk, change may be needed
5-6		Medium risk, need further investigation
7 and above		Very high risk, change required immediately

4.4.1 Seating posture

Figure 4.6 shows the result from seating posture. The final is low risk which is 2. However, this shows that the dimension is quite suitable for using sitting in seating posture for a long time. As a result, the chair suitable for user in seating posture.
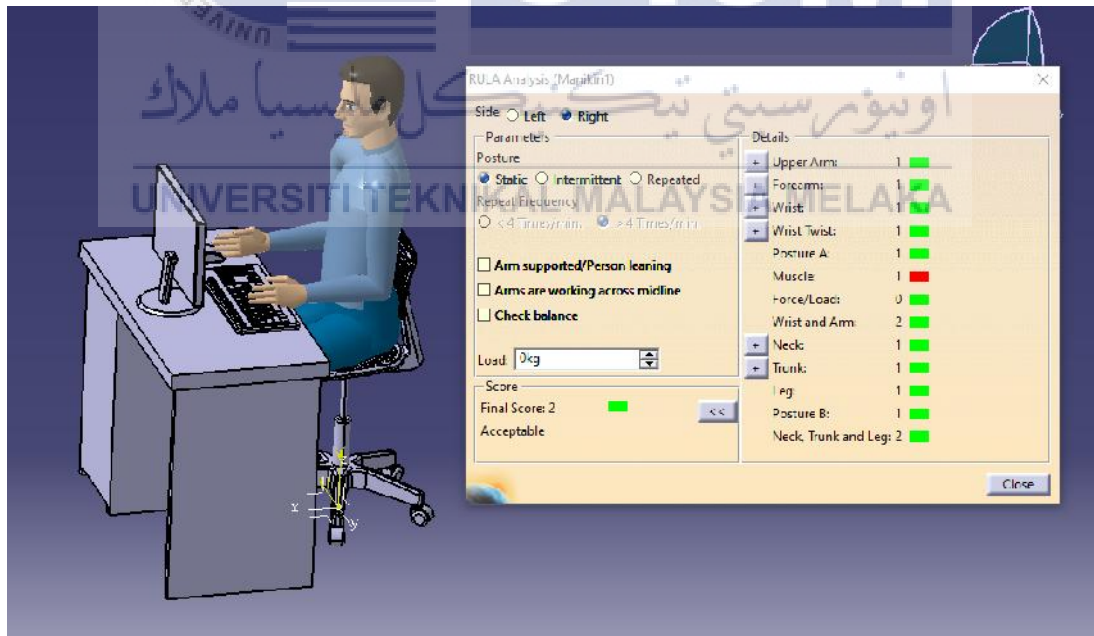

Figure 4.6: Analysis seating posture at computer workstation

4.4.2   Static seating in working position

The Figure 4.7 shows the result from static seating in the working position of the average male user. The final score is low risk and change may be needed. The wrist and arm are the main problems that can lead to pain when sitting for a more extended period.
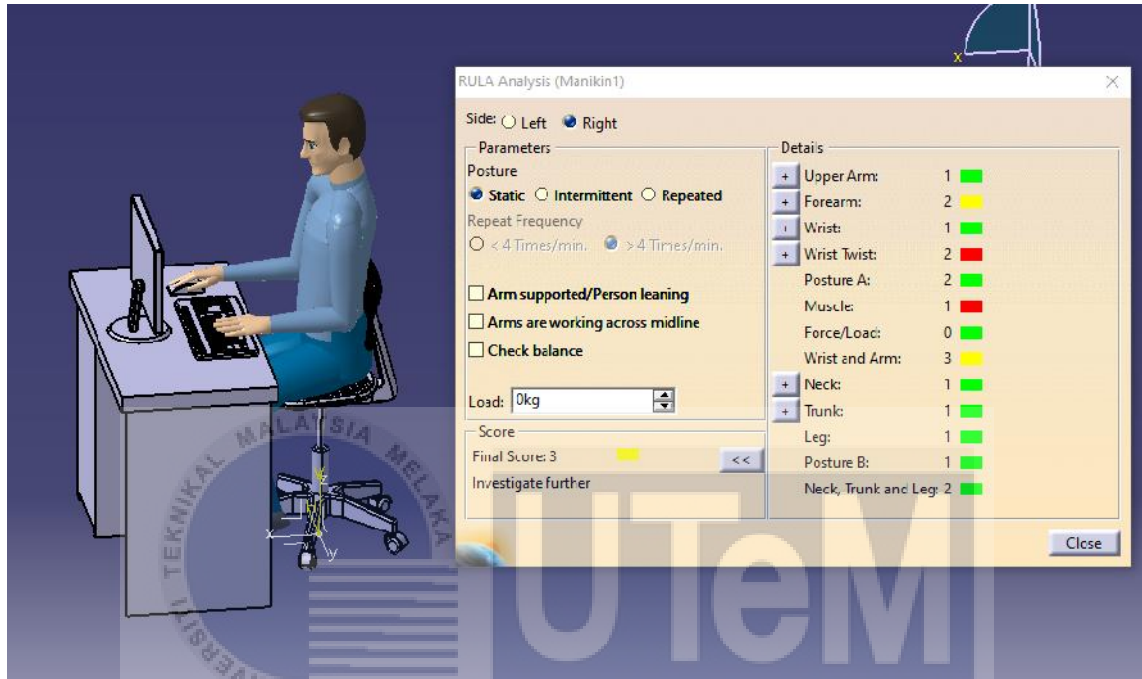

Figure 4.7: Analysis working position at computer workstation.

4.4.3   Flexion angle of lumbar in seating posture

The result from the analysis of flexion angle of lumbar in seating posture are presented in Figure 4.8. 18° angle of lumbar has been setup before conducting the RULA assessment. Final score is 4 which is low risk and change may be needed.
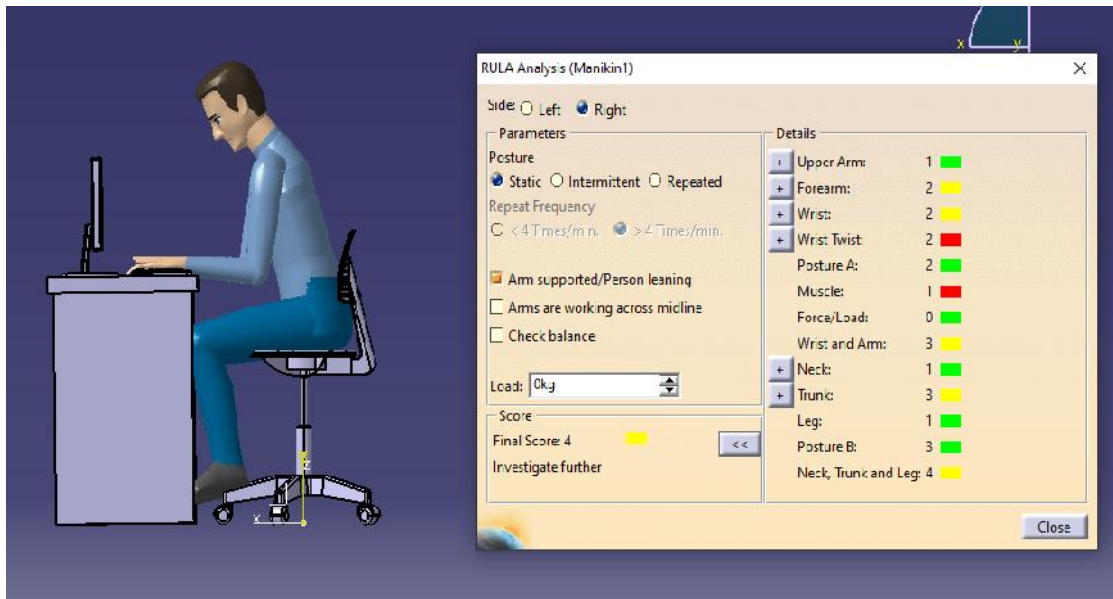
Figure 4.8: Analysis flexion angle of lumbar in seating posture

4.4.4 Discussion of RULA Assessment

By analysing three postures: The seating posture, static seating in working position, and flexion angle of lumbar in seating posture indicate that none of them obtained a score of more than 4. It seems that computer workstations in Laman Hikmah are satisfied for the user. This assessment also indicates the ergonomic risk factor also involved but on a small scale which is contact stress and static loading due to the user's wrist against the edge of the desk and the user was set up in static posture. RULA was not conducted on women due to no significant difference from the male gender. Next, the Training room, SMART room, and Viewing room computer workstation consider having the same design as a reading zone. The other workstation in the reading zone was not conducted in the RULA assessment because this other workstation was conducted in the survey method.

4.5　Data implication for further research

The collected data in this study can be used for further assessment to choose the better furniture for the library, especially chairs, or choose the optimum quantity and make further improvements based on user complaints to serve comfort for Laman Hikmah Library's user. The collected parameter for assessment can be used for library designs

4.6　Data validation

This research conducted during COVID-19 pandemic and limited to access the Laman Hikmah Library. Then, the result will not 100% accurate but still can use for further investigation about ergonomic in Laman Hikmah Library. Computer workstation in Laman Hikmah Library might slightly different from the original.
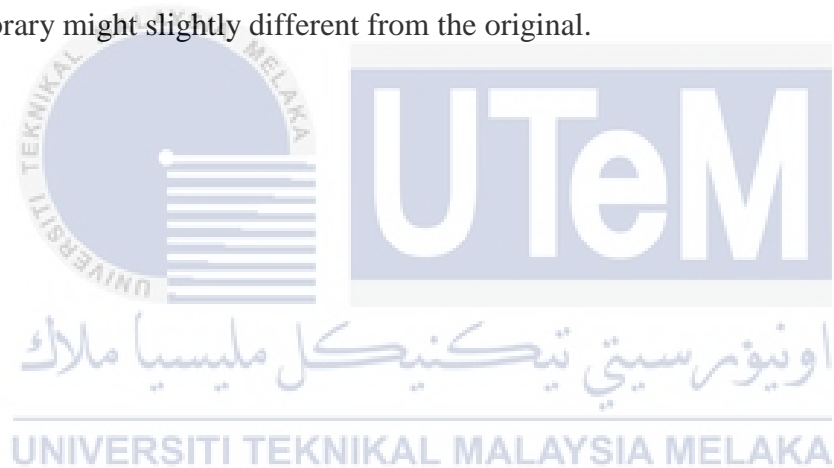
CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1   Conclusion

In a fundamental concept, the library is regarded as an "informal location of learning," in contrast to the classroom, which is regarded as a "formal site of learning" (Montgomery, 2014). Providing a well-designed workstation in the library is essential to prevent users from experiencing health problems like musculoskeletal disorders. Besides, ergonomic awareness plays a role in improving the ergonomic criteria.

The evaluation of the workstation design in Laman Hikmah Library is the first objective of this study. A survey method has been conducted to obtain the information from the Laman Hikmah Library user. Most of the question is related about ergonomic criteria, especially in workstation design. The majority (48.7 %) do not feel fatigued during their task in the library. This percent has not achieved half of the total and needs further improvement. This research paper also compares the standard anthropometric Malaysian male and female published in 2011 with library furniture to strengthen the analysis.

The second objective is to conduct the ergonomic assessment at Laman Hikmah Library workstation. Several ergonomic assessments have been implemented, such as temperature assessment, illuminance assessment and chair assessment. By analysing the library's temperature, most respondents (60%) feel comfortable with the temperature. 31% of respondent feel slightly cold due to technical of air ventilation or individual factor such as rate of metabolism. Reading 1st level has 36 fluorescent lamps, and the power of each

lamp is 36 watts. By comparing the ergonomic guidelines, lighting are satisfied with the Laman Hikmah Library user.

The third objective is to analyse user posture using Rapid Upper Limb Assessment (RULA) at computer workstation in Laman Hikmah Library .RULA assessment was also finished conducted at Computer workstation in Laman Hikmah Library by using CATIA. The score for the seating posture is 2, which means negligible risk, and the score for static seating in a working position is low risk (3). The computer workstation is satisfied for Laman Hikmah Library users. Last objective is to investigate the awareness about ergonomic in Laman Hikmah Library. Ergonomic awareness also has been determined by the survey method. Most respondents (45 %) do not know about ergonomics due to the lack of programs related to ergonomics in Laman Hikmah Library.

Finally, the result analysis from this research gives an advantage for further improvement to design the workstation that fulfilled the ergonomic criteria. The limitation of resources because COVID-19 posed some restrictions of this study.

5.2   Recommendation

Recommendation for further work development and improvement for Laman Hikmah Library evaluation is to ensure the design chair and desk are suitable for all categories: small, medium, and big. The adjusted chair and desk also can be considered for further improvement. Irresponsible also can provide the foam seat rest cushion in Laman Hikmah Library. Next, keep maintaining the air conditioning in Laman Hikmah Library to make the user feel comfortable during their task. Finally, organize the program that related with ergonomic in Laman Hikmah Library to spread awareness about ergonomic.

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41

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APPENDIX A1

(Google form)

User Feedback on Laman Hikmah Library Design

This questionnaires are to obtain the information from UTeM student about the classroom design in Universiti Teknikal Malaysia Melaka. The result will be analyze or evaluate the ergonomic in Laman Hikmah Library

* Required

Gender *

◯ Male

◯ Female

Body size *

◯ Small

◯ Medium

◯ Large

◯ Other: _____

Do you know about ergonomic?

◯ Yes

◯ No

◯ Maybe

How many times you go to library in one week?

○ 0-3 times

○ 4-6 times

○ 6-10 times

○ Other: _____

How much time you spend in the library

○ <1 hours

○ 1-3 hours

○ 4-6 hours

○ Other:

If you were going to the library, which area would you spend the most time?

☐ Reading zone level 1

☐ Leisure area

☐ Reading zone level 2

☐ Working area

☐ Seminar room

☐ Other: _____

In your experience, what do you think about temperature in library? *

○ Cold

○ Slightly cold

○ comfort

○ Slightly hot

○ Hot

Is Lighting in Laman Hikmah Library good? *

○ Yes

○ No

Does chair and table in library suit to you?

○ Yes

○ No

Is the seat durable and strong

○ Yes

○ No

○ Maybe

Do you often experience fatigue and pain during spending time in library?

○ Yes

○ No

○ Maybe

Difficulty that you face in the library

☐ Writing

☐ Moving

☐ Standing

☐ Thinking

☐ Other:

APPENDIX B1

Data collection from several assessments

Temperature:

| Location	Ambient temperature	Ergonomic guideline	Percentage difference
24 hours area	23.6 °C		7.27
Reading zone 2nd level	21.1°C		0
Smart room 1st level	21 °C		0
Working area	24.2°C	20°C-22°C	10
Viewing room 1st level	20.2 °C		0
Viewing room 2nd level	17.8 °C		11.00
Leisure room	23.6 °C		7.27
Carrel room	18.8 °C		6.00

Illuminance:

Location	Recommended average illuminance levels by Malaysia standard 1525 and Chartered Institution of Building Services Engineers (CIBSE)	Illuminance	Percentage difference
24 hours area		664.0	32.8
Reading area 2nd level		623.67	24.7
Smart room 1st level		473.3	0
Working area	300 lux-500 lux	341.3	0
Viewing room 1st level		407.7	0
Viewing room 2nd level		381.0	0
Leisure room		587.1	17.42
Carrel room		356.6	0

47

Humidity:

Location	Humidity	Ergonomic guideline	Percentage difference
24 hours area	50.1%		0
Reading zone 2nd level	70.6%		0.86
Smart room 1st level	68.2%		0
Working area	67.4%	50%-70%	0
Viewing room 1st level	53%		0
Viewing room 1st level	57.4%		0
Leisure room	56%		0
Carrel room	60.0%		0
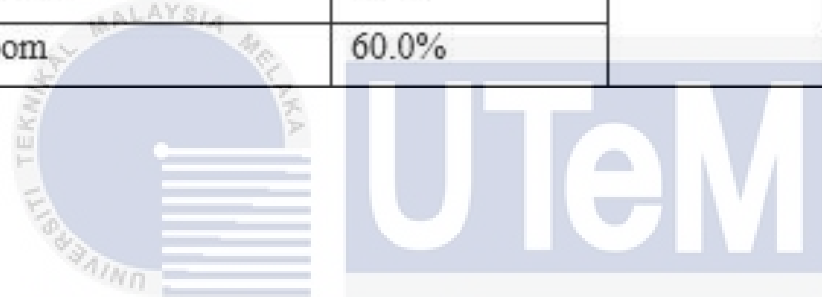
APPENDIX B2

Ergonomic guideline for scoring

Scoring	Percentage difference (%)
10	0.0-5.0
9	6.0-10.0
8	11.0-15.0
7	16.0-20.0
6	21.0-25.0
5	26.0-30.0
4	30.0-35.0
3	36.0-40.0
2	41.0-45.0
1	50.0 above

APPENDIX C1

List of body with description (Karmegam *et al.*, 2011).

Dimension Number	Measure	Description
1	Age (year)	
2	Weight (kg)	Total mass (weight) of the body
3	Stature	Vertical distance from the floor to the highest point of the head (vertex).
4	Eye Height	Vertical distance from the floor to the outer corner of the eye.
5	Shoulder Height	Vertical distance from the floor to the acromion.
6	Elbow Height	Vertical distance from the floor to the lowest bony point of the bent elbow
7	Fist (grip axis) height	Vertical distance from the floor to the grip axis of the fist.
8	Vertical Grip Reach, standing	Vertical distance from the standing surface to the center of a cylindrical rod firmly held in the palm of the right hand, with the right arm and wrist extended upward.
9	Shoulder (biacromial) breadth	Distance along a straight line from acromion to acromion.
10	Elbow-to-elbow breadth	Maximum horizontal distance between the lateral surfaces of the elbow region
11	Thigh clearance	Vertical distance from the sitting surface to the highest point on the thigh.
12	Abdominal Depth, sitting	Maximum depth of the abdomen whilst sitting.
13	Hip Breadth, sitting	Breadth of the body measured across the widest portion of the hips.
14	Sitting height (erect)	Vertical distance from a horizontal sitting surface to the highest point of the head (vertex).
15	Eye height, sitting	Vertical distance from a horizontal sitting surface to the outer corner of the eye.
16	Shoulder height, sitting	Vertical distance from a horizontal sitting surface to the acromion.
17	Elbow height, sitting	Vertical distance from a horizontal sitting surface to the lowest bony point of the elbow bent at a right angle with the forearm horizontal
18	Elbow Grip Length	Horizontal distance from back of the upper arm (at the elbow) to grip axis, with elbow bent at right angles.
19	Grip reach; forward reach	Horizontal distance from a vertical surface to the grip axis of the hand while the subject leans both shoulder blades against the vertical surface.
20	Buttock-popliteal length (seat depth)	Horizontal distance from the hollow of the knee to the rearmost point of the buttock.
21	Buttock Knee Length	Horizontal distance from the foremost point of the knee-cap to the rearmost point of the buttock.
22	Buttock Heel Length	Parallel distance from posterior surface of the right buttock to the heel of the right foot
23	Lower leg length (popliteal height)	Vertical distance from the foot-rest surface to the lower surface of the thigh immediately behind the knee, bent at right angles.
24	Hand Length	Perpendicular distance from a line drawn between the styloid processes to the tip of the middle finger.
25	Hand breadth at metacarpals	Projected distance between radial and ulnar metacarpals at the level of the metacarpal heads from the second to the fifth metacarpal.
26	Hand Thickness	Thickness of the hand at the level of middle portion (circumference passing over the metacarpal joints)
27	Thumb breadth	Breadth of the thumb on the right hand measured when is extended
28	Index finger breadth, proximal	Maximum distance between medial and lateral surfaces of the second finger in the region of the joint between middle and proximal phalanges.
29	Foot Length	Maximum distance from rear of the heel to tip of the longest (first or second) toe, measured parallel to the longitudinal axis of the foot.
30	Foot Breadth	Maximum distance between medial and lateral surfaces of the foot perpendicular to the longitudinal axis of the foot.
31	Head Length	Distance along a straight line between the glabella and the rearmost point of the skull.
32	Head Breadth	Maximum breadth of head above the ears, measured perpendicular to the midsagittal plane.
33	Head Height	Measure the linear distance from the bottom of chin to the highest point (vertex) on the top of the head
34	Head circumference	Maximum, approximately horizontal, circumference of head measured above the glabella and crossing the rearmost point of the skull.

Calculation for match and mismatch analysis

Male:

Component	Category	Range
Seat height	Min	$34.29 \leq SH \leq 39.4$
	Max	$41.31 \leq SH \leq 47.5$
	Average	$37.62 \leq SH \leq 47.5$
Seat Width	Min	$24.31 \leq SW \leq 28.73$
	Max	$44.88 \leq SW \leq 53.04$
	Average	$34.00 \leq SW \leq 53.04$
Seat depth	Min	$30.88 \leq SD \leq 36.67$
	Max	$47.52 \leq SD \leq 56.43$
	Average	$39.24 \leq SD \leq 46.59$
Upper edge of backrest	Min	$21.78 \leq UEBR \leq 29.04$
	Max	$39.18 \leq UEBR \leq 52.24$
	Average	$33.44 \leq UEBR \leq 44.60$
Desk height	Min	$46.09 \leq DH \leq 96.15$
	Min	$81.81 \leq DH \leq 147.3$
	Average	$56.82 \leq DH \leq 115.39$

Female:

Component	Category	Range
Seat height	Min	$30.40 \leq SH \leq 34,97$
	Max	$40.27 \leq SH \leq 46.32$
	Average	$35.78 \leq SH \leq 41.15$
Seat Width	Min	$24.97 \leq SW \leq 29.51$
	Max	$47.08 \leq SW \leq 55.64$
	Average	$34.93 \leq SW \leq 41.28$
Seat depth	Min	$28.64 \leq SD \leq 34.01$
	Max	$44.65 \leq SD \leq 53.01$
	Average	$36.56 \leq SD \leq 43.42$
Upper edge of backrest	Min	$25.44 \leq UEBR \leq 33.92$
	Max	$38.82 \leq UEBR \leq 51.76$
	Average	$31.40 \leq UEBR \leq 41.86$
Desk height	Min	$41.80 \leq DH \leq 50.97$
	Min	$68.07 \leq DH \leq 79.60$
	Average	$55.08 \leq DH \leq 65.35$