Investigation on Ablution (Wuduk) Workstation Design for Wheelchair Users in Malaysia

ABSTRACT

Ablution (wuduk) is an important ritual of cleaning for Muslim that applies to every Muslim regardless of sex, age or physical status. So, this includes wheelchair users. However, the current design of ablution area in mosques around Malaysia do not provide proper accessibility for them. This is due to lack of standards and guidelines for designing the ablution workstation for them. Therefore, this study was conducted to propose an ergonomics design criteria of ablution workstation for wheelchair users especially in the mosques. A total 100 wheelchair users participated in the questionnaire to identify the comfort level, problems of existing ablution workstation and their suggestions for new ablution workstation. Moreover, the 15 anthropometry dimensions have been measured for 100 wheelchair users in Malaysia. Besides, the experiments using inclinometer which are related to posture when performing ablution have been conducted on 15 male and 8 female wheelchair users. The ergonomics design criteria of ablution workstation were listed based on their preferences and anthropometric dimension as well as the analysis results of RULA using CATIA software. The research findings have identified the important design criteria in designing ablution workstation for wheelchair users which are ergonomics shape of the sink, suitable water tap handle and flexible water tap to wash the feet. This study can be considered as preliminary study for the development of ergonomic ablution workstation design for wheelchair users.

Keyword: Ablution; Malaysian wheelchair users; Workstations; Ergonomics; Universal Design.

Penyiasatan ke atas Reka Bentuk Stesen Kerja Tempat Wuduk Untuk Pengguna Kerusi Roda di Malaysia

ABSTRAK

Aktiviti mengambil air sembahyang (wuduk) ialah amalan pembersihan yang penting untuk setiap Muslim tanpa mengira jantina, umur atau status fizikal. Jadi, ia termasuk pengguna kerusi roda. Walau bagaimanapun, reka bentuk tempat wuduk yang sedia ada di masjid sekitar Malaysia tidak mempunyai akses yang sewajarnya untuk mereka. Ini disebabkan kekurangan piawaian dan garis panduan dalam mereka bentuk stesen kerja wuduk untuk mereka. Oleh itu, kajian ini dijalankan untuk mencadangkan kriteria reka bentuk yang ergonomik bagi stesen kerja wuduk untuk pengguna kerusi roda terutamanya di masjid. Seramai 100 pengguna kerusi roda telah mengambil bahagian dalam soal selidik untuk mengenal pasti tahap keselesaan, masalah stesen kerja wuduk yang sedia ada dan cadangan mereka untuk stesen kerja wuduk baharu. Selain itu, 15 dimensi antropometri telah diukur pada 100 orang pengguna kerusi roda di Malaysia. Tambahan lagi, eksperimen menggunakan inclinometer yang berkaitan dengan postur apabila melakukan wuduk telah dijalankan terhadap 15 lelaki dan 8 perempuan yang berkerusi roda. Kriteria reka bentuk ergonomik stesen kerja wuduk yang disenaraikan adalah berdasarkan pilihan/keutamaan mereka dan dimensi antropometri serta keputusan analisa RULA berdasarkan perisian CATIA. Penemuan penyelidikan telah mengenal pasti kriteria penting dalam mereka bentuk stesen kerja wuduk untuk pengguna kerusi roda, antaranya adalah bentuk sink yang ergonomik, pemegang paip air yang sesuai dan paip air yang fleksibel untuk kaki. Kajian ini boleh dianggap sebagai kajian awal bagi pembangunan reka bentuk stesen kerja wuduk ergonomik bagi pengguna kerusi roda.

Kata kunci: Wuduk; Pengguna kerusi roda Malaysia; Stesen Kerja; Ergonomik; Reka Bentuk sejagat.

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Ablution is an important ritual of cleaning for Muslims because it is a prerequisite to perform acts of worship which include prayers, hajj, reading the Holy Book of Quran and many more (Johari, et. al, 2013). This practice applies to every Muslim regardless of sex, age or physical status. Generally, this includes People with Disabilities (PWDs) including wheelchair users (Abdul Kadir & Jamaludin, 2012). In the Constituent, Islam is the country's official religion; hence facilities such as ablution workstations are indeed essential for Muslims. The Muslim population was estimated at the proportion of 61.3% based on the 5th Population and Housing Census of Malaysia conducted in 2010 (Department of Statistics Malaysia, 2010).

Mosques in Malaysia indeed have the ablution workstations. Unfortunately, the facilities are focused on able-bodied population and are not accessible to wheelchair users (Rahim et. al, 2014). According to Department of Islamic Development Malaysia(JAKIM), there are about 6,442 registered mosques across Malaysia in 2017 compared to 6,338 registered mosques in 2016. The frequency of people coming to the mosque is rising. Moreover, based on Dewiyanti et. al (2012), every individual has a different experience of spirituality in a different environment. Religious buildings like mosques are believed to be conducive in building one's spirituality. Then, logically, the facilities in the mosques need to be inclusive and available for all kinds of people, including wheelchair users, for example by providing lifts if the prayer hall, ablution workstation, and mosques entrance are on different levels (Rahim et al.,2014). he accessibility of mosque facilities for them are still lacking. The exposure of designing facilities for PWDs is still inadequate even though it is our job as the normal people to help them attain social equity in all aspects.

Statistically, the number of PWDs registered doesn't match with the accessibility to the mosque for PWDs as the number of registration keep increasing every year. Based on Yearbook of Statistics by Department of Social Welfare (JKM, 2015), registered PWDs in Malaysia was reported to be 264,448 people in 2013. Based on Figure 1.1, the number of PWDs registered increased by 20% in 2014 to 318,132 people. Again, the number of PWDs registered increased by 14.95% in 2015 to 365,677 people. However, the trend may not reflect an actual increase in the disabled population because the registration of PWDs in the country is not a compulsory practice. It is made on a voluntary basis throughout this country. Based on Figure 1.2, among 365,677 people registered in 2015, 34% of them are people with physical disability, which was the second highest category, with a difference of only 1% against the number of people with learning disability registered in 2015 (35%). Besides both of the categories mentioned, the other categories of disabilities are hearing impairment (8%), vision impairment (9%), speech impairment (1%), mental (8%) and miscellaneous disabilities (5%) (Department of Social Welfare, 2016). All the data mentioned were reviewed by going through a data cleansing exercise to omit cases for PWD who have died and so forth.

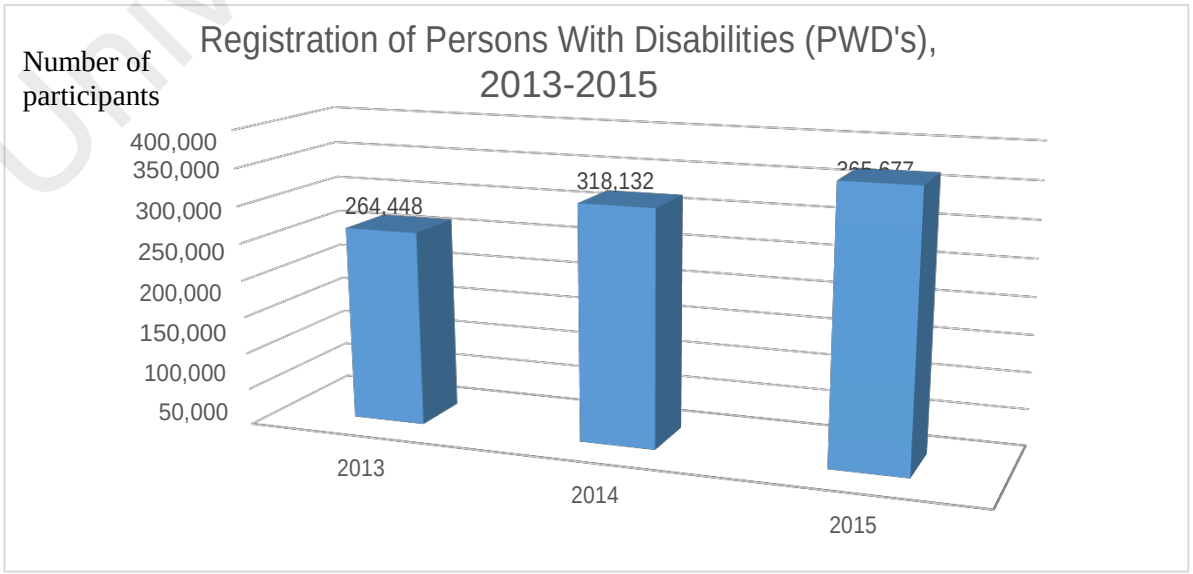

Figure 1.1: Registration of PWDS, 2013-2015

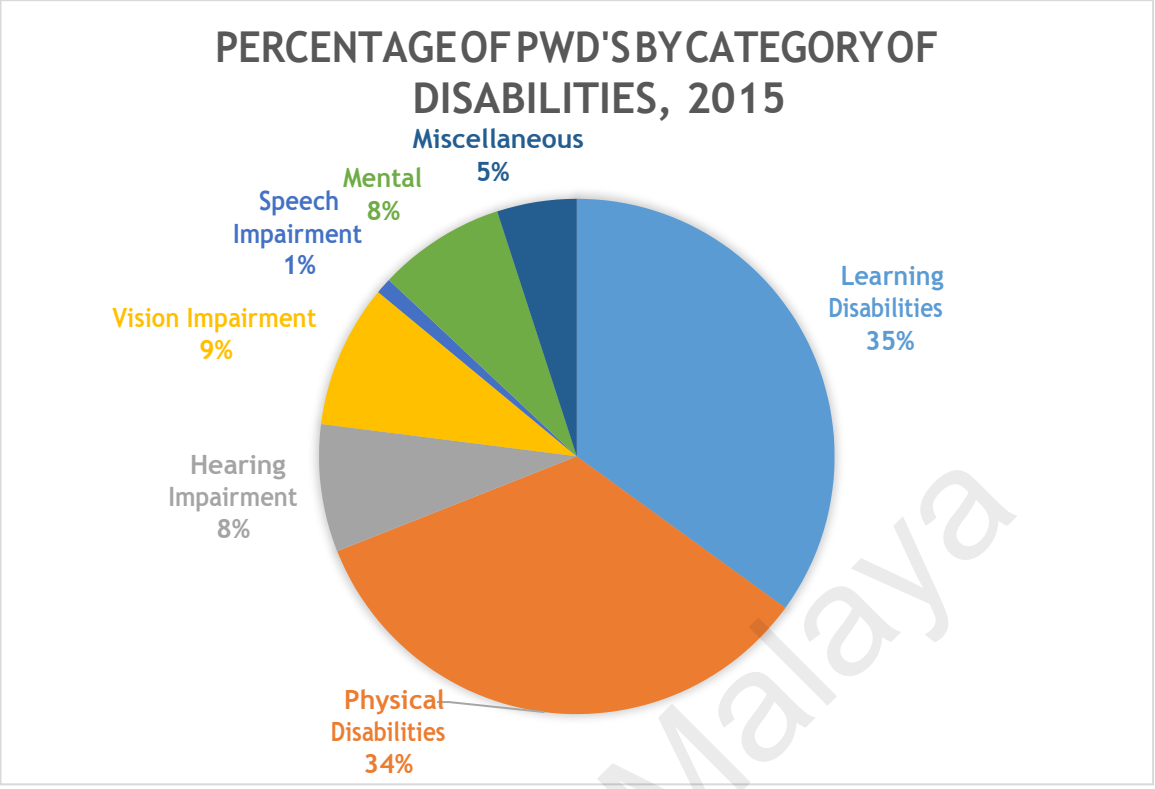

Figure 1.2: Percentage of PWD's by Category of Disabilities, 2015

Based on the Department of Social Welfare, physical disability is characterized by the inability of the body to perform fundamental activities, either due to loss or missing of a limb or disability in any part of the body or organs which affect their functions. Although the disability limits the person's mobility, it is not an obstacle to go to the mosque; even the number of the mosques also keeps increasing. Latest statistic shows that the number of mosques registered with the Department of Islamic Development (JAKIM) in 2016 is 6,430; and in addition to that, there are about 17,727 surau registered all around Malaysia. Hence, this study is conducted to investigate whether alteration on the existing ablution workstation needs to be done at the mosques in Malaysia to increase the level of accessibility for wheelchair users.

1.2 PROBLEM STATEMENT

There are several studies regarding accessibility in the built environment in Malaysia for the disabled, which are for shopping malls (Bashiti & Abdul, 2015), public transport terminals (Soltani, et. al, 2012), public buildings in Putrajaya (Kadir & Jamaludin, 2012), hotels (Rahim, et. al, 2010), tourist attraction (Jamaludin & Kadir, 2012) and others (Hussein & Yaacob, 2012; Rahim, et. al, 2014). Nevertheless, research on ablution workstation for wheelchair users is not available despite the fact that wuduk workstation is considered as one of the most vit=al public facilities particularly in this country with the highest proportion of Muslim population. This statement also corresponds to observations on the mosques in Malaysia. Different mosques have different designs; they are either designed for people with disability or otherwise.

The sustainability of design to be applied to the development of ablution workstation for PWDs cannot be disregarded. This matter is uncertain because there is no universal design guideline that can be alluded in order to design the ablution workstation back when the mosque's construction was initiated. Thus, this matter may influence the ergonomic element of the facilities itself that had resulted in the mismatch of application of architectural design with the anthropometric measurements (Deros, et. al, 2011; Tunay & Melemez, 2008)

Moreover, the problem of designing workstation for them relates back to the application of ergonomics principles. Anthropometric measurements for the able-bodied population is diverse with a wheelchair user population (Steinfeld, et. al, 2002). These distinctions of anthropometric dimensions have impacts on the design of workstation for them (Jarosz, 1996). This is one reason this population cannot fit the workstations intended for able-bodied population. Moreover, wheelchair users are a vulnerable group. Thus, precautions ought to be taken when measuring their

anthropometric dimensions.

1.3 RESEARCH AIM

The aim of this study is to propose ergonomics design criteria of an ablution workstation for wheelchair users based on the identified problems, analyzed posture and anthropometry dimensions.

1.3.1 RESEARCH OBJECTIVES

- To investigate the accessibility of existing ablution workstation for wheelchair users.
- To determine the significant anthropometry dimensions of wheelchair users for ablution workstation.
- To analyze the optimum posture during ablution activity.
- To propose an ergonomics design criteria of ablution workstation for wheelchair users especially in the mosque.

1.4 SCOPE OF STUDY

The scope for this study is focused on the workstation for performing ablution. Indirectly, it will raise public awareness on the importance of ablution and enhance the facility in the mosque. Moreover, wheelchair users are chosen among the classifications of disabilities as the subject of this study. They are entitled with the equivalent rights as the able-bodied population, especially in this developing country. Based on both scopes mentioned above, a universal design will be achieved, as universal design refers to wide range of ideas, intended to establish buildings, products and environments that are naturally applicable to small population, which are people with disabilities (PWDs), and subsequently, for elderly, adult people, and children.

For this study, a few centres were visited to collect data which were Bengkel Daya Klang in Klang, Pusat Latihan Perindustrian Dan Pemulihan (PLPP) in Bangi, Malaysia Paralympic Games Excellence Centre in Kampung Pandan, Kelantan Foundation for The Disabled (YOKUK), SOCSO Tun Razak Rehabilitation Centre in Melaka, Malaysian Association of Malay Disabled Persons (POKUAM), selected Program Pemulihan Dalam Komuniti (PDK) or Community-Based Rehabilitation (CBR) and selected mosque.

There are several lists for anthropometry dimensions, but in this study, the dimensions chosen are the standard anthropometry dimensions for sitting workstation and ablution workstation particularly for wheelchair users.

1.5 RESEARCH OUTLINE

This research report comprises six chapters. A summary of each chapter is as follows:

1) Chapter 1: This section describes a general idea about the study, including abstract, keywords, background of study, problem statement, and scope of work involved in this study. The objectives to be achieved in this study are also presented in this chapter.
2) Chapter 2: This section reviews existing literature to identify gaps that determines the importance of conducting this study. This chapter will give ideas on how previous research were conducted in relation to the topic of this study.
3) Chapter 3: This section explains the methodology of collecting data to achieve the objectives of this study. Every method, flow chart, apparatus, place conducted, subject for this study are also described in this chapter.
4) Chapter 4: This section presents the results based on the methodology used and its

interpretation as well as discussion on respective results. The findings from data collection comprises anthropometric data of wheelchair, survey conducted, workstation dimensions, and postures during performing workstation. The results of RULA are also discussed in this chapter.

5) Chapter 5: This section presents the discussion based on the results collected.
6) Chapter 6: This section presents the conclusions out the whole thesis based on the objectives of the study conducted. This section also proposes a new design criteria of ablution workstation for wheelchair users based on discussion in chapter 4. Every important aspect of chapter 4 will be noted when designing new ablution workstation. Moreover, this chapter provides future work recommendations that can be applied for future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will seek the various literatures that are relevant to the topic of this research. The review will consist of synopsis on the concepts of ablution for all of Muslims including PWDs and the facilities provided at the mosques including ablution workstation. Moreover, this chapter will also discuss about Anthropometry of Wheelchair User, the concept of Experiment using Inclinometer and the concept of Rapid Upper Limb Assessment (RULA). Moreover, this review will also help in identifying the research gaps and summarizing the direction of this research. Figure 2.1 presents the flow of the subtopics of this chapter.

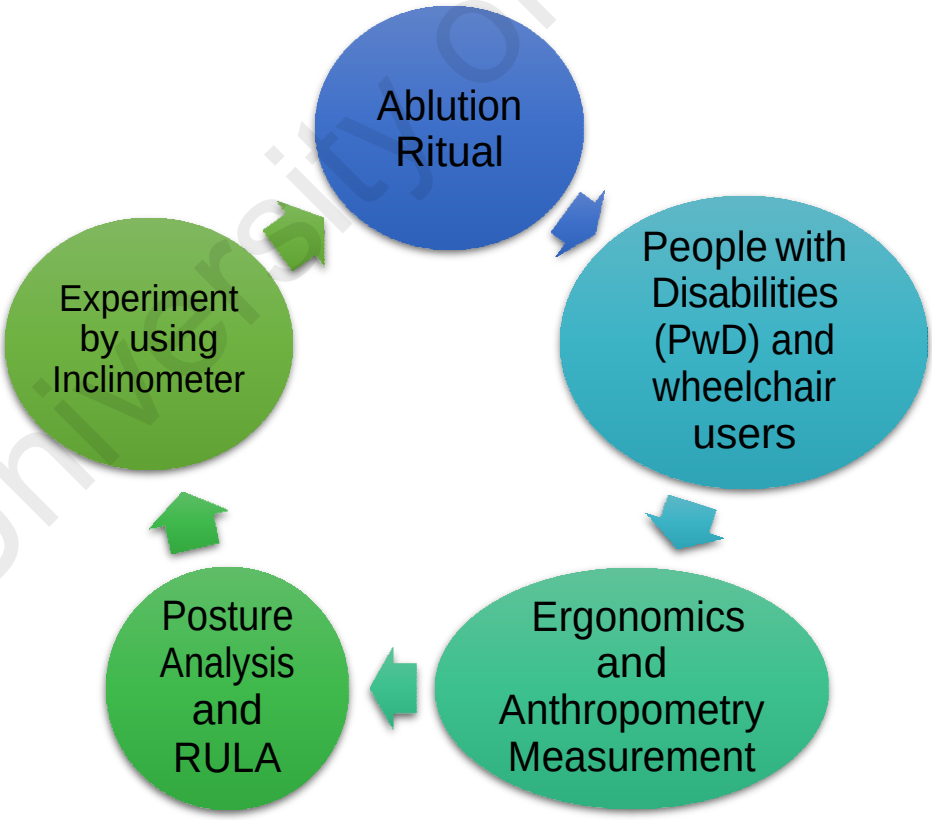

Figure 2.1: Topics covered in Literature Review

2.2. ABLUTION (WUDUK)

2.2.1. The Sequence of Ablution and Its Benefit

Ablution or in other words, wuduk, is an important ritual of cleaning for Muslims since it is a part of compulsory practices for Muslim to ensure cleanliness before performing acts of worship such as prayers, hajj and reading the Quran (Johari et al., 2013). A verse in the Quran (Surah Al- Maida 5:6) states that ablution involves the following acts: washing the face, washing both hands up to the elbows, wiping the head and washing both feet up to the ankles. The sequence in ablution including the obligatory from Quran verse and sunnah is shown in Figure 2.3.

Everything that Allah prescribes has wisdom behind it. Performing ablution has been scientifically proven to have many physical benefits. Each part of ablution has its particular benefits. Firstly, washing the hands prevents the transmission of numerous infectious diseases. Meanwhile, washing the mouth gets rid of food particles that could bring about teeth and gum issues. Then, washing the nostrils discard germs caught inside so they do not achieve the respiratory system. Besides, washing the face rejuvenates organs such as the intestines, stomach and bladder, and in addition, positively refreshes the nervous and reproductive system. Repeated washing of the face stimulates facial skin cells and avoids early wrinkles. Furthermore, washing the ears diminishes hypertension, and additionally expels any extra wax that could cause ear contamination. Last but not least, washing the feet helps to prevent fungal infection. In short, all these advantages of ablution can be attained by everyone including wheelchair users. They can experience the advantages of ablution too, if they have user-friendly ablution workstation.

Besides physical benefits, there are also other advantages of ablution. Based on Sahih Muslim, Book 2, Number 0432, titled The Book of Purification, Abu Malik at-Asha'ri reported, The Prophet, peace be upon him, said, "Cleanliness is half of faith" (Besari, et. al, 2009). Moreover, Allah says in the Quran, "Surely Allah loves those who turn to Him and those who care for cleanliness" (Al-Baqarah 2:222). In addition, The Quran (At-Tauba 9:108) stated that "And Allah loves those who make themselves clean and pure." From these 3 evidences above, the spiritual advantage of doing ablution is being loved by Allah, the one and only God for Muslims.

Furthermore, from Irmak (2014) as well as Preston and Ritter (2012), this ritual is helping the brain to remain cool throughout the day. The blood destined for the brain is cooled by the evaporating surfaces of the head shown in Figure 2.2 below. Notice that the same areas are washed or wiped in ablution. This means that with ablution, the head is cooler, and the brain is healthier. Thus, all Muslims will be going about their daily life healthily and effectively including wheelchair users.

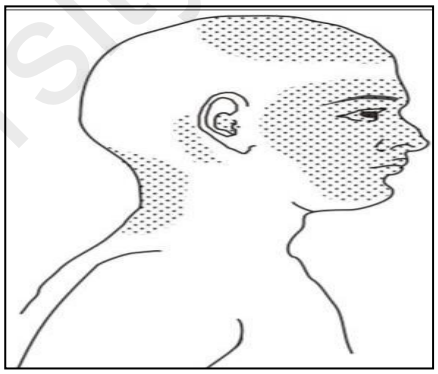

Figure 2.2: Craniofacial regions important in selective brain cooling (Irmak, 2014)

In addition, from the translation of Sahih Muslim, Book 2, Number 0436, Uthman Bin Affan asked for water and performed the steps of ablution, as shown in Figure 2.3 below:

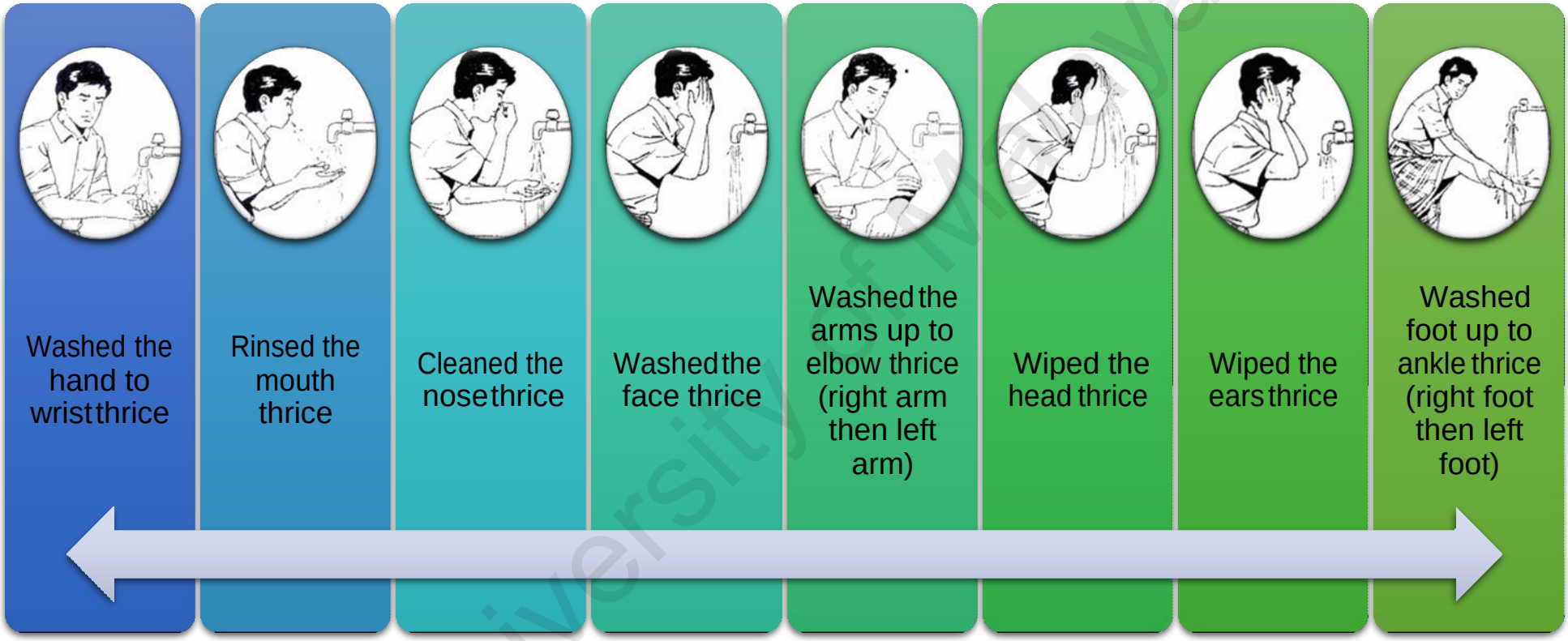

Figure 2.3: The sequence of ablution task (Johari et. al, 2013)

2.2.2 Existing Ablution Workstation Components in Malaysia

Existing ablution workstation at mosques and surau (*musolla)* at public areas such as shopping mall, rehabilitation centres, highway rest areas and hospitals consist of various ablution components. The ablution components are water tap, drain, seat, grab bar, splash barrier and ramp (Mokhtar, 2005; Johari et al., 2013; Mokhtar, 2015). There are various types of water tap being used including lever, pull, push, rotate or automatic type (Besari, et. al, 2009; Abdullahi & Embi, 2013). Some of the workstations have seat, some does not. The Figures 2.4 and 2.5 below show the ablution workstations at selected mosques and rehabilitation centre.

Figure 2. 4: Ablution Workstation at Saidina Abu Bakar As-Siddiq Mosque, Kuala Lumpur

Figure 2. 5: Ablution Workstation at Pusat Latihan Perindustrian Dan Pemulihan (PLPP) Bangi, Selangor

2.2.3 Existing Research About Ablution Workstation

Previous research about design guidelines for ablution spaces in mosques is written by Dr. Ahmed Mokhtar, an Associate Professor of Architecture at The American University of Sharjah at United Arab Emirates in 2003. In this study, 4 desirable models for the design of an ablution workstation are provided. The similarity of all these 4 models are the approaching floor is covered with anti-slippery material that allows water to drain underneath. Besides, a shelf is provided for the user to put personal belongings such as eye glasses and hand watches.

Model one as illustrated in Figure 2.6 provides a seat to the users so they can perform the ablution activity while seated. Octagonal seats allow easy access to the unit. Moreover, the seat's surface is slightly slanted to permit splashed water on them to flow towards the drainage channel, keeping the seat as dry as possible. Furthermore, the color and pattern of the seat surface should allow the user to easily determine whether the seat is wet or not. Then, the water drainage channel is covered with a mesh for safety purpose. The mesh has wide openings of about 5 cm. Despite all the considerations made, this model is not suitable for wheelchair users.

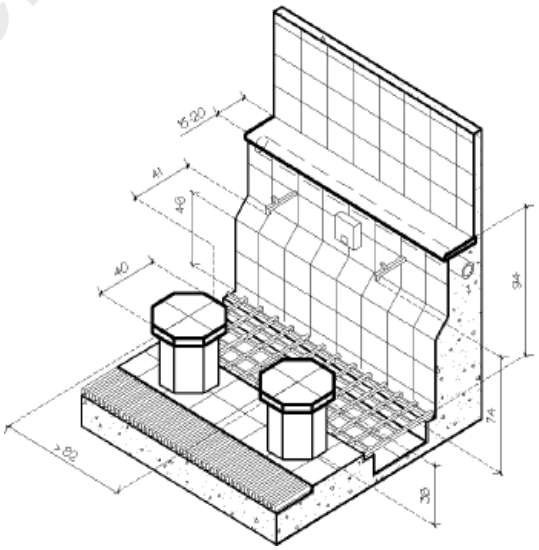

Figure 2. 6: Design guideline for model one – with seats

Model two as shown in Figure 2.7 provides a lavatory (sinks) which most people use in their homes to perform ablution. However, the user needs to bend the back to reach the faucet level as well as to raise their feet to clean them on the lavatory. This idea is good, but it can be upgraded by reducing the number of lavatory into one only, and adding a reachable faucet just beside the lavatory for users to wash their feet. If this idea is upgraded, this model can be wheelchair user-friendly.

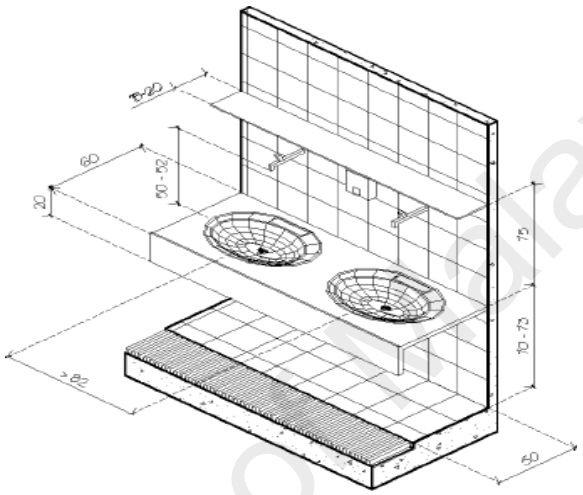

Figure 2. 7: Design guideline for model two – with lavatory

Model three as shown in Figure 2.8 is the most common ablution workstations in the mosques in Malaysia as it is simple and has very few components. This is a low-cost model, but a very uncomfortable one to use. It requires the user to bend their knees or back. This model is just suitable for normal people, not for wheelchair users and the elderlies.

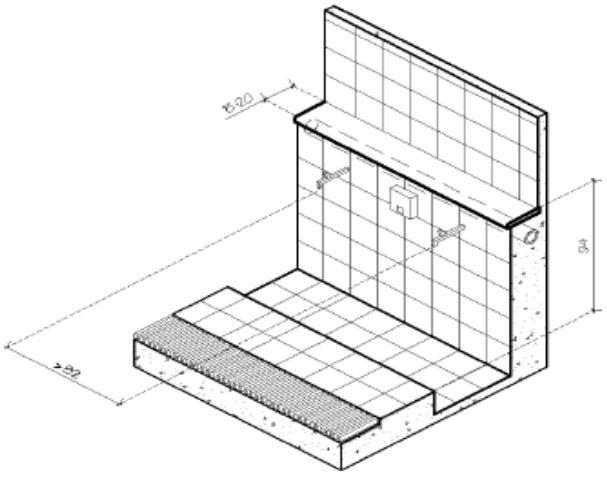

Figure 2. 8: Design guideline for model three – without a seat

Model four as shown in Figure 2.9 provides a barrier. This is better than model three as the risk of wetting the clothes is reduced. Moreover, the faucet level is higher than normal to minimize bending the back. The barrier is low to make it easy to raise the feet and place them under the faucet. Another function of the shelf in this design is to support user body while raising their feet. This is a basic model to build with a relatively low cost. Majority of users think that this design is agreeable to utilize.

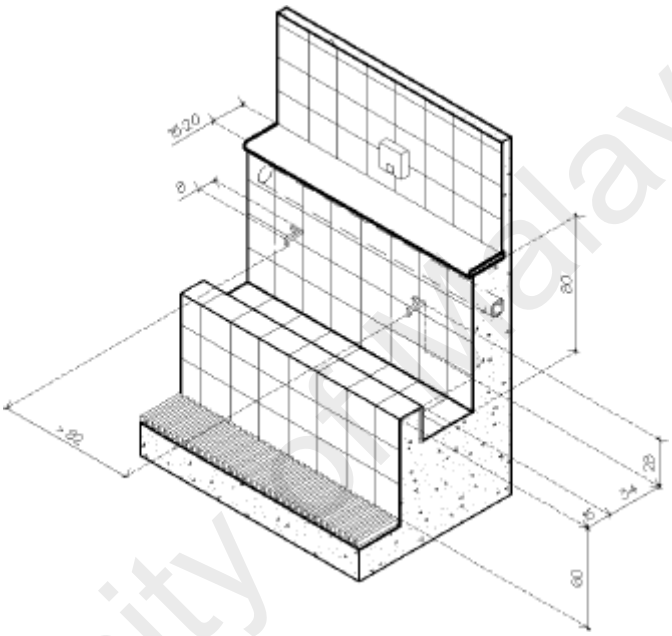

Figure 2. 9: Design guideline for model four – with barrier

In short, all these guidelines are good for normal people, but they are not accessible for wheelchair users. The model from Figure 2.7 is the closest to a wheelchair user-friendly design. If it can be upgraded as suggested above, such that only one lavatory is installed, and another faucet is installed just beside the lavatory to wash the feet, the facilities in the mosques at Malaysia will be more accessible. The type of faucet is also important as some of PWDs have difficulties with the rotating type. It will also be better handrails can be installed at the ablution workstation for wheelchair users to support their body when performing ablution, similar to Figure 2.5 above.

2.2.4 Mosques Facility and Malaysian Standard

Mosques are dedicated buildings for Muslim to worship Allah, the one and only God. They function as the main place where religious activities such as five daily prayers, remembrance (dzikr) of Allah, reading of the Holy Quran, religious class and religious talk take place (Mustafa & Hassan, 2013; Othman, et. al, 2015; Mohamed, et. al, 2015). All of these activities apply to every Muslim regardless of sex, age or physical status. So, PWDs such as wheelchair users are also included (Johari et al., 2013). However, the accessibility in the mosques only focuses on normal people. Majority of mosques do not have proper accessibility for PWDs including wheelchair users (Mohd Haziq, 2014).

Access for disabled persons is defined as a continuous unobstructed path of travel to or within a building capable of being negotiated by a person using a wheelchair or otherwise with limited mobility (Malaysian Standard MS 1184:2002; Kadir & Jamaludin, 2012) In the book of Malaysian Standard MS 1184:2002, Code of Practice on Access for Disabled Persons to Public Buildings (First Revision), there are a lot of guidelines about accessibility in the building for PWDs. The facilities are vehicle parking, ramps, stairs, main entrances, door, lifts, escalators, handrails, grab rails, water closet, urinals, shower, washbasins, work surfaces, wall units and many more.

One of them is grab rails or grab bars. Water closets, urinals, bathtubs, showers and washbasins which may be accessed by wheelchair users and/or the ambulant disabled, require grab rails to be placed around these facilities. Its characteristic is fixed not less than 750 mm nor more than 1200 mm from the floor, with an external diameter of not less than 30 mm nor more than 40 mm. In addition, grab rails need to be constructed with appropriate materials and must be able to support a minimum of 100 kg at any point. Moreover, grab rails should preferably be

contrasting in colour with their supporting wall and not easily corrosive (Dekker, et. al, 2007). Another facility required is water closet. In every public building to which access for PWDs is required, water closets for wheelchair users should be provided in accordance with Table 2.1.

Table 2. 1: Water closets for wheelchair users (Malaysian Standard MS 1184:2002)

Number of water closets in the building	Minimum number for use by wheelchair users
1 to 50	(i) One unit for use by both males and females; or (ii) One unit for use by males only and another one for females only.
51 to 100	(i) Two units for use by both males and females; or (ii) One unit for use by both males and females, one for use by males only, and another one for females only
More than 100	0ne unit for use by both males and females for each additional 50 water closets or part thereof in excess of 100 water closets.

Washbasins are also discussed in this book. Every washbasin provided for use by PWDs should be wall-mounted to provide minimum clearance as shown in Figure 2.10. Then, hot water supply pipes should be insulated. Water supply pipes and waste outlet pipes should not encroach on the required clear space under the washbasin (Department of Standards Malaysia, 2012).

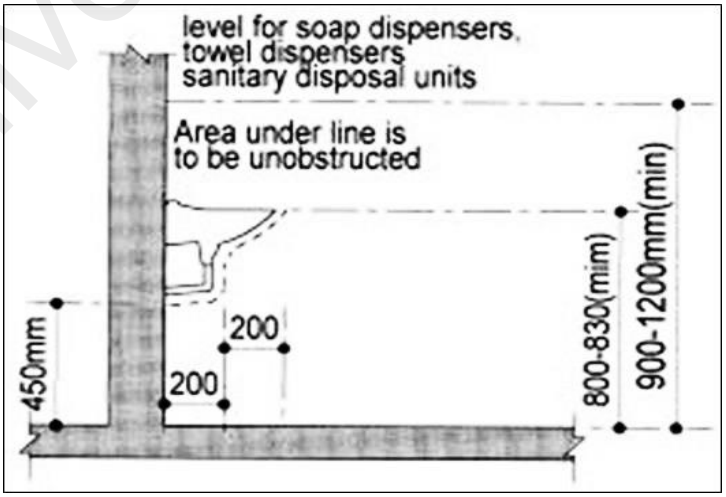

Figure 2. 10: Location of washbasin (Malaysian Standard MS1184:2002)

Fixed work surfaces provided for use by wheelchair users where the arm rests of the wheelchair are removable should be in accordance with Figure 2.11 and have an unobstructed seating width of not less than 750 mm, within which there should be clear space at least 450 mm void. Edges and corners of fixed work surfaces should be rounded.

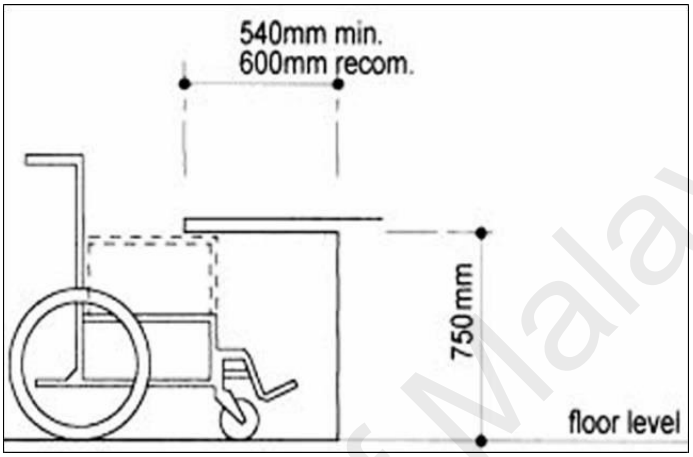

Figure 2. 11: Fixed work surface for disabled (Malaysian Standard MS 1184:2002)

Floor finishes should have a non-slip surface with a texture traversal by PWDs. The following finishes are acceptable: For wet locations including interior surfaces which are frequently washed are concrete with abrasive or textured surface, concrete with exposed aggregate finish, bituminous concrete, natural stone with rough finish, vinyl, or specially formulated with embossed surface or rubber (Department of Standards Malaysia, 2012).

Water taps should have long handles lever. The water should be delivered through a centre mixing bib. The taps should not be less than 50 mm away from the back wall (Malaysian Standard MS 1184:2002).

2.2.5 Universal Design and Accessibility in The Built Environment - Code of Practice

In 2014, by launching the new Malaysian standards (MS 1184:2014) Universal Design and Accessibility in the Built Environment - Code of Practice, various access audits have been done to measure the current level of universal access and usability as shown in Table 2.2 below (Department of Standards Malaysia, 2014).

Table 2. 2: Development of Universal Design in Malaysia (Bashiti & Abdul, 2015)

YEAR	DEVELOPMENT
1957	Malaysia has just regained its independence and is still underdeveloped. The development was on education, agriculture, economy, infrastructure and basic facilities. Buildings erected in this period are mostly not accessible for the PWDs.
1960s and 1970s	The government was still focusing on developing the country in various fields in urban and rural areas.
late 1980s	The development of Malaysian Standards and code of practices were initiated, and 3 standards were published in 1990s, which are MS 1183:1990, MS1184:1991 and MS 1331:1993. Malaysia has started to address the needs of People with Disabilities (PWDs) in the built environment.
2000	International Islamic University Malaysia (IIUM) was invited to conduct barrier free workshop at Pan Pacific Hotel, Kuala Lumpur to train their technical staff. The second workshop was held in KLCH headquarters, which later was followed by a series of other workshops.
2002	Malaysia, as a member of the United Nation Economic and Social Commission of Asia pacific (UNESCAP).
2002-2003	MS 1184 and MS 1331 were published. At the same time, the author was invited to chair four standards on public toilet to be developed, which are MS 2015: 2006 Part 1, Part 2, Part 3 and Part 4.
2008	KAED Universal Design (KUDU), IIUM conducted access audits in various building typologies in Malaysia such as transportation hubs, waterfront facilities, shopping complexes, markets, heritage buildings, housing and jetties to identify the level of accessibility in these public buildings and spaces. It was found that only 25% of buildings in Malaysia were considered good in terms of accessibility.
2011	KAED Universal Design joined a smart partnership with the Department of Standards Malaysia to promote Malaysian Standards related to universal design and accessibility in the built environment to local authorities, professionals, academicians and mass public through access audit workshops, international conferences and national universal design product competition.
2014	The latest Malaysian Standards (MS 1184:2014) are developed through consensus by committees. MS1184 is made mandatory by regulatory authorities. This document was prepared to include the latest standards, data and information to accommodate persons with disabilities (PwDs), the aged and children in various building typology such as heritage, parks and other public spaces.

Based on the table above, there has been a lot of improvement in Universal Design in Malaysia. But, there it is still lacking in terms of ablution workstation for wheelchair users. Recently, the awareness of the ablution workstation design is starting to gain momentum due to the research investigation by researchers in Malaysia.

2.3 PEOPLE WITH DISABILITIES (PWDS)

2.3.1 Definition of People with Disabilities (PWDs)

People with disabilities in Malaysia can be considered as one of the most vulnerable groups in the Malaysian population (Kamaruddin, 2007). Persons with Disabilities (PWDs) are individuals who have long term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society (*Laws Of Malaysia*, The Persons with Disabilities Act 685, 2008).

The establishment of Law of Malaysia, Act 658, The Persons with Disabilities (PWDs) in 2008, marked the first disability legislation in Malaysia that came into force on 7 July 2008. This Act is to provide for the registration, protection, rehabilitation, development and wellbeing of persons with disabilities, the establishment of the National Council for Persons with Disabilities, and for matters connected therewith. However, it is yet to be seen how efficient this Act is in enforcing its pledge in improving the quality of life for PWDs.

According to Department of Social Welfare (2016), Persons with Disabilities (PWDs) are categorized under 7 categories as shown in Figure 2.12 below.

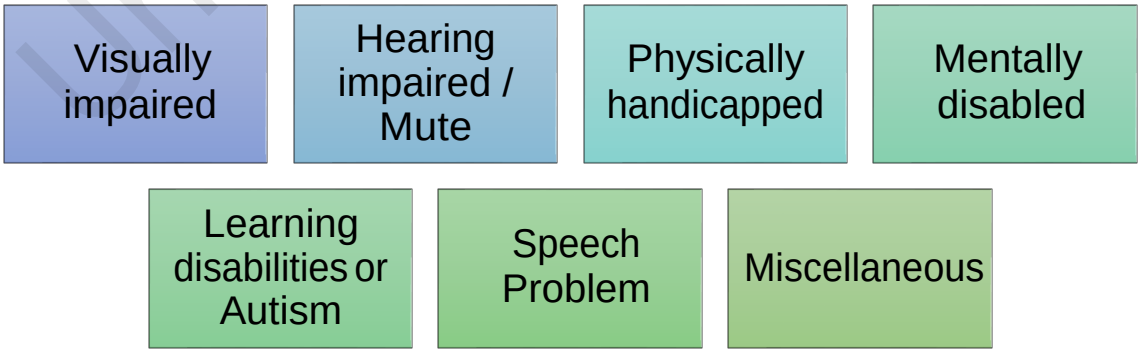

Figure 2. 12: Types of Person with Disabilities (Department of Social Welfare, 2016)

2.3.2 Categories of People with Disabilities

2.3.2.1 Hearing Impairment

Hearing Disability means the person cannot hear clearly in both ears without the use of a hearing aid or not to hear directly even with the use of hearing aids. Hearing disabilities can be divided into four levels. Firstly, the minimum level at 15 < 30dB for children and at 20 < 30 dB for adults. Secondly, medium level at 30 < 60dB. Thirdly, severe level at 60 < 90dB. Finally, very severe (profound) level at ≥ 90dB (Department of Social Welfare, 2016).

2.3.2.2 Vision Impairment

Vision Disability means blind in both eyes, blind in one eye or impaired vision in both eyes. It also can be permanent vision disorders. Visual disabilities can be divided into 3 levels. Firstly, limited which means vision is worse than 6/18 but equal to or better than 3/60 despite using visual aids, or visual field of less than 20 degrees from fixation. Secondly, blindness which means lack of vision of 3/60, or visual field of less than 10 degrees from fixation. Thirdly, lack of vision of less than 3/60, which include Counting Fingers (CF), Hand Movement (HM), Perception of Light (PL) and No-Light Perception (NPL). Other permanent visual disturbances can only be confirmed by an ophthalmologist (Department of Social Welfare, 2016).

2.3.2.3 Speech Impairment

Speech Disabilities means inability to cannot speak because of interference to communicate properly and cannot be understood by those interacting with the person. This condition is permanent and will not heal. For children, a diagnosis must be based on the assessment at the age of five years. For speech impairment cases, otorhinolaryngology specialist are the experts that should be consulted (Department of Social Welfare, 2016).

2.3.2.4 Physical Impairment

Based on Department of Social Welfare, 2016, Physical Disability means the permanent disability of part of body due to loss or disabled of any part of body which can affect their functions in performing daily tasks. Fundamental activity is defined as basic activities such as personal care, movement and body position changes. This condition can occur as a result of injury (trauma) or disease in any of the nervous system, cardiovascular, respiratory, haematology, immunology, urology, musculoskeletal, gynaecology and others that cause malfunction. Examples of causes of disability are:

a. Limb defects (congenital/acquired), including loss of thumb

b. Spinal Cord Injury

c. Stroke Cerebral Palsy

d. Traumatic Brain Injury

e. Dwarf ≤ 142cm for men and ≤ 138cm for women

Individuals suffering from lack of state (impairment) without compromising the function, for example the loss of a finger, has more fingers (polydactyl) and having no perfect ear are not considered for registration purposes.

2.3.2.5 Learning Problems

Based on Department of Social Welfare, 2016, learning problems means intelligence problems that are not consistent with his/her biological age. Those who fall into this category are Late Global Development, Down syndrome and intellectual disabilities. This category also includes conditions that affect individual learning capabilities such as autism (autistic spectrum disorder), Attention Deficit Hyperactivity Disorder (ADHD) and specific learning difficulties such as (dyslexia, dyscalculia and dysgraphia).

2.3.2.6 Mental Disability

Mental Disability refers to a state of severe mental illness which makes a person unable to function either partially or fully in matters pertaining to his or her relationships in society. Among the types of mental illness was serious organic mental disorder and chronic schizophrenia, paranoid, mood disorder (depression, bipolar) and other psychotic disorder and schizoaffective disorder such as persistent delusional disorder. The condition for this category are firstly, clients must have undergone at least two years of psychiatric treatment. Then, psychiatrists will determine the level of social functioning, cognitive and behavioural control whether it is significantly affecting the patient or worse before he can be considered a PWDs (Department of Social Welfare, 2016).

2.3.2.7. Miscellaneous (Multiple Disabilities)

Miscellaneous (Multiple Disabilities) have more than one type of disability, and that is generally not appropriate to be classified in category 1 to 6.

2.3.3 Wheelchair User Among PWDs In Malaysia

Wheelchair User is categorized under physically handicapped according to the definition of this category which is permanent disability of part of body due to loss or disabled of any part of body which can affect their functions in performing daily tasks (Department of Social Welfare, 2015). Meanwhile, in the Malaysian Standard (MS 1184:2002, Code of Practice on Access For Disabled Persons to Public Buildings), wheelchair users are persons who depend on a wheelchair for mobility. These include attendant propelled wheelchairs, powered wheelchairs and self-propelled wheelchairs. Based on Jarosz (1996), there are a lot of causes of lower extremities dysfunctions such as spinal cord injury, fragility of bone, cerebral palsy, multiple sclerosis, muscular dystrophy, polyneuropathy, and stroke.

2.3.4 Hadith for People with Disabilities to Go to The Mosque

The importance of praying for every Muslim regardless physical status are being told in the hadith. From Rahman M et.al (2016), one of the noble friends of Prophet Muhammad, Abdullah bin Ummi Maktum, a blind, poor man. One day he came to the Messenger of Allah (peace be upon him) and said: "O Messenger of Allah, my house is very far from the mosque, and I have no guidance in walking, then is there a light for me (leaving the prayer of the congregation in the mosque)?" Then Rasulullah SAW gave him lightness. But when he turned, the Prophet said to him, "Did you hear the voice of the azan?" He answered, "Yes." The Prophet (peace and blessings of Allah be upon him) said, "Then answer His call, for I do not get any relief for you." (Writen by Imam Ahmad in Al-Musnad: 3/23 And Ibnu Mâjah: Kitabul Masâjid, Chapter At-taghlidh Fit Takhalluf 'Anil Jamâ'ah, 792)

In addition, there is hadith about Jabir (r.a.) reported: 'Umar b. Khattab said that a person performed ablution and left a small part equal to the space of a nail (unwashed). The Prophet of Allah (PBUH) saw that and said: Go back and perform ablution well. He then went back (performed ablution well) and offered the prayer. [Sahih Muslim, book 2, Hadith no 474] 'Abdullah b. 'Amr (r.a.) reported: We returned from Mecca to Medina with the Messenger of Allah (PBUH), and when we came to some water on the way, some of the people were in a hurry at the time of the afternoon prayer and performed ablution hurriedly; and when we reached them, their heels were dry, no water had touched them. The Prophet (PBUH) said: Woe to (dry) heels, because of Hell−fire. Make your ablution thorough from Sahih Muslim, Book 2, No 468, Suratkon et. al. (2018).

2.4 BASIC OF ERGONOMICS

Ergonomics or in other word Human Factors are the study of helping people to work more efficiently through design of tools, work process, work environment and organizational structure.

2.4.1 Anthropometry Measurement

Anthropometry is the measurement of physical characteristics and abilities of people that provides information that is essential for the appropriate design of occupational and non- occupational environments, as well as for the design of consumer products, clothing, tools and equipment (Paquet & Feathers, 2004).

The field of anthropometry encompasses a variety of human body measurements, such as weight, height, and size, including skinfold thicknesses, circumferences, lengths, and breadths (Fryar, et. al, 2012).

Failure to incorporate anthropometric characteristics of user in designing workstation or furniture has a negative effect on health (Tunay & Melemez, 2008). Furthermore, mismatch between anthropometric dimensions of user and workstation dimensions causes occurrence of awkward posture and subsequently body discomfort (Agrawal, et. al, 2014). Based on Jarosz (1996), there is lack of anthropometric data for wheelchair user population in Poland. So, the measurements were taken using the Martin-Saller's (1957) anthropometric technique, in a special chair with adjustable height and depth, constructed in the Institute of Industrial Design (Jarosz, 1996). Figure 2.13 below shows the picture of dimensions measured on the user followed by Table 2.3 which shows the label of the anthropometric characteristics that were measured in the sitting position.

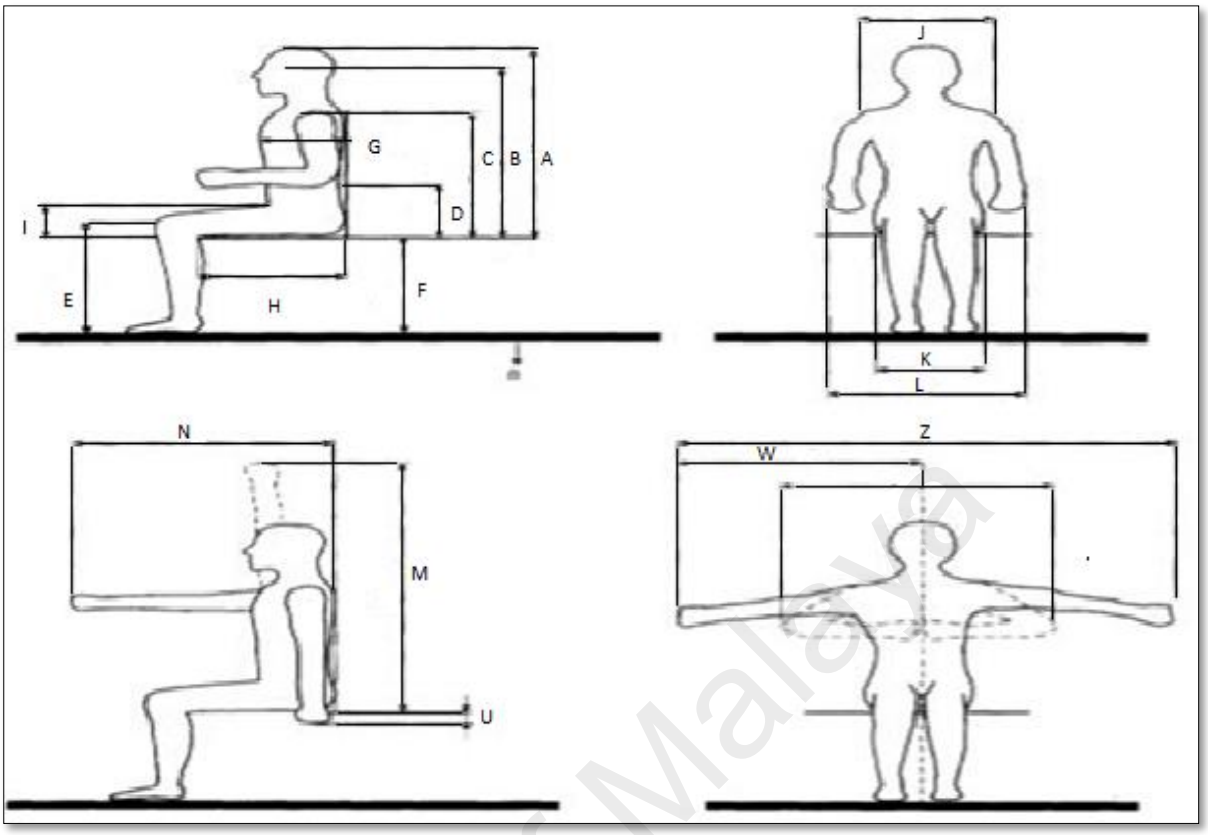

Figure 2. 13: Dimensions measured on the user (Jarosz, 1996)

Table 2. 3: The anthropometric characteristics were measured in the sitting position

A	Stature	J	Shoulder breadth
B	Eye height	K	Hip breadth
C	Shoulder height	L	Max elbows span
D	Elbow height	M	Arm overhead reach
E	Knee height	N	Arm reach forward
F	Popliteal height	U	Arm reach down
G	Trunk depth	W	Lateral reach
H	Popliteal depth	Z	Arms Span
I	Thigh thickness		

The most influential percentile measures are the 5th, 50th and 95th percentiles. Although some people may argue that other percentile range ought to be utilized rather than these, many ergonomists consider it impossible to incorporate extremes of the population, such dwarfs and giants, in the basic design range due to design practically (Helander, 2005).

By applying the idea of percentile to the ablution design, the 5th percentile is vital to decide the reachability and limitation for the ablution workstation while the 95th percentile is utilized to guarantee sufficient clearance to avoid undesirable contact or trapping (Dawal et. al, 2015). By applying these concepts into this study, percentiles were used because it helps to establish the portion of wheelchair user population that will be included in designing the ablution workstation. Therefore, this study was intended to fit wheelchair user who has more than the 5th percentile but less than 95th percentile in different anthropometry measurements (Helander, 2005).

Percentiles values are determined by multiplying standard deviation SD by a factor k then adding the product to the mean ($p = m + k$ x SD). This is the perfect approach to present the results of anthropometry surveys. In order to calculate the percentiles, the mean and standard deviation values were obtained for each of the four selected measurements of the population based on equations in table 2.4 below (Dawal et. al, 2015).

Table 2.4: The formula of Statistic Elements

Statistic Elements	**Equations**
Mean, $\dot{X}$ or m	$\dot{X} = \frac{\sum X}{N}$
Standard Deviation, Õ or SD	$Õ = \sqrt{\frac{\sum(X-\dot{X})^2}{N-1}}$
Percentile, P	$p = m + k$ x SD

2.4.2 Mean Dimensions of The Wheelchair

Mean dimensions of the wheelchair were assumed according to those developed during the studies conducted in the Institute of Industrial Design (Skaradzinska, 1986) as shown in Table 2.5 and Figure 2.14 below.

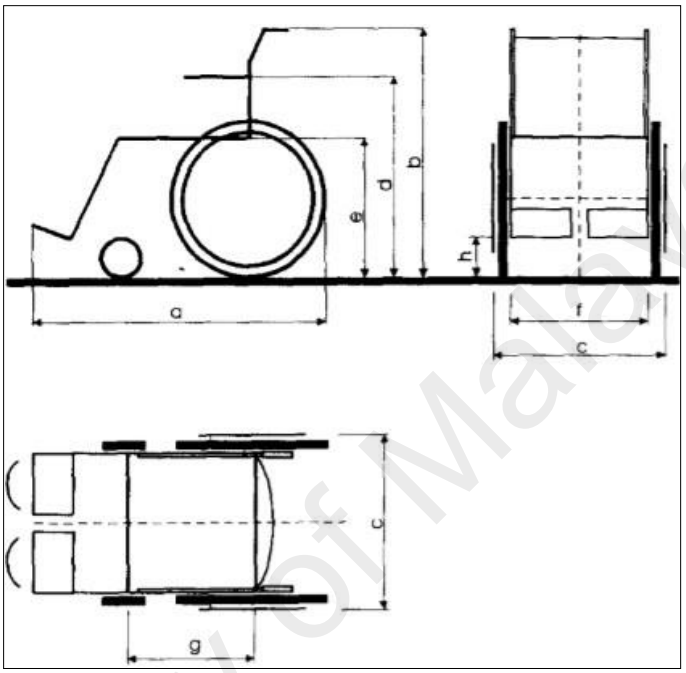

Figure 2. 14: Draft of wheelchair (Jarosz, 1996)

Table 2. 5: Mean Dimensions (Jarosz, 1996)

a	Total Length	1250 mm
b	Total Height	950 mm
c	Total Breadth	660 mm
d	Arm Rest Height	760 mm
e	Seat Height	530 mm
f	Seat breadth	430 mm
g	Seat depth	430 mm
h	Foot rest height	300 mm

2.4 VERTEBRAL COLUMN

The experiments of measuring back posture angle are to study the optimum posture during ablution workstation. The vertebral column performs five major functions as shown in Figure 2.15 below. Firstly, it supports the weight of the head and trunk. Secondly, it protects the spinal cord. Thirdly, it allows spinal nerves to exit the spinal cord. Moreover, it provides a site for muscle attachment. Furthermore, it permits movement of the head and trunk (Seeley et. al, 2014).

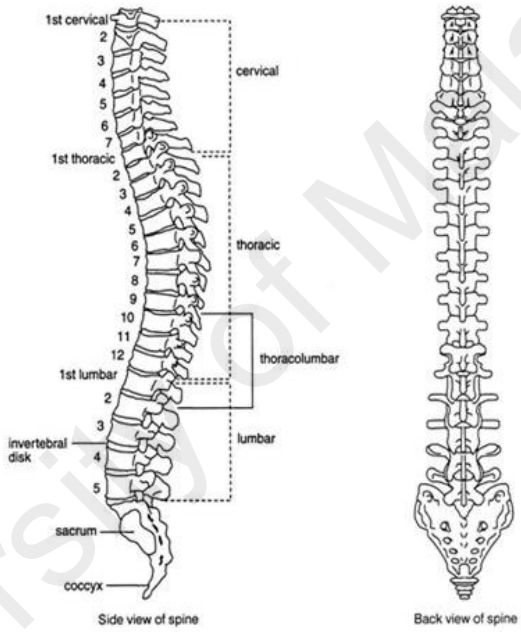

Figure 2. 15: Vertebral Column

The vertebral column usually consists of 26 bones called vertebrae, which can be divided into five regions: 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, 1 sacral bone, and 1 coccygeal bone. (Seeley et. al, 2014).

The cervical vertebrae are designated “C”, thoracic “T” and lumbar “L”. A number after the letter indicates the number of the vertebra from superior to inferior, within each vertebral region. For examples, “C1” refers to the first cervical vertebra. The developing embryo has about 33 or 34 vertebrae, but by adulthood the 5 sacral vertebrae have fused to form 1 bone, and the 4 and 5 coccygeal bones usually have fused to form 1 bone (Seeley et. al, 2014).

The five regions of the adult vertebral column have 4 major curvatures. In adult vertebral column, the cervical region is convex anteriorly, the thoracic region is concave anteriorly, the lumbar is convex anteriorly, and the sacral and coccygeal regions together are concave anteriorly. These spinal curvatures help accommodate our upright posture by aligning our body weight with our pelvis and lower limbs.

2.5.1 Clinical Impact of Low Back Pain

Low Back Pain can result from injury, poor posture, being overweight, or lack of fitness. It is the primary cause of missed work and the second most common neurological affliction in the United States. In addition to chronic pain, an LBP is often accompanied by muscle spasms, which are spontaneous, painful, uncontrolled muscle contractions. A few changes may help to prevent more spasms and reduce pain. Patients should sit and stand up straight, use a low back support when sitting, lose weight, exercise especially the back and abdominal muscles and try to sleep on their side on a firm mattress. If lifestyles changes are not sufficient, treatment with muscle relaxants, anti-inflammatory drugs, or pain medication may be necessary (Seeley et. al, 2014).

2.6 THE ANALYSIS OF POSTURE

RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) provide a quick analysis of demands on a person's musculoskeletal system when performing a specific task (Ghazali, et. al, 2009). For this study, we focus on RULA because wheelchair users have limitation on lower limb as REBA need to analyse entire body.

2.6.1 Rapid Upper Limb Assessment (RULA)

RULA is a survey method developed for use in ergonomics investigations of workplaces involving assessment on neck and upper limb loading for mainly sedentary tasks (repetitive tasks). The outcome of the analysis presents the exposure of individual workers to risks associated with work-related upper limb disorders, in other words, identify postural stress of upper limbs. It examines risk factors such as number of movements, static muscle work, force, working posture, and time worked without a break. All these factors combine to provide a final score that ranges from 1 (Good) to 7 (Worst) as shown in Table 2.6 below. It was originally developed by McAtamney and Corlett (Ansari & Sheikh, 2014).

RULA assessment is geared more towards upper side of the body. It is best applied for sitting, sedentary and seated works. There are four levels of actions to indicate the obtained scores as shown in Table 2.6 below (Ghazali et al., 2009).

Table 2. 6: RULA Action Level (McAtamney & Corlett,1993)

Score	Colour	Requirements for action
1 and 2	Green	Indicates that posture is acceptable if it is not maintained or repeated for long periods
3 and 4	Yellow	Indicates that further investigation is needed and changes may be required
5 and 6	Orange	Indicates investigation and changes are required soon
7	Red	Indicates investigation and changes are required Immediately

The awkward postures could be detected using RULA assessment in CATIA V5 R19. Several postures from the subject working cycle then are chosen and replicated into a manikin in the CATIA V5R19 software. Later, the RULA analysis was performed on the manikin with exact replication to assess the subject's posture level of discomfort (Vyavahare, 2015). In this study, the dimensions of manikin will be keyed in based on anthropometry measurements of Malaysia wheelchair users collected.

2.7 SUMMARY

Literature review in this chapter has provided essential information related to ablution workstation for wheelchair users. Besides that, it is established that posture and vertebral column are affected by this important ritual for Muslim including wheelchair users. Several definitions, design, models and frameworks related to this ablution were discussed. Past literatures on model ablution workstation provided an understanding of the designing ablution workstation. Malaysia Standard provided some of the information needed but it is still lacking in terms of ablution workstation design. The model from previous research could be improved and developed as an upgraded ablution workstation for wheelchair users. Anthropometry characteristics of subjects are significant points to be noted as they will be used in the methods of this research. Besides that, the anthropometry dimension of wheelchair will also be used. Other than that, the RULA analysis is also important to discover the optimum posture during ablution activities. In addition, the information about back posture measurement using inclinometer was also discussed.

The review of the literatures has provided the basic to develop the new integrated framework for this research. Thus, this research proposes a development of upgraded ablution workstation design for wheelchair users for them to perform ablution in effective and comfortable manner.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, methods to achieve the objectives of this study are explained. The flowchart for this study is portrayed in Figure 3.1. Besides that, data collection, subjects, places, apparatus, survey, anthropometry of wheelchair user, anthropometry of ablution workstation, interviews and observation, RULA analysis and experiment using inclinometer are also been described in this chapter.

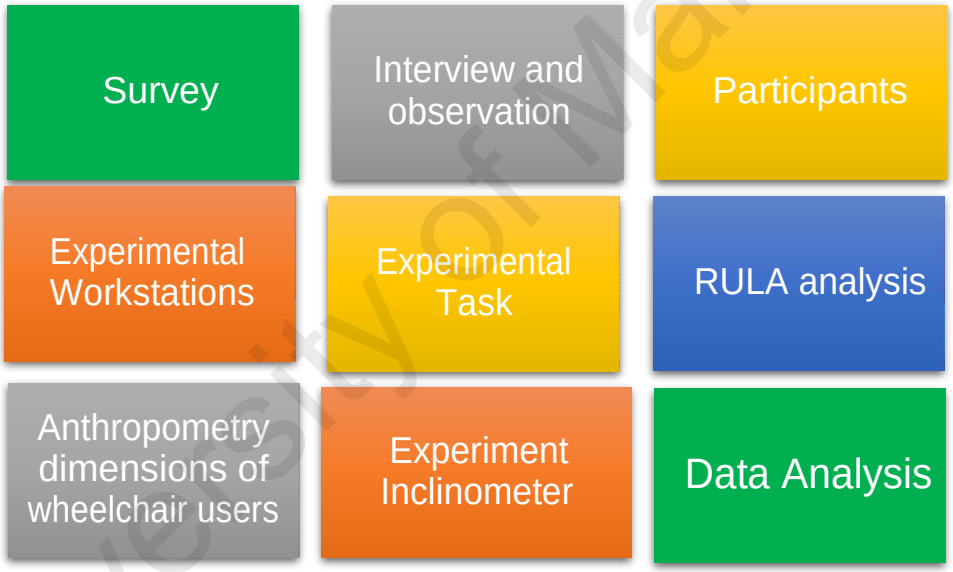

Figure 3. 1: Information that are discussed in this chapter

3.2 FLOWCHART

A flowchart as shown in Figure 3.2 below was developed based on the methodological framework and objectives of the study.

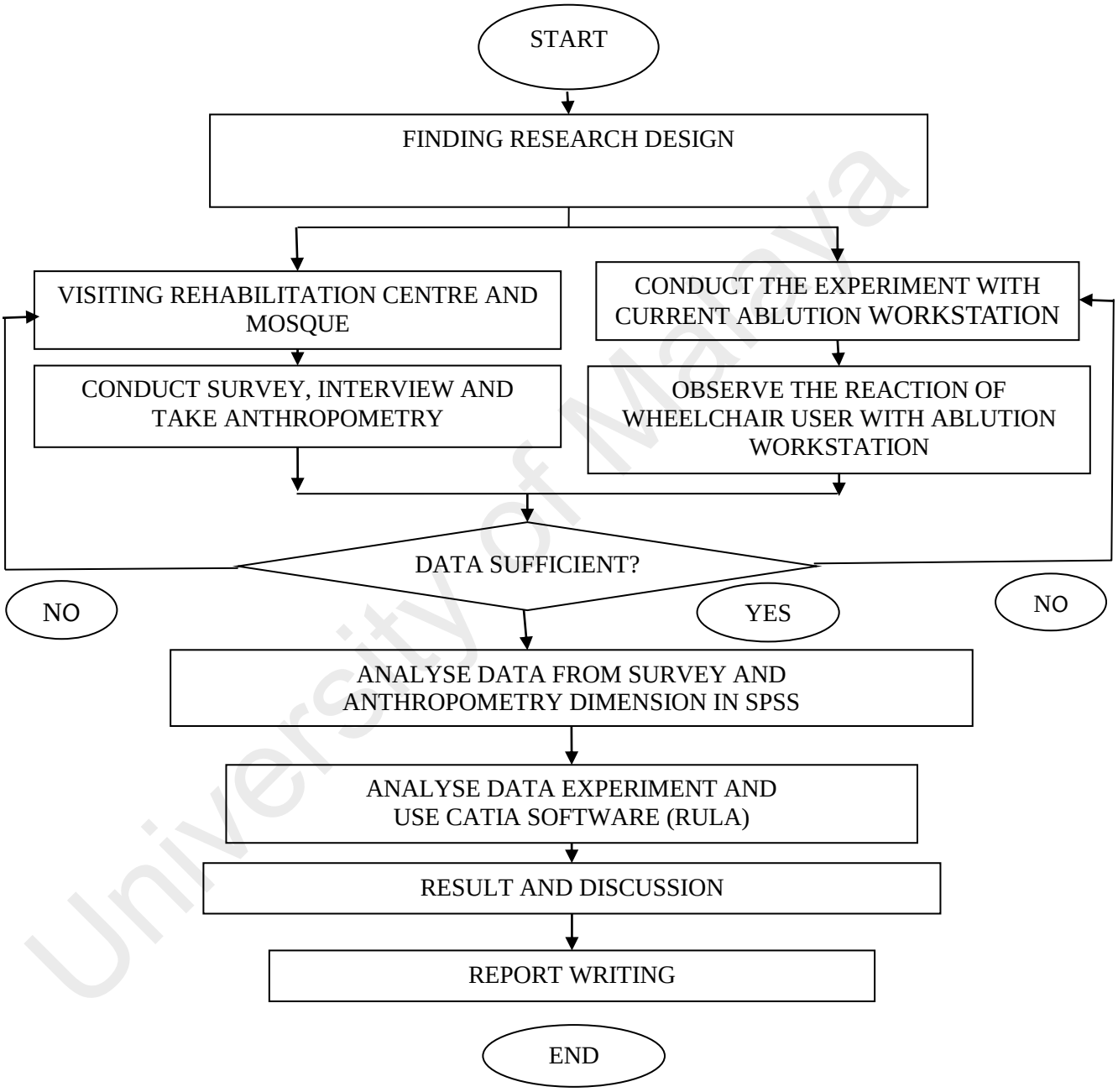

Figure 3.2: Flow Chart of study

3.3 DATA COLLECTION

3.3.1 Subjects

The subjects for this study are 100 people comprising 74 males and 26 female wheelchair users or people with lower limb impairment.

3.3.2 Places

The places visited for this study are majority in Selangor and Kuala Lumpur which is PLPP Bangi Selangor, Bengkel Daya Klang Selangor, Malaysian Paralympic Games Excellence Centre Kampung Pandan Kuala Lumpur, Kelantan Foundation for The Disabled (YOKUK), SOCSO Tun Razak Rehabilitation Centre Melaka, Malaysian Association of Malay Disabled Persons (POKUAM) and others.

3.3.3 Apparatus

Figure 3.3: Anthropometer measuring set

Figure 3.4: Inclinometer

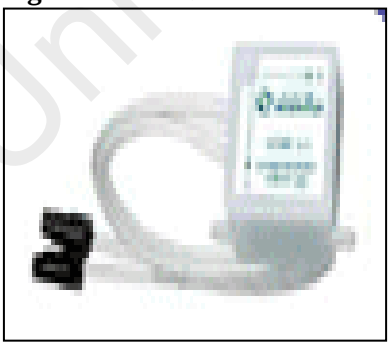

Figure 3.5: Calipers for both sizes

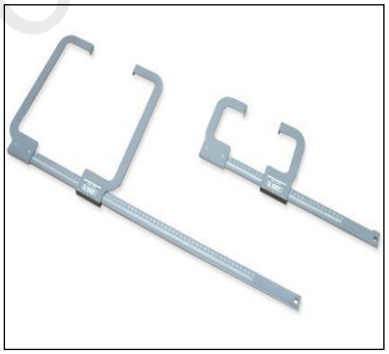

Figure 3.6: Transmitter

3.3.3.1 Existing Ablution Workstation Design Used in This Research

It is crucial to find out if the wheelchair users have different needs compared to able- bodied users specifically in terms of ablution workstations. People with disabilities especially the wheelchair users should be able to use ablution facilities with full comfort without any assistance. In this research, the existing ablution workstation used in the experiment are:

Figure 3.7: Sahala Ablution Workstation

This is an ergonomic wuduk station for the disabled and people with special needs. The ergonomic wash basin design prevents water from spilling over whilst providing comfort to the user to perform wuduk. However, the material used for the wash basin is quite fragile. It is not strong enough to bear the force if the wheelchair users want to move to the front. The multi-directional fountain water system ensures that the feet can be washed properly whilst performing wuduk. This prototype is produced by MEAS-Tech Solution Company.

Figure 3.8: Salsabila Ablution Workstation

This is the latest existing ablution workstation produced for people with disabilities including wheelchair users. It also features ergonomic wash basin to prevent water from spilling over. The water taps to wash the feet is more convenient. This is Wuduk (Ablution) Design: Industrial Patent Number MYIPO 14-01339-0101 from the ORKID Research Group. It is more suitable for the Malaysian PWDs compared to Sahala Ablution Workstation.

Figure 3.9: Ablution Workstation at Surau Al-Hidayah, PLPP Bangi

This is the existing ablution workstation at Surau Al-Hidayah in the Centre for Industrial Training and Rehabilitation (PLPP, Bangi). These 3 designs of ablution workstation are used in this study.

3.3.4 Questionnaire

One of the data collection methods used for this study is by conducting survey. The purpose for conducting the survey is to achieve the first objective which is to study the comfort level and problems faced by wheelchair users. Furthermore, the survey is done to acquire their suggestions about ablution workstation and many more. The survey is distributed to wheelchair users at the rehabilitation centers listed and mosques.

The questionnaire distributed is attached as Appendix. The questions were adapted from Dutch Musculoskeletal Questionnaire by Hildebrandt, et. al (2001) and Workstation Analysis and Self-Assessment Questionnaire by Manchester Metropolitan University.

3.3.5 Anthropometry of Wheelchair User

From the journal written by Jarosz (1996), seventeen anthropometric dimensions were measured when the subject is seated with the thigh parallel to the surface and the knees flexed by 90 degrees (see Figure 3.10). The selection of the anthropometry body dimensions was considered according to their significance and usefulness for the development of designing the sitting workstation and ablution workstation. The description for each anthropometric dimension was referred to the book entitled ‘Body Space: Anthropometry, Ergonomics and the Design of the Work’ by Stephen Pheasant as well as Malaysia Standard, MS ISO 7250-1:2008, as shown in Table 3.1 below.

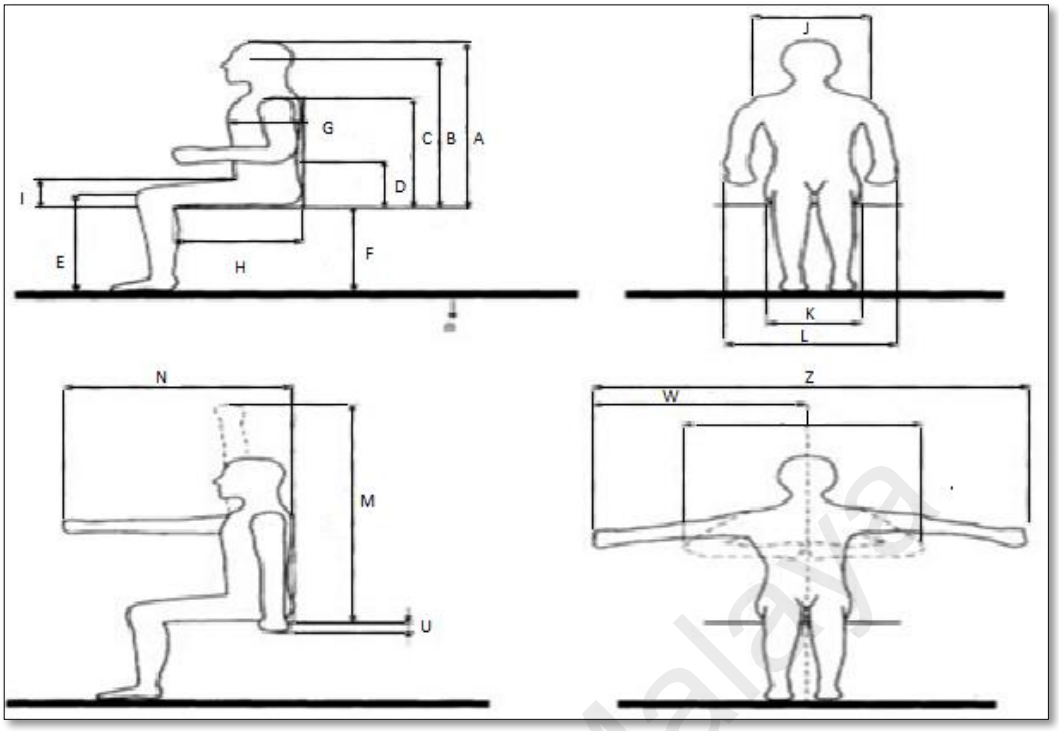

Figure 3. 10: Anthropometry Dimensions measured on the subjects (Jarosz, 1996)

Table 3. 1: Description of Anthropometric Dimensions (Jarosz, 1996 and Pheasant, 1996)

A	Stature	Distance from the seat to the crown of the head
B	Sitting Eye height	Height above the ground of the eye of a person standing erect.
C	Shoulder height	Distance from the seat to the top of the shoulder
D	Elbow height	Distance from the seat to the below part of the elbow
E	Knee height	Taken above floor to the upper knee
F	Popliteal height	Height of the popliteal fossa (back of the knee) above the ground
G	Trunk depth	Horizontal distance between the anterior point of the abdomen and the back at the same level.
H	Buttock Popliteal length	Horizontal distance between the most posterior point on the buttock and the back of the knee as measured in the sitting position with knee flexed 90 degrees.
I	Thigh thickness	Distance taken above the floor to the upper thigh of a seated person
J	Shoulder breadth	Distance between left and right shoulder
K	Hip breadth	Lateral maximum hip or tight breadth (whichever is broader) of a seated subject
L	Max Elbows span	Distance between left and right elbow
M	Arm overhead reach	Highest Distance when arm doing overhear reach during sitting
N	Arm reach forward	Distance between shoulder to finger tips horizontally
U	Arm reach down	Distance between seat and reach down
W	Lateral reach	Half of arm span
Z	Arms Span	Widest distance across the arm

3.3.6 Inclinometer Signal Detection

3.3.6.1 Capture the Signal

Proper skin preparation is important to get a good signal and to avoid artifacts. Before applying inclinometers, the skin surface is ensured clean and dry. The skin is abraded with an abrasive cream or use an alcohol wipe and let it dry.

3.3.6.2 Back Postural Angle Procedure

Before and after the inclinometer experiment, the Reference Body Posture needs to be recorded. The position in Figure 3.11 below is called Unsupported Upright Sitting, with arms hanging along the side of the body, knees flexed at 90 degrees, feet flat on the floor and eyes fixed at a distant eye-level point. Postural angles were recorded for 45 s both before and after work. The average of the recorded angles was determined and used for calibration. This position was used as the reference for recording occupational seated back posture. The subjects were instructed to adopt a comfortable relaxed sitting posture with alignment of the spinal column and head to minimize the sensation of forward or backward rotation of the pelvis, trunk, and head. Sitting posture in the occupational recordings was mostly determined by reference to unsupported upright sitting (Szeto et. al, 2009).

Figure 3.11: Unsupported Upright Sitting

3.4 DATA ANALYSIS

3.4.1 Analysis of Questionnaire

The result from collected questionnaire will be analyzed using SPSS Software. The reliability test will be analyzed to determine the validity of the results from the questionnaire. Meanwhile, the frequency, percentage will also be analyzed and tabulated. The pie chart or bar chart will be presented.

3.4.2 Analysis of Anthropometry Measurement

The statistics analysis is using IBM Statistical Package for Social Science (SPSS) for Windows version 23 software. Somatic characteristics were determined using arithmetic means (x), standard deviation (SD) and the values of the 5th, 50th, and 95th percentile. The 5th, 50th, and 95th percentile of the measurements are calculated for both male and female wheelchair users. Independent t-test is carried out to evaluate significant differences of each anthropometric measurement between wheelchair users and able-bodied adults since the significant differences of dimensions are useful in the application of anthropometric data design. The p-value for the dimensions analyzed need to be less than 0.05 in order to be significantly different between the dimensions of Wheelchair Users and Able-bodied Adults.

3.4.3 Analysis of Experiment Using Inclinometer

The results from experiments using inclinometers will be calculated, analyzed and tabulated in the Excel. Then, the results will be analyzed by Friedman's ANOVA test.

3.4.4 RULA Analysis by Catia Software

The postures when performing ablution that are gained from the analysis of experiment will be filled into RULA analysis using CATIA software. Then, CATIA software will present the effectiveness of the workstation.

CHAPTER 4: RESULTS AND DATA ANALYSIS

4.1 OVERVIEW

The results of all the methods used are presented and analyses in this chapter. Figure 4.1 below shows the topics discussed in this chapter. The results of the questionnaire from the participants were first to be analyses, followed by the results from anthropometry measurements. Then, the result from the experiments using inclinometer will be shown. After that, results from the statistical analysis is discussed out to determine the significant difference between anthropometry measurement of wheelchair users and normal people. The results of the RULA analysis by Catia software are also shown in this chapter.

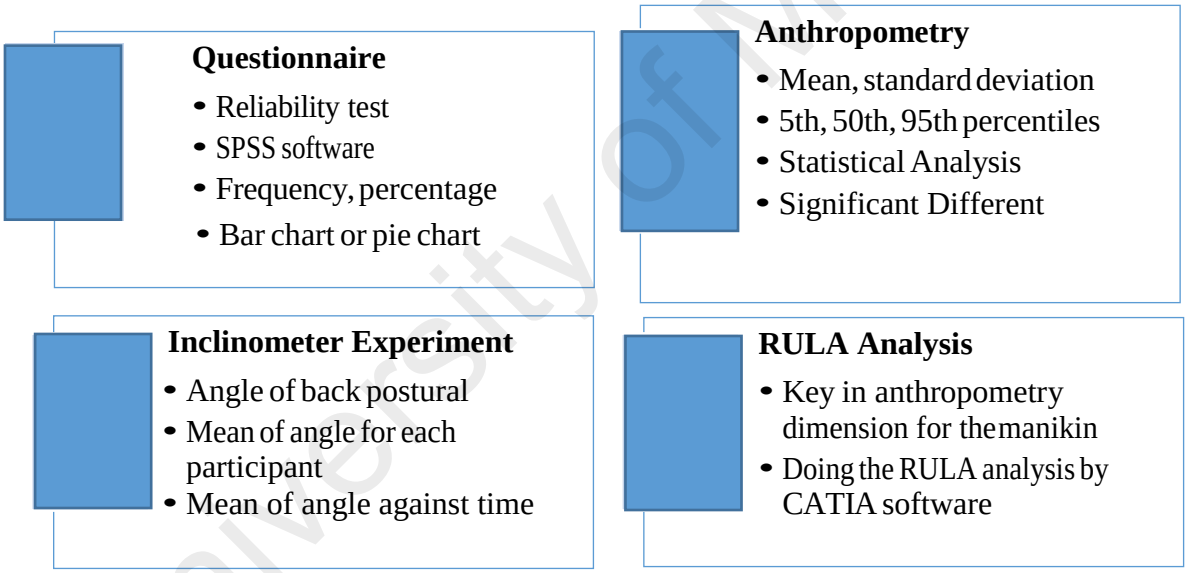

Figure 4. 1: The Subtopics of the Result and Discussion Chapter

4.2 RESULTS FROM QUESTIONNAIRE

In this questionnaire, there are 4 parts of questions. The first part covers the demographic characteristics. The second part is on ablution activity evaluation in the mosque. The third part is about facilities provided in the mosque. Finally, the fourth part allows the respondents to voice out their problems, suggestions and overall evaluation for ablution workstations provided in mosque.

4.2.1 Reliability Test

The questionnaire used are analyzed using the reliability test. Reliability test are the test to validate the questions in questionnaire are reliable or not. The reliability coefficients (also called coefficients of stability) vary between 0 and 1 as shown in Table 4.1 below:

Table 4.1: The reliability coefficients

1: perfect reliability	≥ 0.6 < 0.7: questionable reliability
≥ 0.9: excellent reliability	≥ 0.5 < 0.6: poor reliability
≥ 0.8 < 0.9: good reliability	< 0.5: unacceptable reliability
≥ 0.7 < 0.8: acceptable reliability	0: no reliability

The results of analyses using the reliability test for this questionnaire is 0.778. Based on the table 4.1 above, result from the questionnaire falls under acceptable reliability. The table 4.2 below shows the results of reliability test for the questionnaire used in this study.

Table 4.2: Results of reliability test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.778	0.831	49

4.2.2 Demographic Factors

A total of 93 people had answered the questionnaire which consists of 68 males and 25 females. The table 4.1 below shows some personal information about the participants.

Table 4.3: Demographic Categories of Respondents

No.	Question	Category	Frequency	Percentage
1	Gender	Male	68	73.12
		Female	25	26.88
2	Age	Below 18 years old	3	3.23
		18 – 29 years old	52	55.91
		30 – 39 years old	28	30.11
		40 – 49 years old	7	7.53
		50 – 60 years old	3	3.23
3	Wheelchair experience	0 – 3 years	11	11.83
		4 – 6 years	30	32.26
		7 – 9 years	27	29.03
		10 years and above	25	26.88
4(a)	Is it because of accident?	Yes	31	33.34
		No	62	66.66
4(b)	If No, what is the reasons? (62/93)	Spinal Injury	23	37.1
		Nerve cell damage	7	11.3
		Cerebral Palsy	8	12.9
		Fragility bone	6	9.7
		Amputee	10	16.1
		Others	8	12.9

4.2.2.1 Age of Respondents

The number of respondents based on their age is shown in Figure 4.2 below. It can be observed that the highest number of respondents is in the 18-29 years old bracket with a total of 52. A total of 28 respondents are in the 30-39 years old bracket. Based on the sample size in this study, the results indicate that most of the respondents are in their young adult stage compared to teenagers and older people.

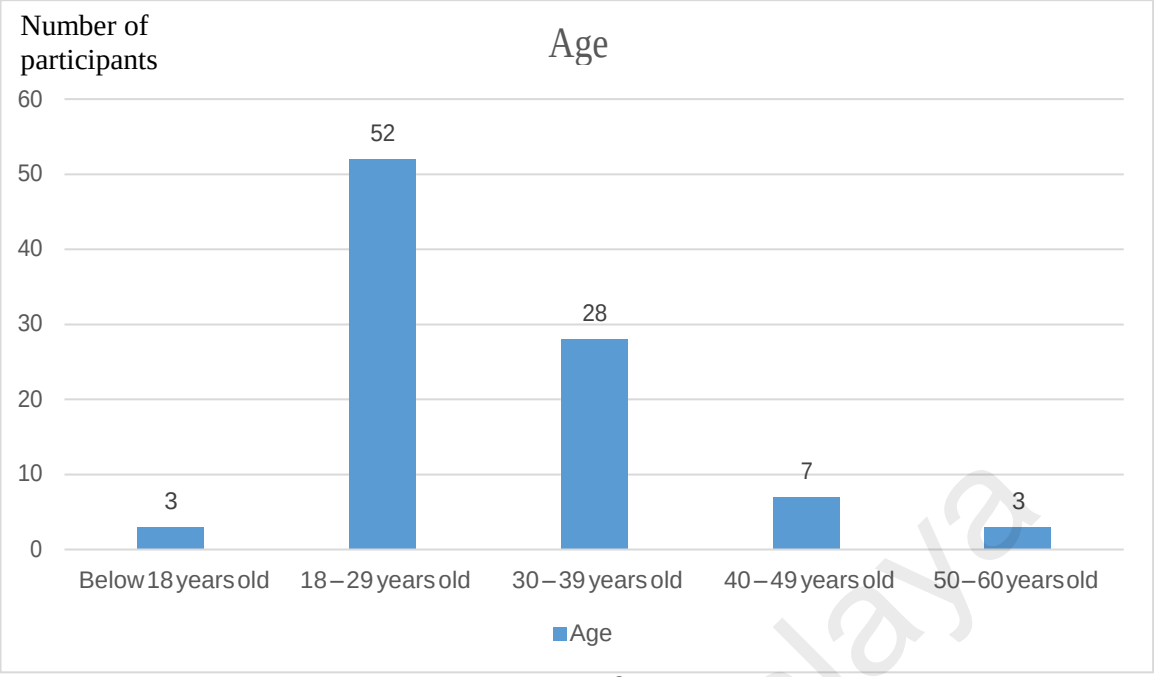

Figure 4.2: Age of respondents

4.2.2.2 Wheelchair Experience

The experience of the wheelchair user respondents was also identified in this study, as shown in Figure 4.3 below. The majority of respondents have been using wheelchair for 4 until 6 years followed by 7-9 years. It is found that only 11 respondents have been using wheelchair for 3 years or below. It shall be noted that the respondents who participated in this study are all experienced wheelchair users.

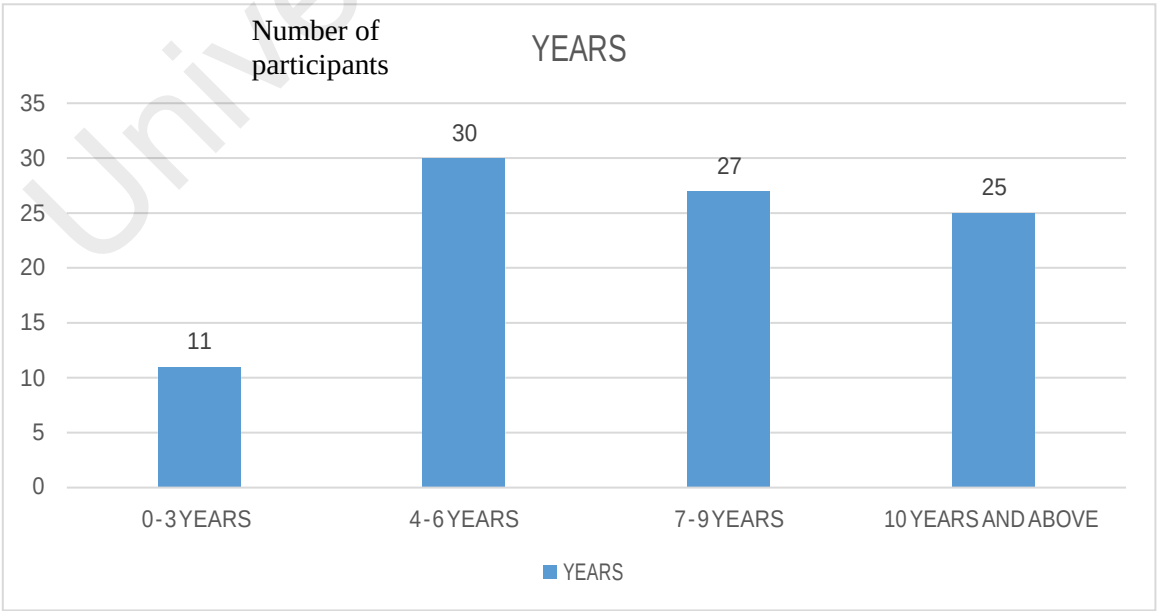

Figure 4.3: Years using wheelchair

4.2.3 Ablution Activity Evaluation in Mosque

The table 4.4 below shows the results from the questionnaire for Part 2 which is the ablution activity evaluation in the mosque.

Table 4.4: Part 2 of Questionnaire

No.	Question	Category	Frequency	Percentage
5	Frequency of going to mosque	Never	1	1.08
		Rarely	16	17.2
		Sometimes	37	39.78
		Usually	24	25.81
		Always	15	16.13
6	Place for taking ablution	Home	45	48.39
		Mosque / Public facility	16	17.2
		Workplace / Rehab Center	32	34.41
7(a)	Comfort – Wash Wrist	Very uncomfortable	6	6.45
		Uncomfortable	17	18.28
		Natural	35	37.63
		Comfortable	22	23.66
		Very comfortable	13	13.98
7(b)	Comfort - Gargle	Very uncomfortable	5	5.43
		Uncomfortable	16	17.39
		Natural	35	38.04
		Comfortable	24	26.09
		Very comfortable	12	13.04
7(c)	Comfort – Wash Nose	Very uncomfortable	5	5.38
		Uncomfortable	21	22.58
		Natural	34	36.56
		Comfortable	22	23.66
		Very comfortable	11	11.83

4.2.3.1 Frequency of Visit to Mosque

The frequency of the participants reflects on the accessibility of facilities in the mosque for them. Based on the Figure 4.4 below, there are 15 of them who always go to mosque, and 24 of them usually go to mosque. This is because most of respondents are from rehabilitation center like PLPP Bangi, Bengkel Daya Klang, YOKUK, SOCSO and others. Even though majority of them are from same places, 37 from the sample size are only sometimes going to the mosque. One of the reasons is because the ablution workstation is not suitable for them. It is easier for them to pray at their room.

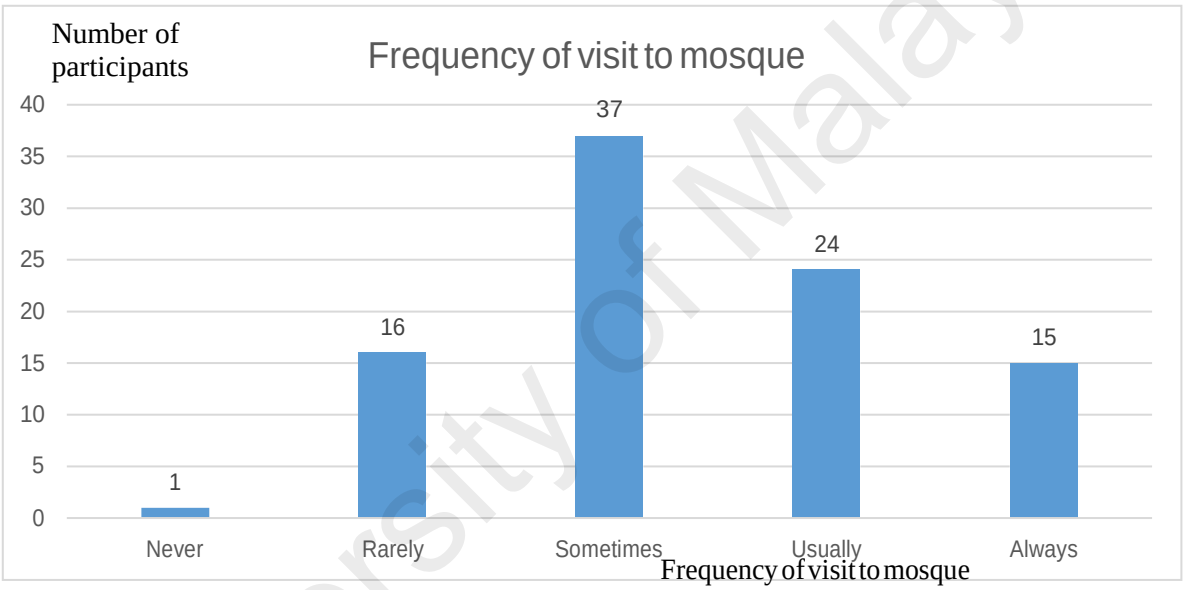

Figure 4.4: Frequency of visit to mosque

4.2.3.2 Place Taking Ablution

Figure 4.5 below shows the number of respondents based on the answer to the question about the place they would take ablution if they are praying at the mosque. It is evident that the highest number of respondents chose to perform ablution at their own home, which is about 45 people. A total of 32 people answered that they took ablution at the workplace or rehabilitation center. The results indicate that the majority of them reported that the ablution workstation and accessibility for them at the mosque are not in good condition. Only 16 out of 93 respondents said that they take ablution at the mosque.

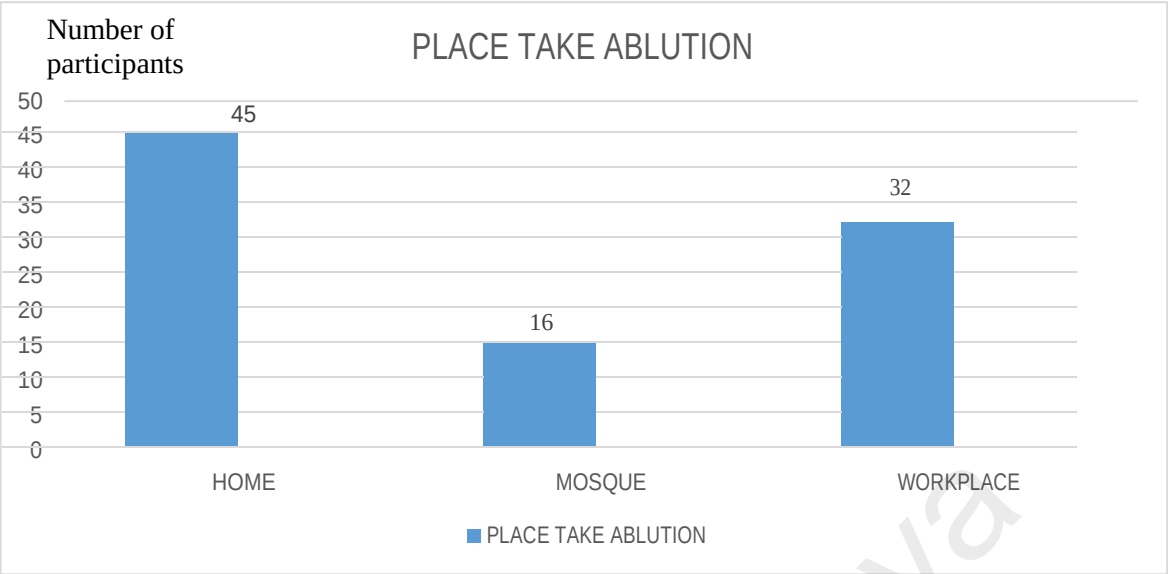

Figure 4.5: Place Take Ablution

Table 4.5: Comfort in ablution task

No.	Question	Category	Frequency	Percentage
7(d)	Comfort – Wash Face	Very uncomfortable	6	6.45
		Uncomfortable	24	25.81
		Natural	33	35.48
		Comfortable	18	19.35
		Very comfortable	12	12.90
7(e)	Comfort – Wash Hand	Very uncomfortable	7	7.53
		Uncomfortable	29	31.18
		Natural	29	31.18
		Comfortable	17	18.28
		Very comfortable	11	11.83
7(f)	Comfort – Wash Head	Very uncomfortable	7	7.53
		Uncomfortable	25	26.88
		Natural	32	34.41
		Comfortable	17	18.28
		Very comfortable	12	12.90
7(g)	Comfort – Wash Ears	Very uncomfortable	7	7.53
		Uncomfortable	23	24.73
		Natural	32	34.41
		Comfortable	20	21.51
		Very comfortable	11	11.83

No.	Question	Category	Frequency	Percentage
7(h)	Comfort – Wash Feet	Very uncomfortable	16	17.20
		Uncomfortable	32	34.41
		Natural	21	22.58
		Comfortable	15	16.13
		Very comfortable	9	9.68
8	Need help	Yes	19	20.43
		No	74	79.57

4.2.3.3 Comfort During Feet Washing

Wheelchair users have problems in their lower limb. Majority of them are uncomfortable using the existing ablution workstation provided in the mosque. It is shown on Figure 4.6 that 16 of them were very uncomfortable followed by 32 people who feel uncomfortable when washing their feet at the existing ablution workstation. Only 9 respondents feel very comfortable and 15 respondents feel comfortable. The design for washing feet should be paid extra attention when designing the new ablution workstations.

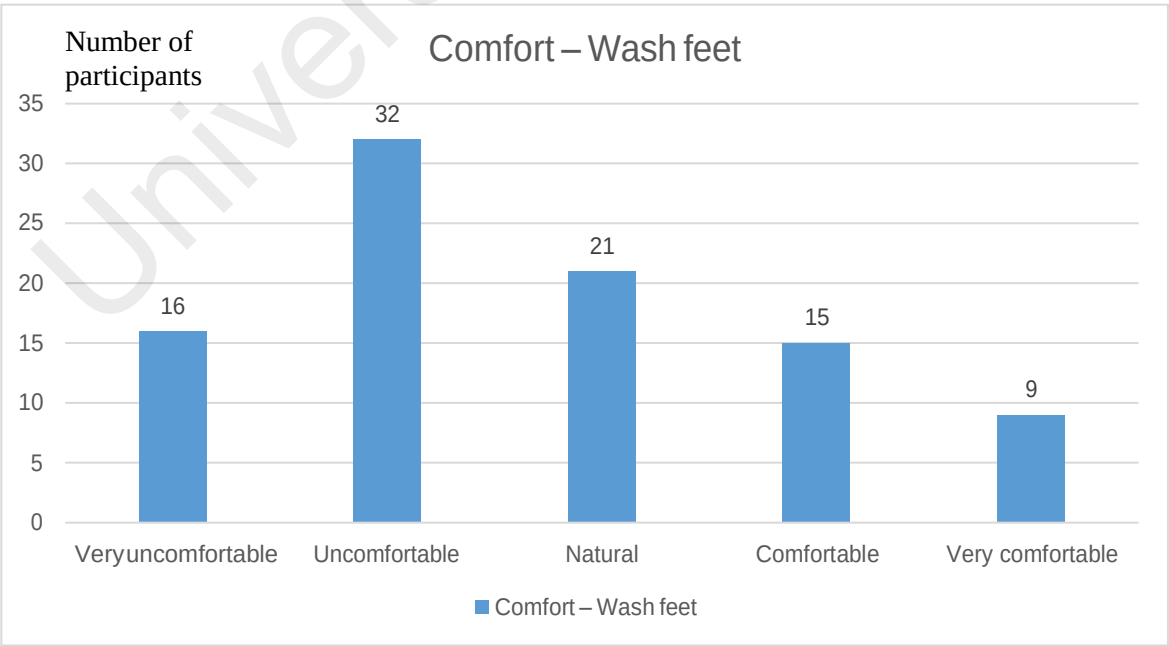

Figure 4.6: Comfort during wash Feet

4.2.3.4 Need Help

Independence are quite important nowadays. Based on the results, only 19 out of 93 respondents need help from other people when they are performing the ablution. Majority of them have no difficulties to carry out the ablution task on their own. This is related to the previous question which is related to their experience using wheelchair.

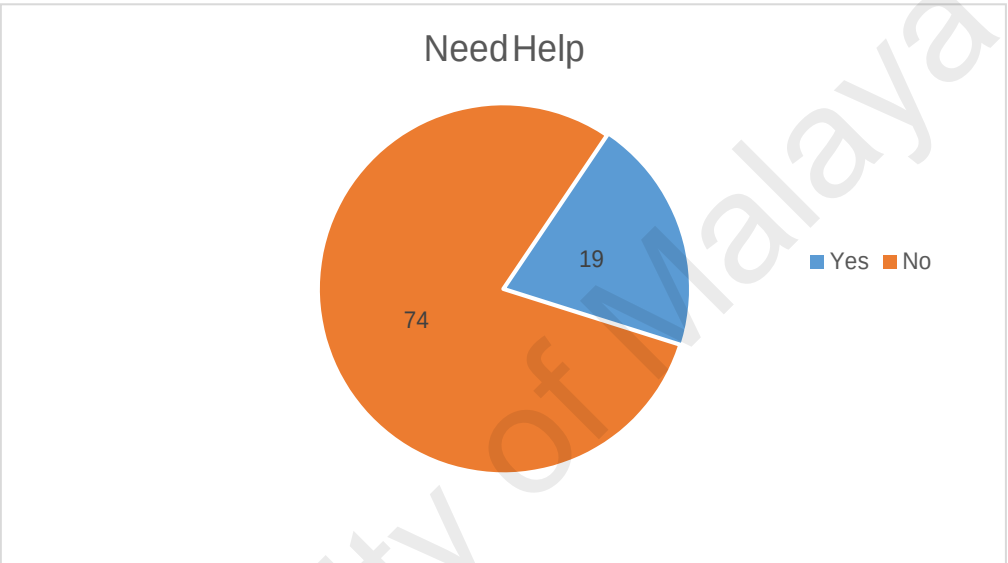

Figure 4.7: Need Help

4.2.4 Facilities Provided in Mosque

The Table 4.4 and Figure 4.8 below shows the results from the questionnaire for Part 3 about the facilities provided in mosques in Malaysia.

Table 4.6: Part 3 of Questionnaire

No.	Question	Category		Frequency	Percentage
9(a)	Grab bar	Yes	No need	10	10.75
			It helps	29	31.18
		No	I need it	49	52.69
			I don't need it	5	5.38
9(b)	Seat	Yes	No need	26	27.96
			It helps	26	27.96
		No	I need it	9	9.68
			I don't need it	32	34.41

9(c)	Splash Barrier	Yes	No need	24	25.81
			It helps	46	49.46
		No	I need it	17	18.28
			I don't need it	6	6.45
9(d)	Drain	Yes	No need	47	50.54
			It helps	36	38.71
		No	I need it	5	5.38
			I don't need it	5	5.38
9(e)	Ramp	Yes	No need	5	5.38
			It helps	38	40.86
		No	I need it	41	44.09
			I don't need it	9	9.68

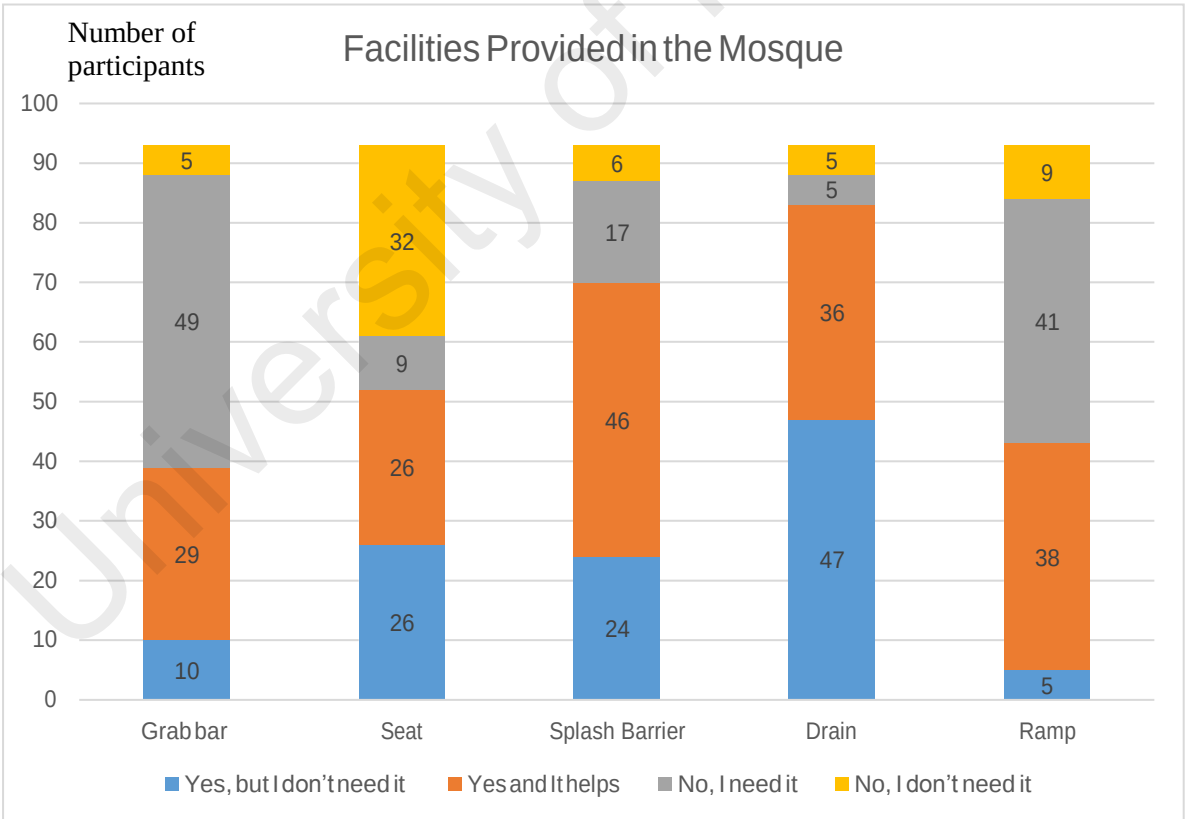

Figure 4.8: Facilities Provided in the Mosque

4.2.4.1 Additional Facilities

Table 4.7 below shows continuality of the part 3 of Questionnaire. Sink and water tap at the feet level are additional facilities that can be included in the future design of ablution workstation if they wish for it. Based on the Figure 4.9 below, 62 out of 93 respondents would like to have sinks for the future design. The main reason is because it can reduce the water splash. Moreover, 66 out of 93 respondents wish to have water tap at the feet level. The main reason is because it can help them not to bend too much when washing the feet.

Table 4.7: Part 3 of Questionnaire- cont'

No.	Question	Category	Frequency	Percentage
10(a)	Sink	Yes	62	66.67
		No	31	33.33
10(b)	Water tap at feet	Yes	66	70.97
		No	27	29.03
11	Distance between toilet, ablution workstation and prayer hall has to be strategic?	Very unneeded	0	0
		Unneeded	2	2.15
		Average	14	15.05
		Need	34	36.56
		Very need	43	46.24
12	Height of tap	Too short	8	8.60
		Short	22	23.66
		Natural	44	47.31
		High	15	16.13
		Very High	4	4.30
13	Distance between water tap and user	Too far	12	12.90
		Far	26	27.96
		Natural	36	38.71
		Near	17	18.28
		Very near	2	2.15
14	Type of water tap	Rotating water tap	2	2.15
		Ball tap	47	50.54
		Up and Down water tap	16	17.20
		Automatic water tap	28	30.11
15	Speed of water	Very slow	0	0.00
		Slow	16	17.20
		Natural	57	61.29
		Fast	18	19.35
		Very fast	2	2.15

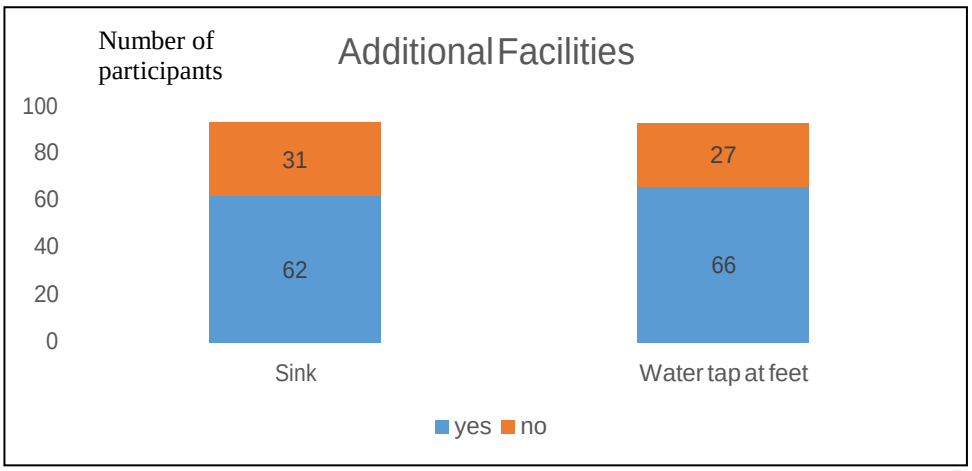

Figure 4.9: Additional Facilities

4.2.4.1 Height of water tap

Optimum height of the water tap will lead to good posture while performing the task. The Figure 4.10 below illustrates when the water tap is too short, too high or natural for them. Majority of them answered that the height is naturally good for them.

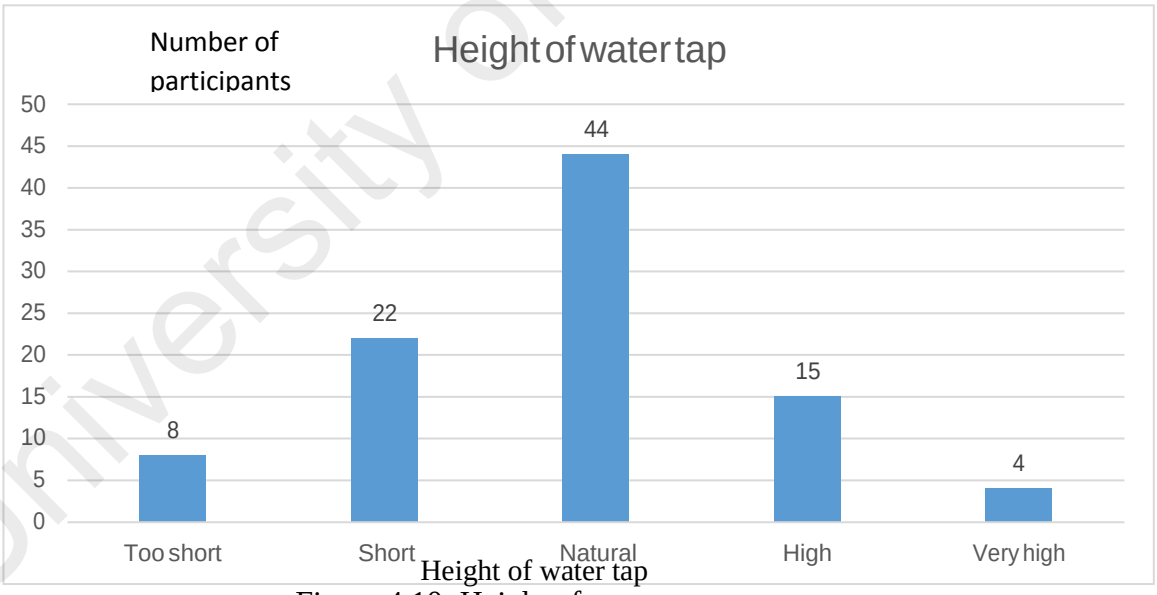

Figure 4.10: Height of water tap

4.2.4.4 Distance between water tap and user

Good distance between water tap and user will also lead to good posture while performing the task. The Figure 4.11 below shows whether the water tap is too far, too near or natural for them. Majority of them answered that the height is naturally good for them.

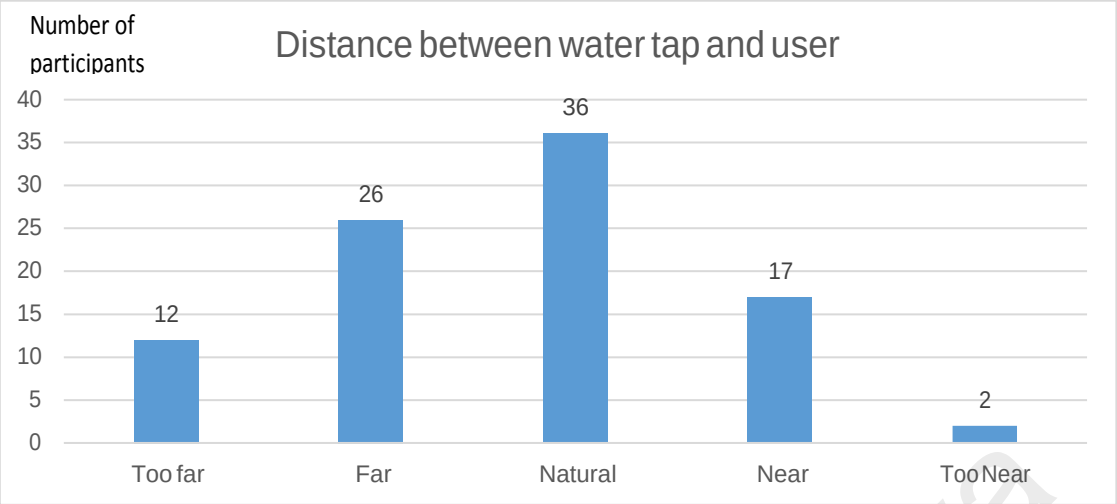

Figure 4.11: Distance between water tap and user

4.2.4.5 Type of water tap handle

The type of water tap handle is also some important criteria to design ablution workstation for wheelchair users and others. Some wheelchair users have deficiency on their fingers. Thus, rotating water tap is not recommended to be used in this design. A total of 47 respondents have chosen the ball tap as the preferred type of water tap as shown in Figure 4.12 below. There were 28 respondents who wish to have automatic water tap.

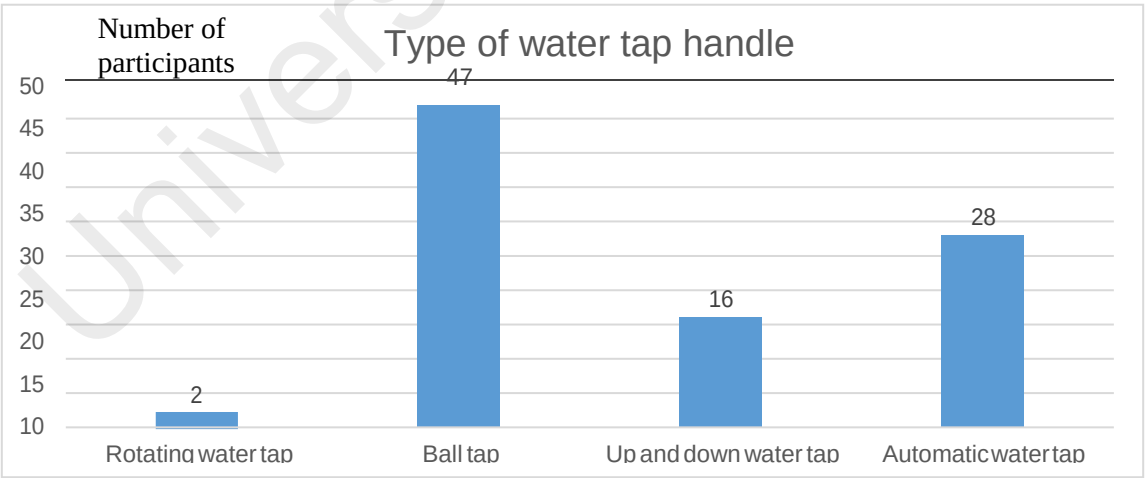

Figure 4.12: Type of water tap handle

4.2.5 Overall Satisfaction on Existing Ablution Workstation

Finally, the last part of the questionnaire is about overall satisfaction of wheelchair users on existing ablution workstation in Malaysia. The Figure 4.13 below shows respondents' answers on the overall satisfaction on existing ablution workstation. A total percentage of 32.3% answered that they are either very uncomfortable or uncomfortable, while 28% answered that they are either very comfortable or comfortable with it.

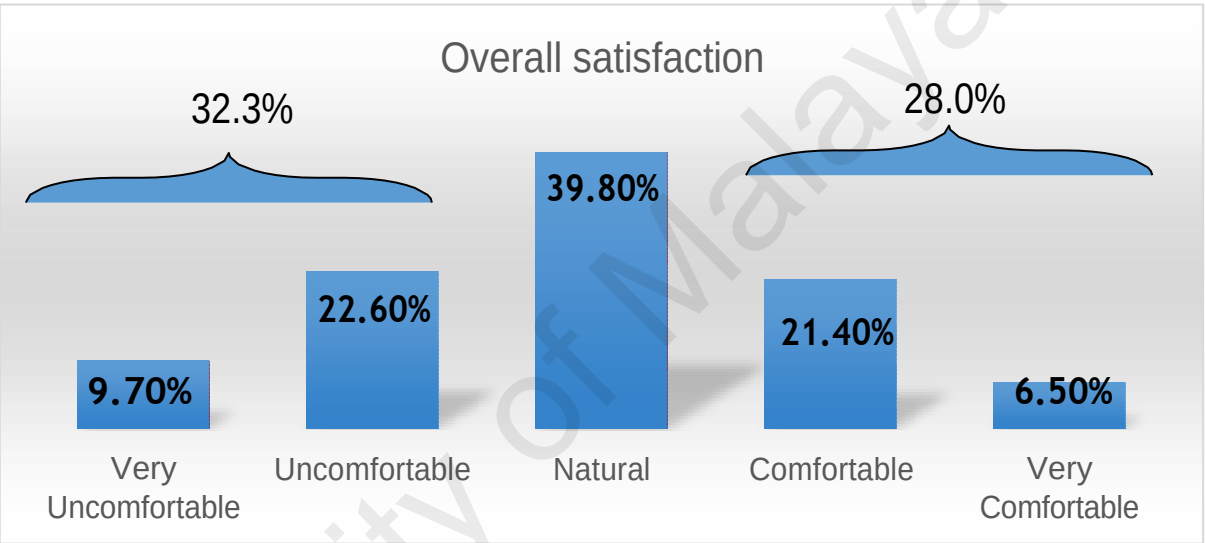

Figure 4.13: Overall Satisfaction

4.2.5.1 PROBLEM ABOUT EXISTING ABLUTION WORKSTATION

The most complaint we obtain on the problems is that existing ablution workstations are not wheelchair users-friendly. Majority of them have problems when washing their feet. There were also problems when the distance between the participants and water tap are uncomfortable. They also have problems with rotating water tap. Every problem will be noted when designing the future ablution workstation.

4.2.5.2 SUGGESTION ABOUT FUTURE ABLUTION WORKSTATION

The participants prefer the ablution workstation to be wheelchair user-friendly for example sink, water tap at feet, type of water handle and many more. All the suggestions will be noted and taken into account when designing the future ablution workstation.

4.3 ANTHROPOMETRY MEASUREMENT

A total of 100 wheelchair users had participated in the anthropometry measurements which consists of 74 males and 26 females. However, 6 participants comprising 5 males and a female were not in the age range of 18 until 59 years old. Thus, the anthropometry measurements of 94 wheelchair users which consists of 69 males and 25 females, aged between 18 to 59 years old were analyzed in this study. The anthropometry data of the participants were analyzed and summarized in the Table 4.8 below. The mean, standard deviation and percentiles of the participants' body dimensions are presented in this table.

Table 4.8: Anthropometry Measurement collected in this study

Measurement	Male Wheelchair User (n=69)					Female Wheelchair User (n=25)				
	Mean	SD	Percentiles			Mean	SD	Percentiles		
			5th	50th	95th			5th	50th	95th
Sitting Height	78.41	8.16	64.53	79.85	88.05	72.31	8.33	57.88	74.90	83.22
Sitting Eye Height	67.53	7.10	55.93	68.68	77.77	60.53	6.66	48.81	62.25	68.01
Sitting Shoulder Height	52.53	6.30	43.52	52.60	61.68	47.39	5.88	36.57	48.60	54.44
Sitting Elbow Height	19.65	4.81	13.43	20.08	25.07	17.02	4.86	7.82	17.40	22.89
Sitting Knee Height	51.04	5.76	41.79	50.30	61.06	49.85	7.36	39.77	51.05	63.66
Sitting Popliteal Height	43.26	9.57	34.21	42.15	52.95	40.38	7.41	31.00	39.58	53.61
Buttock Knee Length	52.23	5.75	42.10	52.10	59.98	51.78	5.99	42.44	52.08	59.48
Buttock Popliteal Length	43.61	5.04	34.90	43.10	50.95	43.41	4.54	36.35	42.65	49.10
Thigh Clearance	11.55	3.09	6.55	11.05	16.85	11.77	3.31	6.69	12.05	16.46
Shoulder Breadth	42.55	4.51	35.92	42.33	49.69	38.39	4.13	32.30	37.90	44.46
Hip Breadth, Sitting	32.81	4.54	25.61	32.80	39.72	35.82	4.35	31.50	35.25	43.88
Span	169.80	9.37	155.27	169.85	183.77	154.91	6.03	144.75	156.30	162.29
Elbow Span	83.56	20.02	68.10	80.03	104.79	75.02	8.30	65.27	73.60	89.62
Arm Reach Upward	119.04	16.20	95.26	122.10	137.93	102.76	9.63	88.65	105.15	114.74
Arm Reach Forward	79.96	6.38	70.50	79.80	89.69	73.53	5.26	67.76	73.83	81.22

In this study, there were several dimensions that could not be measured precisely due to physical weakness to hold certain required postures. Based on the table 4.8 shown, 13 out of 15 means of dimensions for male wheelchair users were bigger than female wheelchair users. These results were compared with the sample population of able-bodied population in Malaysia to evaluate the significant differences between them by independent t-test analysis using SPSS software.

4.3.1 Comparison of Anthropometric Data between Male Wheelchair Users and Male Able- bodied Adults

Table 4.9: Anthropometric Measurements between Male

Measurements	**Male Wheelchair User (N=69)**					**Male Able-Bodied Adults (N=62)**					***t*-value**	***p*-value**
	Mean	**SD**	**Percentiles**			**Mean**	**SD**	**Percentiles**				
			5th	**50th**	**95th**			**5th**	**50th**	**95th**		
Sitting Height	78.41	8.16	64.53	79.85	88.05	86.08	3.62	80.73	86.15	91.47	-6.878	0.000*
Sitting Eye Height	67.53	7.10	55.93	68.68	77.77	74.97	3.02	71.39	74.50	80.66	-7.860	0.000*
Sitting Shoulder Height	52.53	6.30	43.52	52.60	61.68	58.53	3.93	52.14	58.60	63.71	-6.116	0.000*
Sitting Elbow Height	19.65	4.81	13.43	20.08	25.07	23.57	4.17	17.20	24.10	29.75	-4.428	0.059
Sitting Knee Height	51.04	5.76	41.79	50.30	61.06	49.44	4.17	43.18	49.25	54.86	2.556	0.003*
Sitting Popliteal Height	43.26	9.57	34.21	42.15	52.95	42.92	2.33	40.36	42.85	45.66	0.771	0.000*
Buttock Knee Length	52.23	5.75	42.10	52.10	59.98	54.70	3.72	47.88	55.00	59.65	-2.611	0.006*
Buttock Popliteal Length	43.61	5.04	34.90	43.10	50.95	43.52	3.12	39.65	43.45	48.94	0.885	0.001*
Thigh Clearance	11.55	3.09	6.55	11.05	16.85	12.20	1.83	10.35	12.15	14.49	-3.146	0.007*
Shoulder Breadth	42.55	4.51	35.92	42.33	49.69	36.77	6.65	30.11	33.10	45.68	5.542	0.004*
Hip Breadth, Sitting	32.81	4.54	25.61	32.80	39.72	36.79	4.01	31.98	36.40	44.54	-1.911	0.031*
Span	169.80	9.37	155.27	169.85	183.77	172.83	7.86	162.10	171.75	184.23	0.231	0.776
Elbow Span	83.56	20.02	68.10	80.03	104.79	87.45	4.65	81.90	87.20	95.40	-0.932	0.002*
Arm Reach Upward	119.04	16.20	95.26	122.10	137.93	128.49	5.93	119.64	123.45	137.65	-1.371	0.109
Arm Reach Forward	79.96	6.38	70.50	79.80	89.69	82.34	6.23	75.16	82.00	93.72	0.659	0.434

All dimensions are in cm *Significant at $p<0.05$

4.3.2 Comparison of Anthropometric Data between Female Wheelchair Users and Female Able-Bodied Adults

Table 4.10: Anthropometric Measurements between Female

Measurements	Female Wheelchair User (N=25)					Female Able-Bodied Adults (N=76)					*t*-value	*p*-value
	Mean	SD	Percentiles			Mean	SD	Percentiles				
			5th	50th	95th			5th	50th	95th		
Sitting Height	72.31	8.33	57.88	74.90	83.22	81.81	5.05	76.15	82.00	87.94	-5.159	0.000*
Sitting Eye Height	60.53	6.66	48.81	62.25	68.01	71.06	5.71	64.66	70.80	78.09	-6.813	0.000*
Sitting Shoulder Height	47.39	5.88	36.57	48.60	54.44	54.31	4.18	48.80	54.00	60.38	-4.906	0.000*
Sitting Elbow Height	17.02	4.86	7.82	17.40	22.89	21.40	2.58	18.37	21.00	25.77	-6.562	0.000*
Sitting Knee Height	49.85	7.36	39.77	51.05	63.66	46.89	3.85	41.42	47.13	52.04	2.287	0.031*
Sitting Popliteal Height	40.38	7.41	31.00	39.58	53.61	39.63	3.61	33.78	39.80	44.39	0.372	0.713
Buttock Knee Length	51.78	5.99	42.44	52.08	59.48	52.04	5.21	46.78	52.65	58.18	-0.823	0.413
Buttock Popliteal Length	43.41	4.54	36.35	42.65	49.10	43.02	3.94	37.23	42.90	49.42	-0.677	0.500
Thigh Clearance	11.77	3.31	6.69	12.05	16.46	14.22	2.92	10.52	13.33	19.02	-2.795	0.006*
Shoulder Breadth	38.39	4.13	32.30	37.90	44.46	37.40	3.65	33.83	37.10	41.70	-0.786	0.436
Hip Breadth, Sitting	35.82	4.35	31.50	35.25	43.88	34.61	3.87	29.60	34.15	40.82	0.268	0.789
Span	154.91	6.03	144.75	156.30	162.29	80.89	8.87	73.76	80.00	88.00	-0.218	0.828
Elbow Span	75.02	8.30	65.27	73.60	89.62	155.04	10.02	143.34	156.00	165.40	-1.808	0.047*
Arm Reach Upward	102.76	9.63	88.65	105.15	114.74	116.43	10.05	102.93	117.93	126.87	-6.922	0.000*
Arm Reach Forward	73.53	5.26	67.76	73.83	81.22	74.79	8.12	66.90	74.80	82.20	0.473	0.637

All dimensions are in cm *Significant at $p<0.05$

Based on the Table 4.9 and 4.10 above, 11 dimensions showed significant differences between male Malaysian wheelchair users and male Malaysian able-bodied adults. Meanwhile, there were 8 dimensions with significant differences between female Malaysian wheelchair users and female Malaysian able-bodied adults.

4.3.3 Visual comparison of Anthropometric Dimension between Male Wheelchair Users Adults and Male Able-Bodied Adults in Malaysia

The mean body segment proportions of male wheelchair users adults and male able-bodied adults in sitting posture are presented in the Figure 4.14 below. Based on the proportions in the Figure 4.14, there were clear differences in the mean dimensions between male wheelchair users and male able-bodied adults. The sitting height, shoulder height, elbow height, buttock knee length, arm reach upward, and arm reach forward of male able-bodied adults were obviously larger compared to male wheelchair users. Thus, when designing the facilities for wheelchair users, it is important to differentiate against the able-bodied adults in terms of the dimensions used.

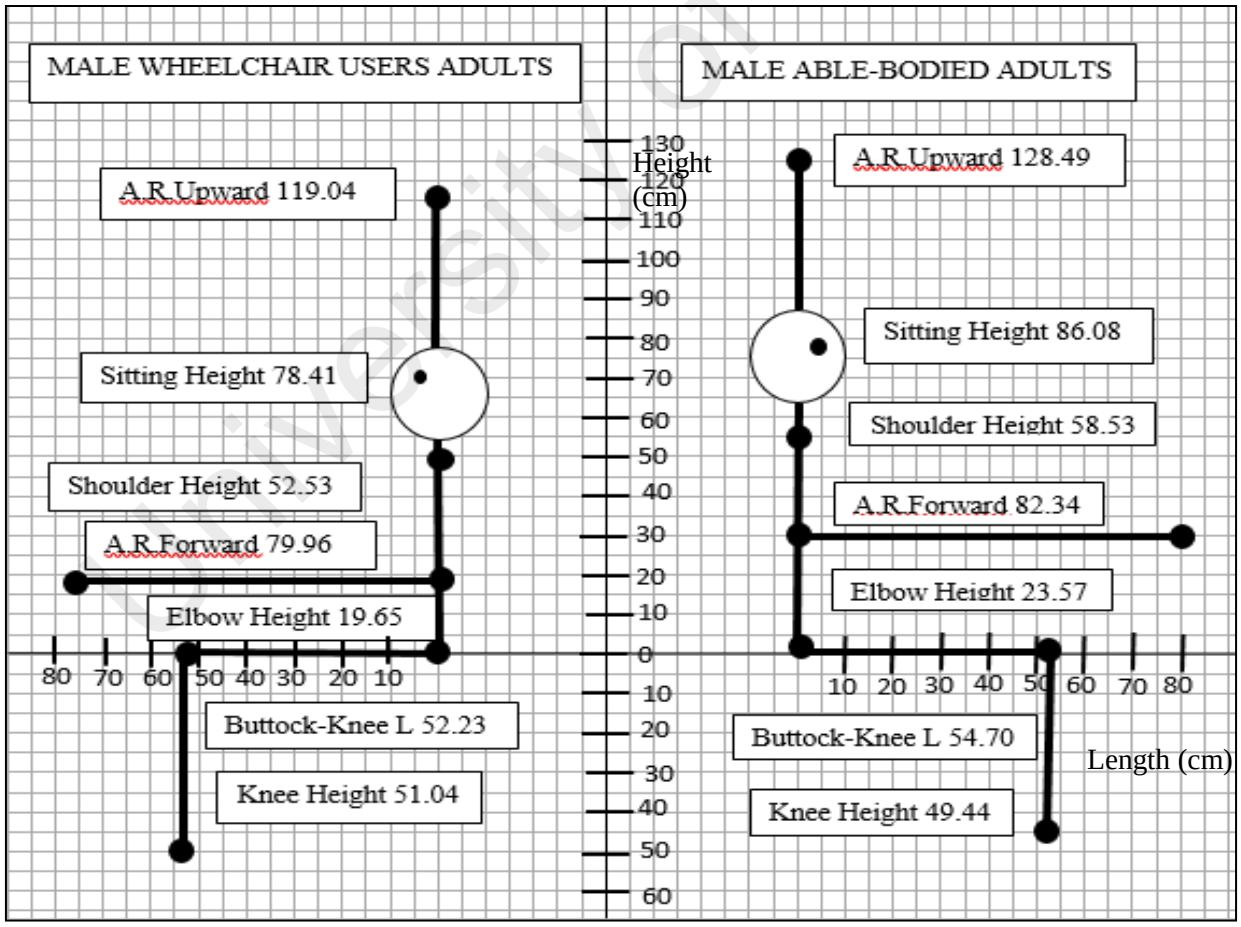

Figure 4.14: Visual comparison between Male

4.3.4 Visual comparison of Anthropometric Dimension between Female Able-Bodied Adults and Female Wheelchair Users in Malaysia

The mean body segment proportions of female wheelchair users and female able-bodied adults in sitting posture are presented in Figure 4.15 below. Based on the proportions in Figure 4.15, there are clear differences in the mean dimensions between female wheelchair users and female able-bodied adults. The sitting height, shoulder height, elbow height, buttock knee length, arm reach upward and arm reach forward of female able-bodied adults were obviously larger compared to female wheelchair users. Therefore, it is important to differentiate with dimensions of able-bodied adults in terms of the dimensions used when designing the facilities for wheelchair users.

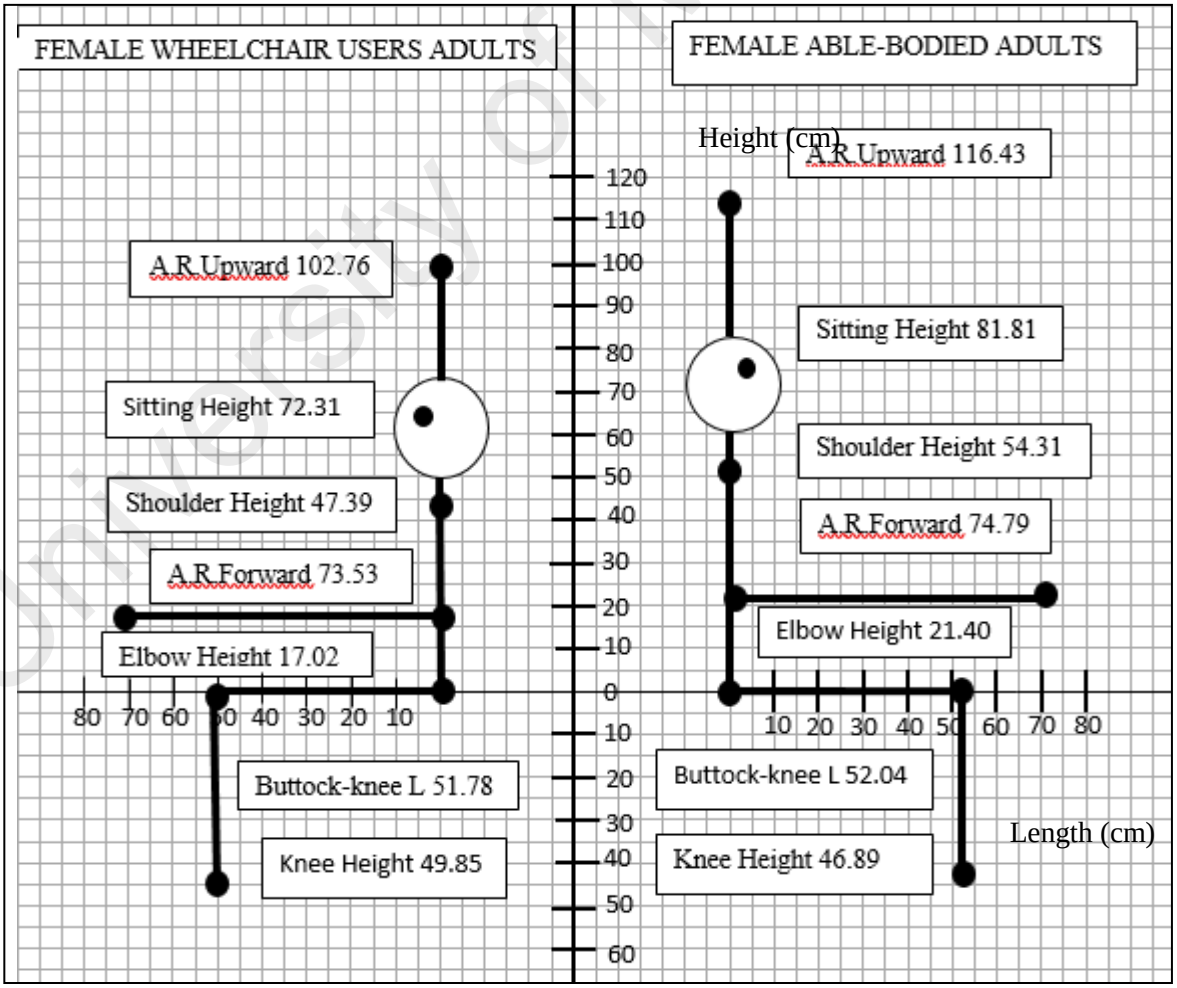

Figure 4.15: Visual comparison between Female

4.3.5 Summary of statistical analysis between wheelchair users' adults and able-bodied adults

Based on Registration of Persons with Disabilities by State in 2015 (Department of Social Welfare, 2016), the highest number of PWD registered are from Selangor. Thus, the locations of this study mostly took place in Selangor. The anthropometric data for male and female subjects of wheelchair users were collected from many locations. One of them was Bengkel Daya Klang, Selangor. Another location was Pusat Latihan Perindustrian dan Pemulihan (PLPP) Bangi, Selangor. Besides that, Program Pemulihan Dalam Komuniti (PDK) or "Community- Based Rehabilitation" (CBR) were also involved, which were PDK Selayang, PDK Kuala Kubu Bharu, and PDK Sungai Buloh. Last but not least, the Malaysian Paralympic Games Excellence Centre in Kampung Pandan, Kuala Lumpur was also selected as a location for the study. Table 4.11 below show summary of significant differences for the Independent t-test on male and female for the anthropometric dimensions.

Table 4.11: Summary of Significant Differences for the Independent t-test on Male and Female for the Anthropometric Dimensions ($p<0.05$)

Measurement	Differences between Wheelchair User and Able- bodied Adults in male	Differences between Wheelchair User and Able- bodied Adults in female
Sitting Height	√	√
Sitting Eye Height	√	√
Sitting Shoulder Height	√	√
Sitting Elbow Height	√	√
Sitting Knee Height	√	√
Sitting Popliteal Height	√	-
Buttock Knee Length	√	-
Buttock Popliteal Length	√	-
Thigh Clearance	√	√
Shoulder Breadth	√	-
Hip Breadth, Sitting	√	-
Span	-	-
Elbow Span	√	√
Arm Reach Upward	-	√
Arm Reach Forward	-	-

4.4 BACK POSTURAL ANGLES

The results of the back postural angles of the participants recorded from the upper trunk and pelvis are shown in this section. The results were analysed to determine the back postural angles of the participants during ablution task with 3 different ablution workstations. The back postural angles for each participant during ablution task were analysed in terms of the mean angle deviation from sagittal plane. For upper trunk angle, a positive value indicates upper trunk flexion, whereas a negative value indicates upper trunk extension. For pelvic angle, a positive value indicates forward rotation of pelvis meanwhile a negative value indicates backward rotation of the pelvis (Caneiro et al., 2010).

4.4.1 Back Postural Angles using Surau Al-Hidayah (PLPP Bangi) Ablution Workstation

The mean upper trunk angle for each participant during ablution task at Surau Al-Hidayah (PLPP Bangi) is shown in Figure 4.16 below. The results revealed that 18 participants experienced upper trunk flexion whereas 5 participants experienced upper trunk extension while carrying out the ablution task. It was found that the mean upper trunk angle of the participants during flexion and extension varied from 6.03º to 34.76º and -5.44º to -14.24º. It is range under 50º.

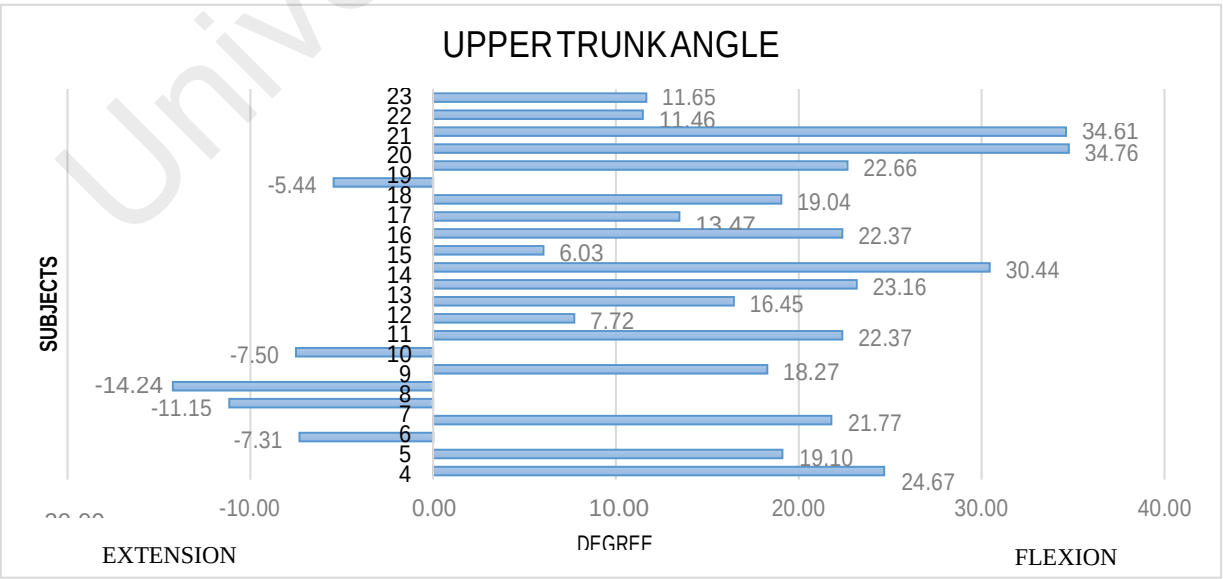

Figure 4.16: The mean upper trunk angle at Ablution workstation 1

The mean pelvic angle for each participant during ablution task is shown in Figure 4.17 below. A total of 16 out of 23 participants experienced forward pelvic rotation when performing the ablution task. In contrast, only 7 participants experienced backward pelvic rotation. The mean pelvic angle of the participants during forward pelvic rotation varied from 0.85° to 39.04° whereas the mean pelvic angle of the participants during backward pelvic rotation varied from -0.01° to -24.88°. It is range under 50°.

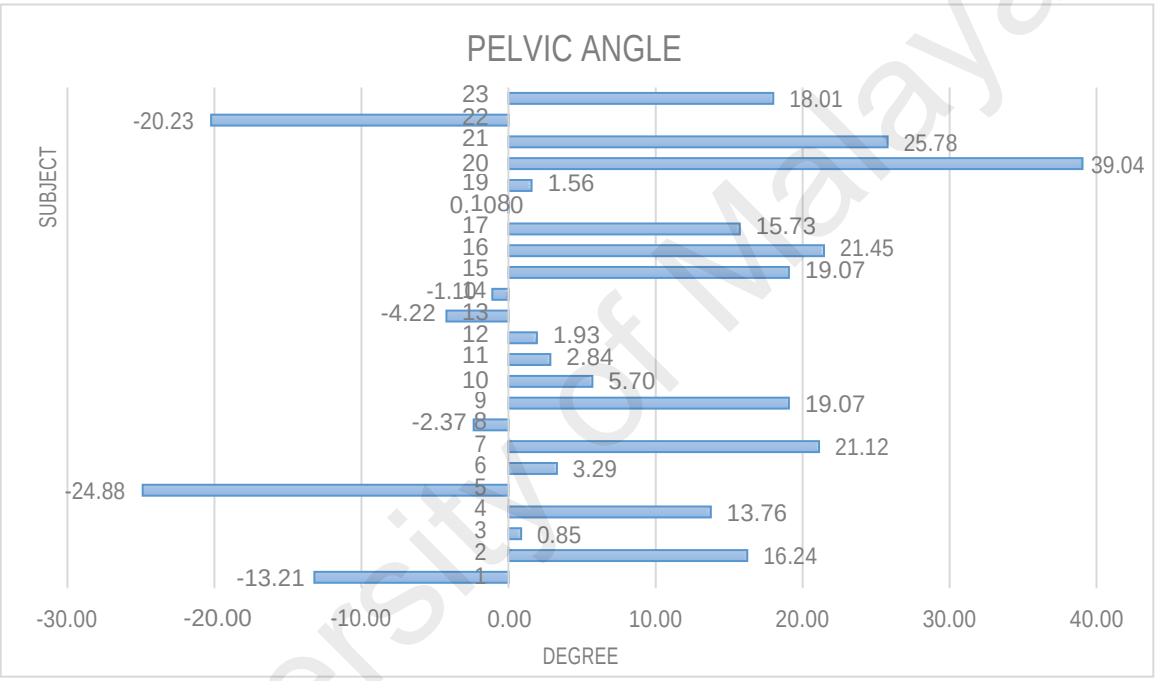

Figure 4.17: The mean pelvic angle at Ablution workstation 1

4.4.2 Back Postural Angles using Sahala Ablution Workstation

The mean upper trunk angle for each participant during ablution task using Sahala ablution workstation is shown in Figure 4.18 below. The results revealed that 15 participants experienced upper trunk flexion whereas 8 participants experienced upper trunk extension while carrying out the ablution task. It was found that the mean upper trunk angle of the participants during flexion and extension varied from 0.36° to 28.80° and -0.42° to -30.39° respectively. It is range under 50°.

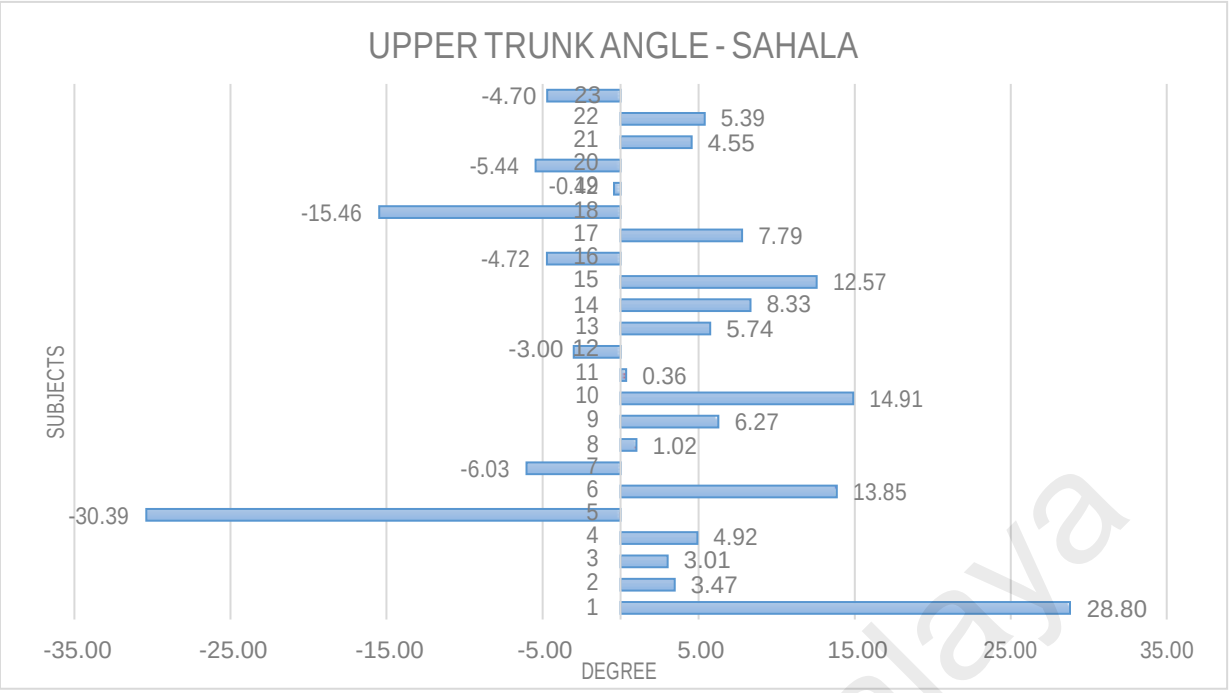

Figure 4.18: The mean upper trunk angle at Ablution workstation 2

The mean pelvic angle for each participant at Sahala ablution workstation is shown in Figure 4.19 below. A total of 13 out of 23 participants experienced forward pelvic rotation when performing ablution task. In contrast, 10 participants experienced backward pelvic rotation. The mean pelvic angle of the participants during forward pelvic rotation varied from 0.29º to 26.03º whereas the mean pelvic angle of the participants during backward pelvic rotation varied from -0.34º to -14.47º. It is range under 50º.

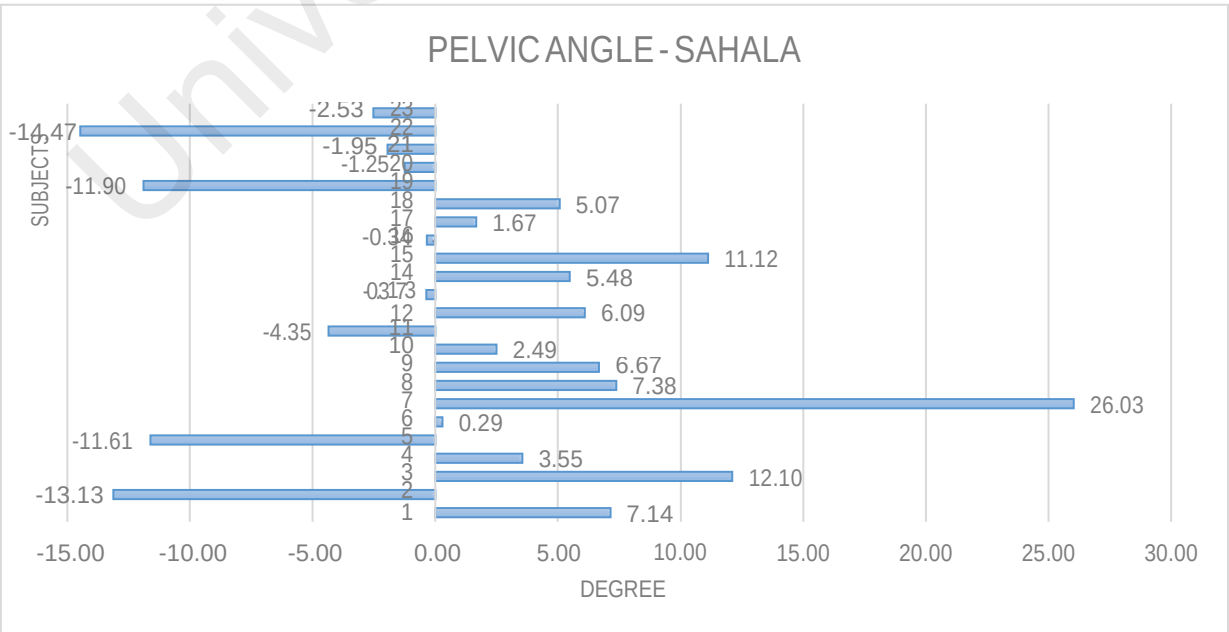

Figure 4.19: The mean pelvic angle at Ablution workstation 2

4.4.3 Back Postural Angles at Salsabila Ablution Workstation

The mean upper trunk angle for each participant using Salsabila ablution workstation is shown in Figure 4.20 below. A total of 15 out of 23 participants experienced upper trunk flexion when performing ablution task. In contrast, only 6 participants experienced upper trunk flexion. The mean upper trunk angle of the participants during upper trunk flexion varied from 1.88^{o} to 27.42^{o} whereas the mean upper trunk angle of the participants during upper trunk extension varied from -0.01^{o} to - 15.40^{o}. It is range under 50^{o}.

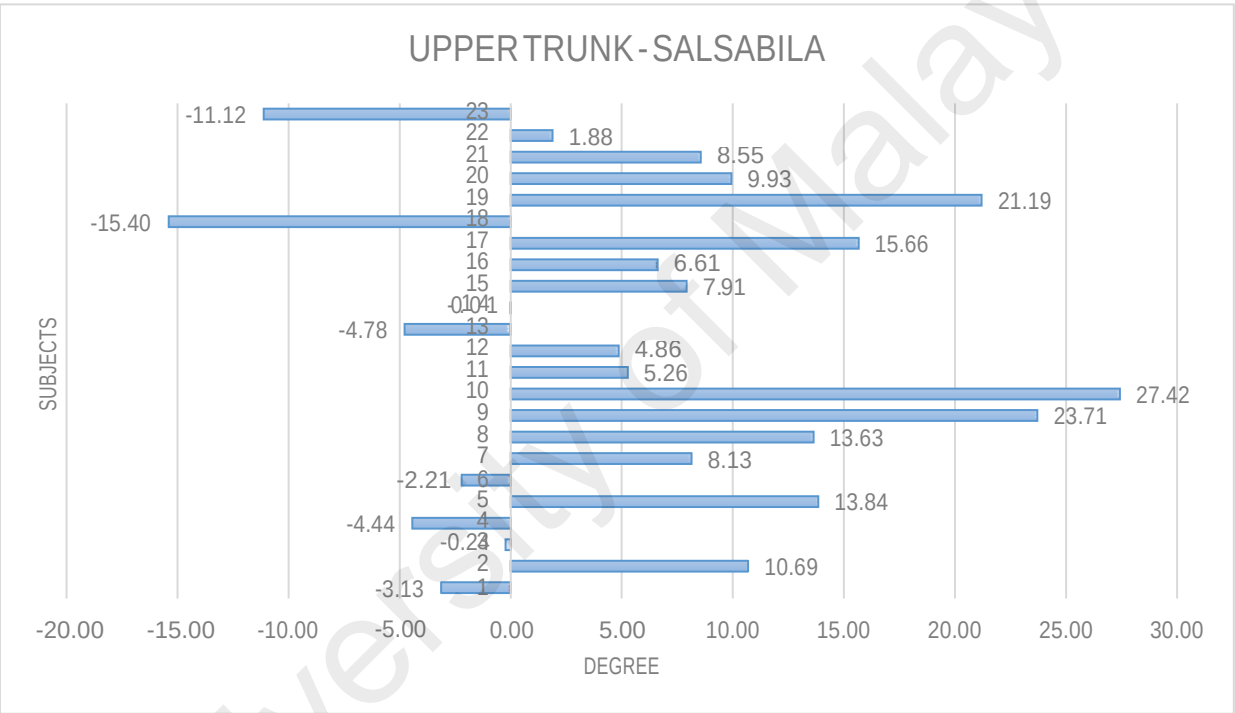

Figure 4.20: The mean upper trunk angle at Ablution workstation 3

The mean pelvic angle for each participant during ablution task using Salsabila ablution workstation is shown in Figure 4.21 below. The results revealed that 15 participants experienced forward pelvic rotation whereas 8 participants experienced backward pelvic rotation while carrying out the ablution task. It was found that the mean pelvic angle of the participants during forward and backward varied from 0.12^{o} to 37.37^{o} and -0.01^{o} to -39.70^{o}. It is range under 50^{o}.

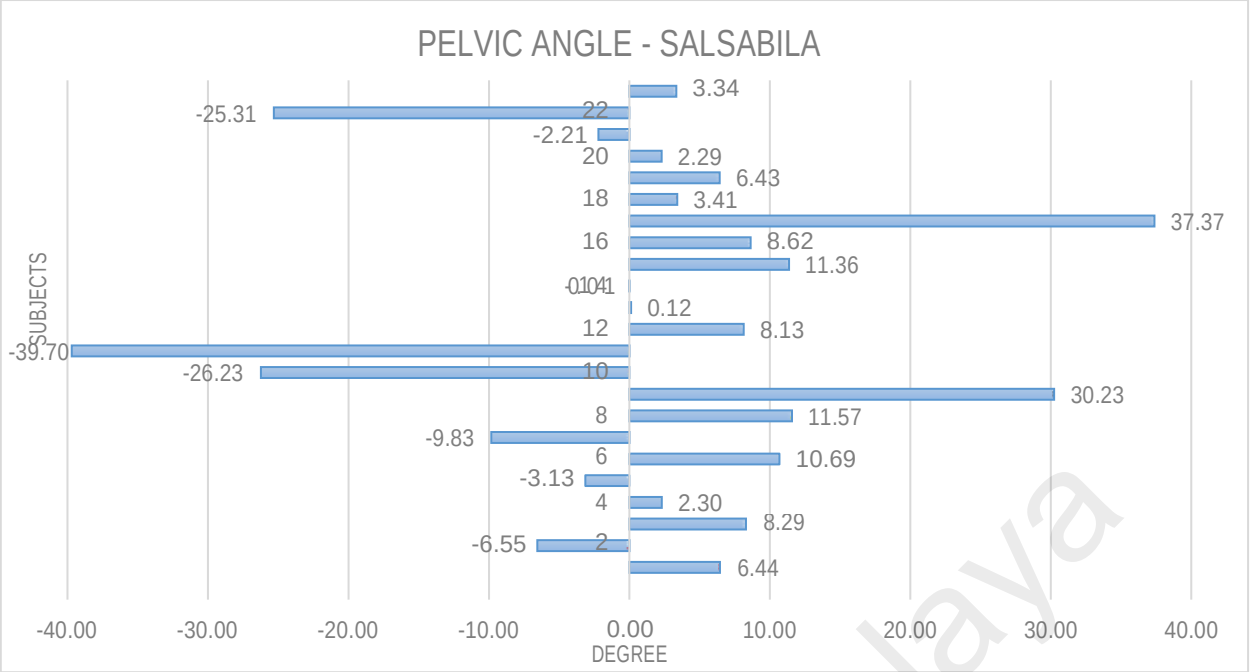

Figure 4.21: The mean pelvic angle at Ablution workstation 3

4.4.4 The upper trunk angle and pelvic angle against time

The results of the experiment which is ablution task at 3 different ablution workstations are tabulated in tables 4.12 - 4.14 below. There are 8 activities of ablution task such as; 1) washed the hand to wrist thrice, 2) rinsed the mouth thrice, 3) cleaned the nose thrice, 4) washed the face thrice, washed the arms up to elbow thrice, 6) wiped the head thrice, 7) wiped the ears thrice and 8) washed feet up to ankle thrice. Each activity of the ablution task is specified into 20 s each activity based on average time of activity during experiment task.

Table 4.12: Results of experiment task at ablution workstation 1

Activity	Time, sec	Existing ablution at PLPP Bangi			
		Upper trunk angle, °		Pelvic angle, °	
		x-axis	y-axis	x-axis	y-axis
1	20	-2.25777	14.82571	6.468508	6.763004
2	40	-4.52854	22.5185	10.29742	13.34962
3	60	-1.86711	27.0294	11.05448	15.17571
4	80	-0.4495	19.67203	5.575429	10.39389
5	100	-3.25131	14.89559	3.141323	9.743112
6	120	-5.00724	14.05848	2.779491	6.951195
7	140	-2.70631	11.29523	-4.44452	1.897187
8	160	-4.22235	-1.03223	-3.61407	-8.46982

Table 4.13: Results of experiment task at ablution workstation 2

Activity	Time, sec	Sahala ablution workstation			
		Upper trunk angle, °		Pelvic angle, °	
		x-axis	y-axis	x-axis	y-axis
1	20	-3.60306	-1.56518	-3.25652	1.741402
2	40	-1.71106	6.137659	1.229112	6.798028
3	60	-0.88831	4.517557	11.88296	6.704929
4	80	-3.95456	5.298675	1.5587	4.029563
5	100	-0.4287	1.291568	16.15203	2.040883
6	120	-0.35571	4.829151	-8.91631	0.330374
7	140	0.167409	3.638899	-2.7852	-3.89806
8	160	3.83333	1.34934	-4.95411	-6.20302

Table 4.14: Results of experiment task at ablution workstation 3

Activity	Time, sec	Salsabila ablution workstation			
		Upper trunk angle, °		Pelvic angle, °	
		x-axis	y-axis	x-axis	y-axis
1	20	-4.29298	1.111717	1.573058	1.26548
2	40	-6.96466	9.062685	2.437596	3.633
3	60	-6.70941	11.39731	2.267103	3.874034
4	80	-5.46861	7.202901	10.64522	7.349278
5	100	-6.55334	6.335516	10.25385	5.336184
6	120	-2.87156	7.123246	6.437981	1.79604
7	140	-2.90441	5.553292	-3.78487	0.775254
8	160	0.476414	0.200697	-6.48238	2.623966

4.4.5 Statistical Analysis

Statistical analysis was carried out to determine the difference in back postural angles between existing ablution workstation at PLPP Bangi, Sahala ablution workstation and Salsabila ablution workstation. The Z and p-values of the Friedman's ANOVA test are summarized in Table 4.15 below.

Table 4.15: Results of Friedman's ANOVA test

Back Posture	Surau Hidayah	Sahala	Salsabila	Z	Sig (2-tailed)
Upper Trunk	2	2.75	1.25	2	0.011
Pelvic	2.13	1.88	2	2	0.882

The Friedman's ANOVA test results revealed that there was a significant difference in the upper trunk angle (Z=2, p= 0.011), meanwhile no significant difference in pelvic angle (Z=2, p= 0.882) between Surau Hidayah, Sahala and Salsabila ablution workstations was observed. It was found that the back postural angles for Sahala ablution workstation were greater compared to others. This clearly indicates that the back postural angles in upper trunk are influenced by different designs of ablution workstation.

4.5 RULA ANALYSIS IN CATIA

The RULA analysis using Catia software at 3 different ablution workstations are presented in this section. The anthropometry dimension collected were keyed in into the manikin with different gender. Then, the manikins were inserted into the design of 3 ablution workstations. The results of RULA analysis were compared between 3 ablution workstations.

4.5.1 Surau Al-Hidayah Ablution Workstation

The Figure 4.22 and 4.24 below shows the design of ablution workstation that are installed in Surau Al-Hidayah, PLPP Bangi. The workstation consists of grab bar to help wheelchair users to move accordingly. Then, it also consists of water tap that is the same with normal ablution workstation. The illustration shows the posture when the wheelchair users were performing ablution task. As mentioned, there were 2 different manikins, one for each gender as they have different anthropometry dimension. The Figure 4.23 and 4.25 below shows the result of RULA analysis for male and female respectively. The final score for ablution workstation for both figures were 3 which means that there is a need to investigate further. The investigation required such as measurements of the dimensions of workstation, the survey to users and angle obtained during activity.

Figure 4.22: Design of ablution workstation number 1 (male)

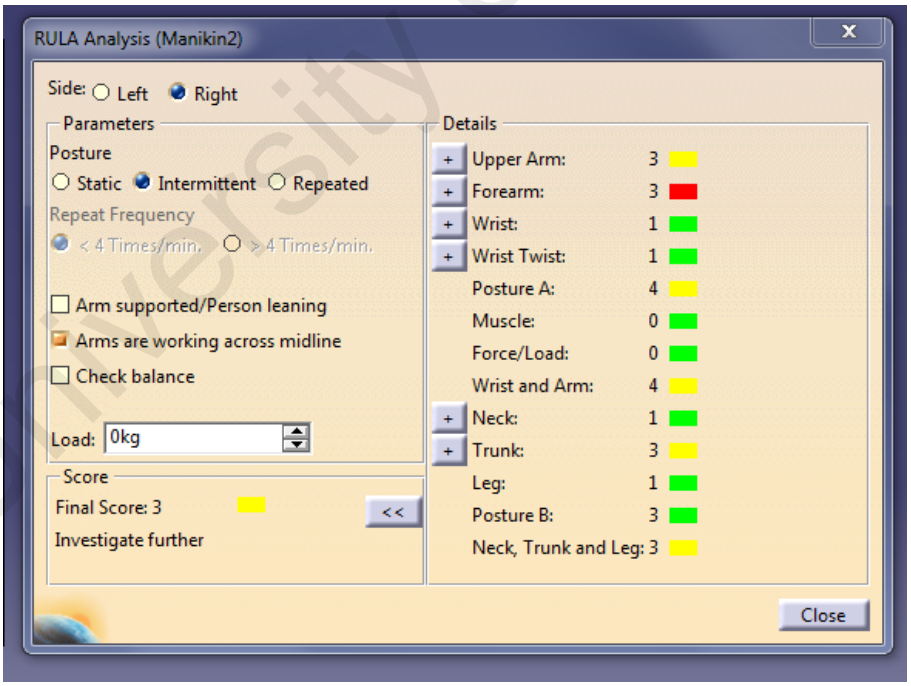

Figure 4.23: RULA analysis of ablution workstation number 1 (male)

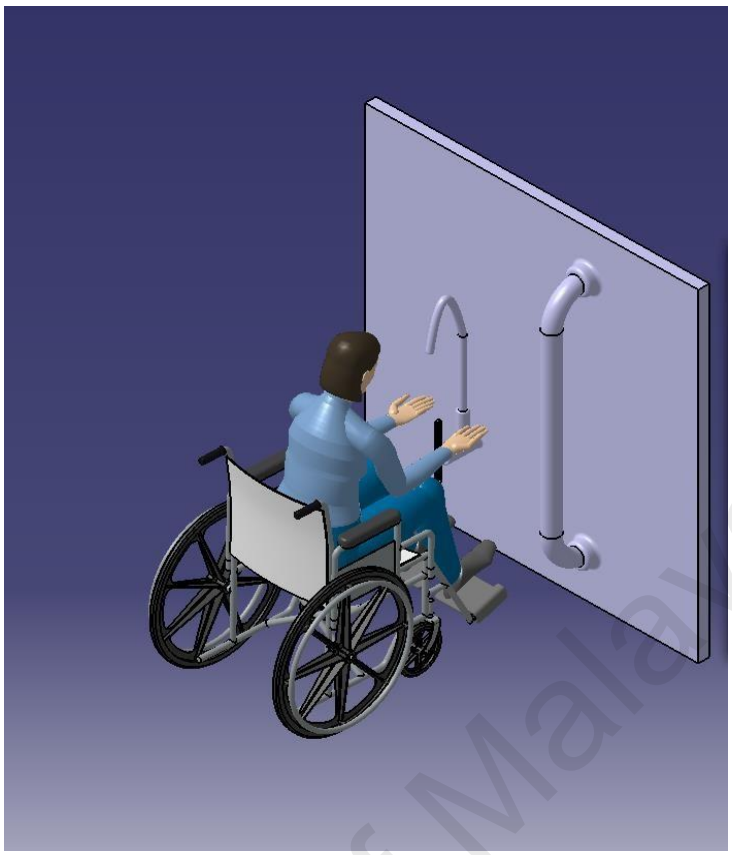

Figure 4.24: Design of ablution workstation number 1 (female)

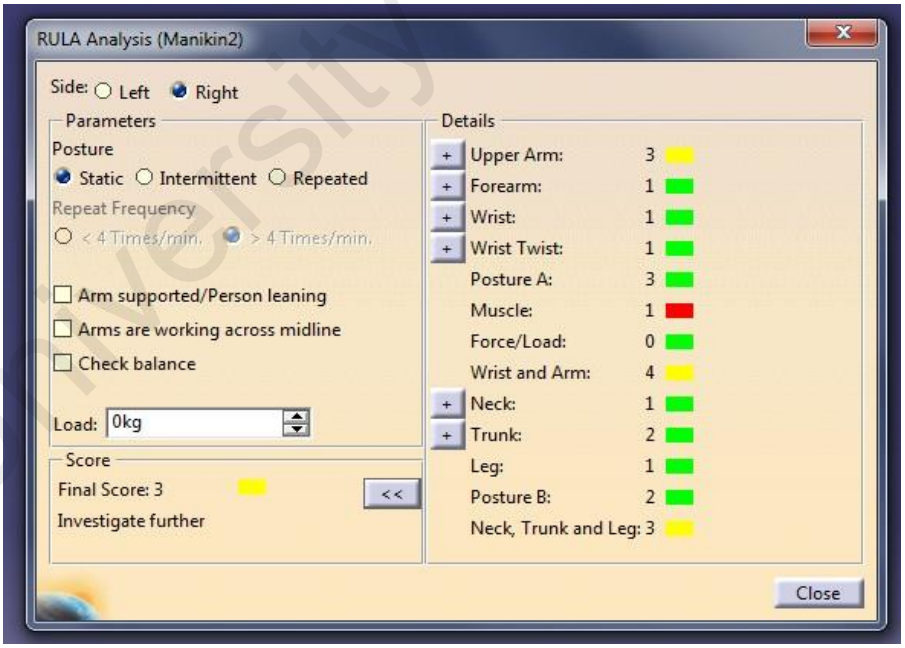

Figure 4.25: RULA analysis of ablution workstation number 1 (female)

4.5.2 Sahala Ablution Workstation

The Figure 4.26 and 4.28 below shows the design of Sahala ablution workstation created by Measat company. The illustration shows the posture when the wheelchair users were performing ablution task. There were also 2 different manikins, one for each gender as they have different anthropometry dimension. The Figure 4.27 and 4.29 below shows the result of RULA analysis for male and female respectively. The final score for ablution workstation for both figures were 3 which means that there is a need to investigate further. It was the same results as previous ablution workstation.

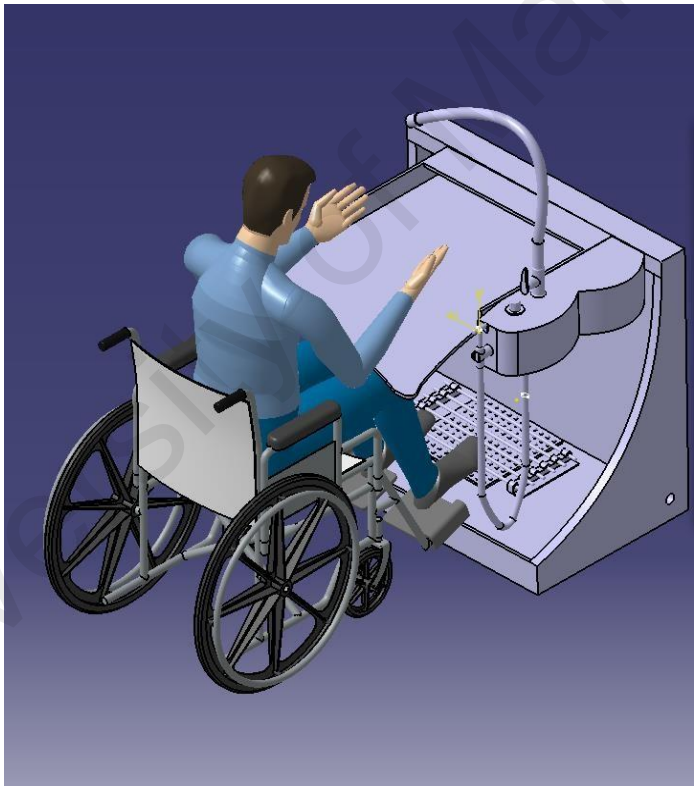

Figure 4.26: Design of ablution workstation number 2 (male)

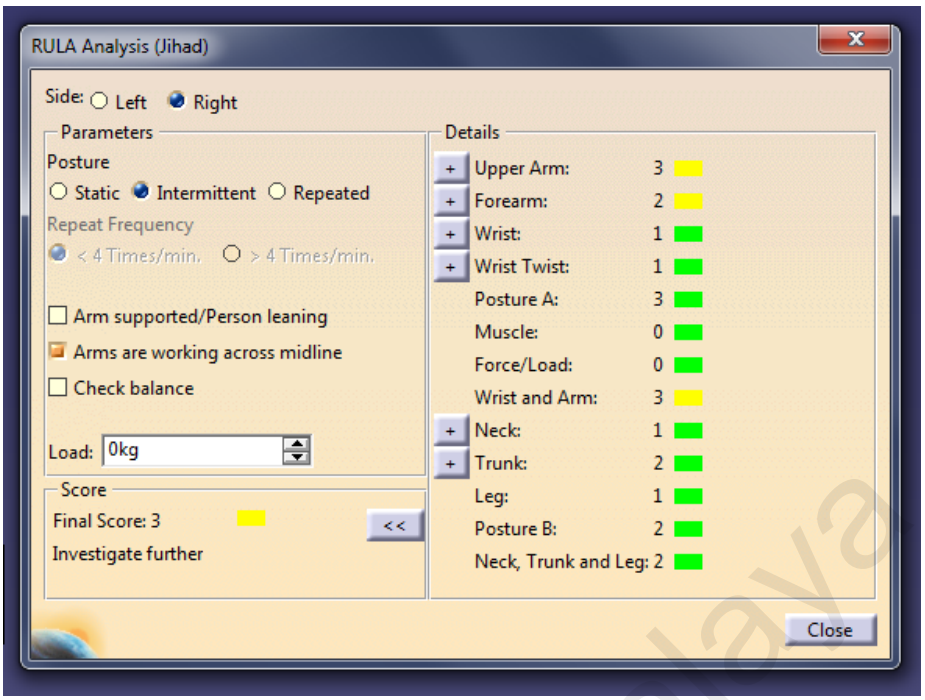

Figure 4.27: RULA analysis of ablution workstation number 2 (male)

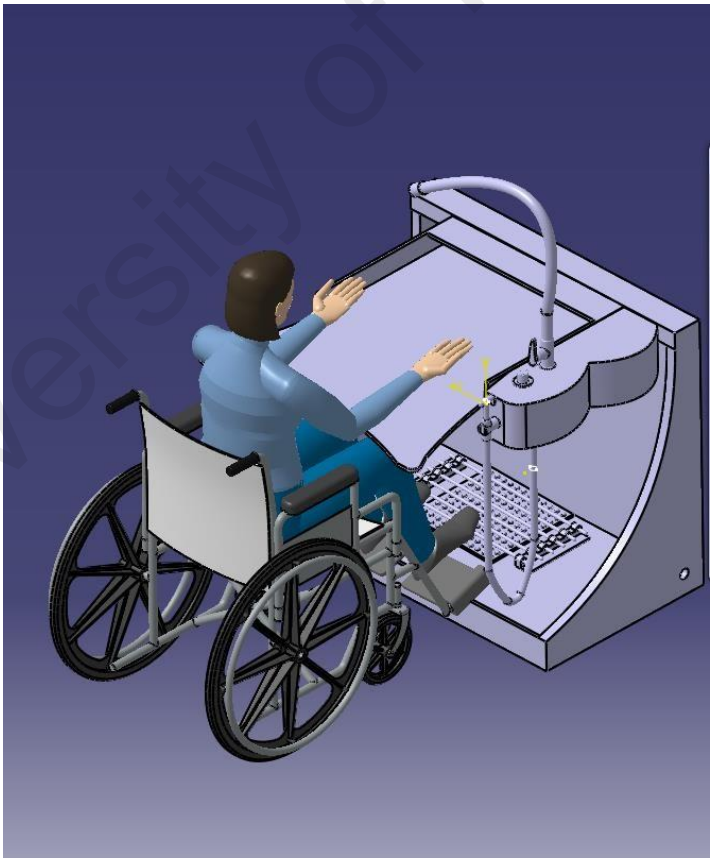

Figure 4.28: Design of ablution workstation number 2 (female)

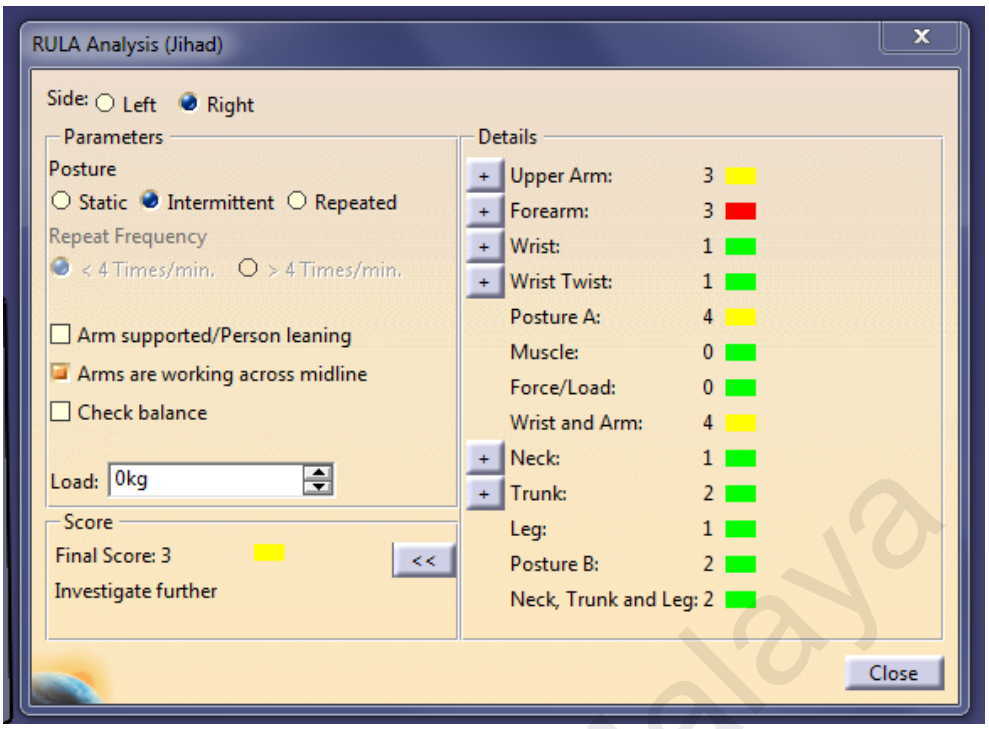

Figure 4.29: RULA analysis of ablution workstation number 2 (female)

4.5.3 Salsabila ablution workstation

The Figure 4.30 and 4.32 below shows the design of Salsabila ablution workstation created by ORKID Research Group. The illustration shows the posture when the wheelchair users were performing ablution task. There were 2 types of manikins, one for each gender, as they have different anthropometry dimension. The Figure 4.31 and 4.33 below shows the result of RULA analysis for male and female respectively. The final score for ablution workstation for both figures were 2 which means that it is acceptable. This is the best result compared to others.

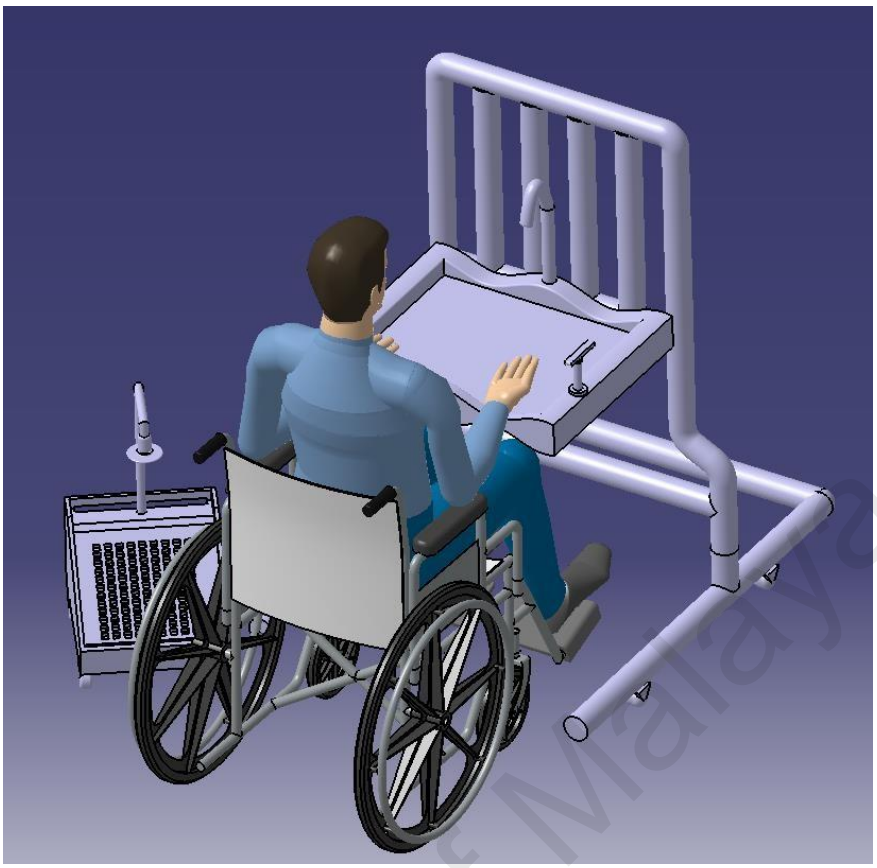

Figure 4.30: Design of ablution workstation number 3 (male)

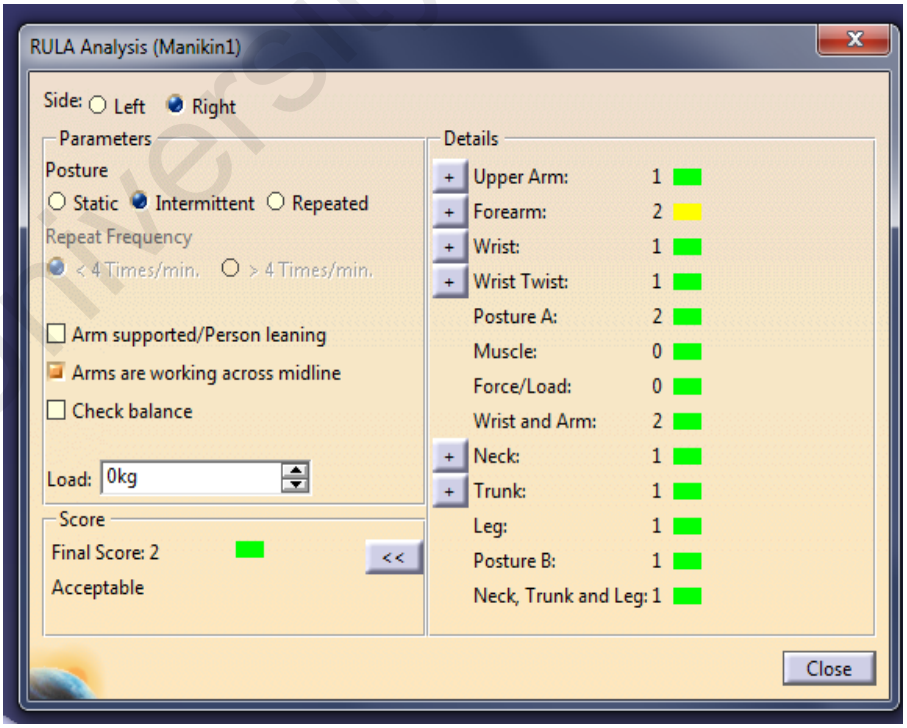

Figure 4.31: RULA analysis of ablution workstation number 3 (male)

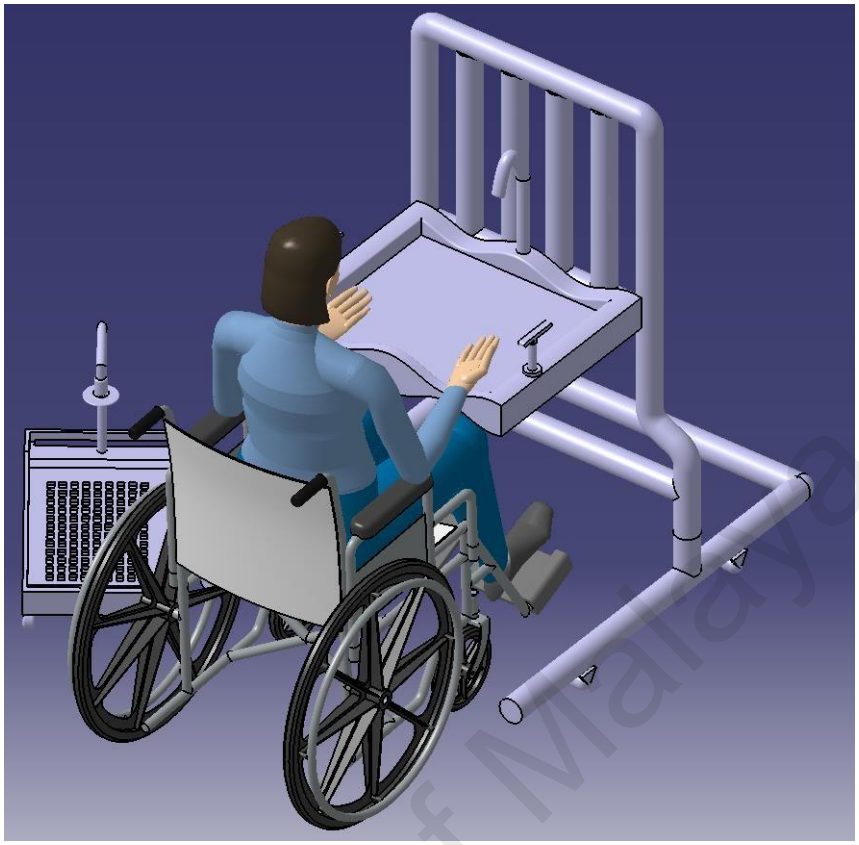

Figure 4.32: Design of ablution workstation umber 3 (female)

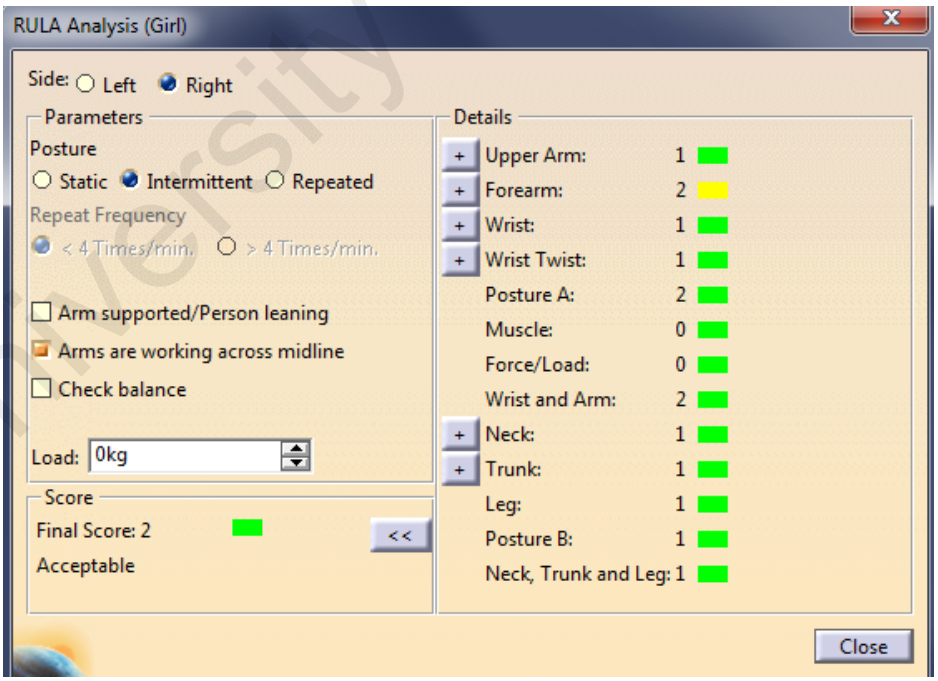

Figure 4.33: RULA analysis of ablution workstation number 3 (female)

4.5.4 Final score of RULA analysis for 3 ablution workstations

The Table 4.16 below shows the result of RULA analysis for 3 ablution workstations with 2 types of manikins, one each for male and female. Both gender for Surau al-Hidayah and Sahala ablution workstation shared the same results. However, the Salsabila ablution workstation showed the best result compared to others.

Table 4.16: RULA analysis result in this study

Ablution workstation	Gender	Score	Colours	Statement	Risk Level	Meaning
PLPP	Male	3		Investigate Further	Low	Further investigation is required, and changes may also be required
	Female	3				
Sahala	Male	3				
	Female	3				
Salsabila	Male	2		Acceptable	Negligible	The posture is acceptable if it is not retained or repeated for longer period
	Female	2				

4.6 SUMMARY

Based on the questionnaire and interview, the majority of wheelchair users from sample population preferred Salsabila ablution workstation. Meanwhile, the 95th percentile wheelchair users preferred Sahala ablution workstation as the dimensions of that workstation were more suitable for them. Moreover, based on statistical analysis which is the Friedman's ANOVA test results revealed that the back postural angles for Sahala ablution workstation was greater compared to others while the Salsabila ablution workstation was the lowest. This clearly indicated that the back postural angles in upper trunk of Salsabila ablution workstation were the least influenced during ablution task. This statement was further reinforced by the RULA analysis when Salsabila ablution workstation showed the best results compared to others. Thus, the dimensions and criteria of Salsabila ablution workstation can be adopted as the criteria for ablution workstation for wheelchair users.

CHAPTER 5: DISCUSSION

5.1 OVERVIEW

The results shown in the previous chapter are discussed in detail in this chapter. The findings from the questionnaire are first discussed, then, the findings on anthropometry measurements, followed by back postural angles. The RULA analysis using CATIA are also discussed.

5.2 QUESTIONNAIRE

The questionnaire form can be found in Appendix. The questionnaire has 49 questions split into 4 different parts of questions. The first analysis for this questionnaire was the reliability test. The reliability test result for this survey was 0.778. Thus, the result from the questionnaire fell under acceptable reliability (Deniz & Alsaffar, 2013). A total of 93 wheelchair users who had answered the questionnaire were from many places such as Selangor, Kuala Lumpur, Melaka, Kelantan and Terengganu as presented in subtopic 3.3.2. In term of gender, majority of them are male at 73.12%, and 55.91% of sample population were in the 18 to 29 years old bracket. The questionnaire was conducted mostly at the training site. This was one of the reasons why majority of the respondents were young adult male. They were still young in age and they have the passion to work for their future despite their circumstances (Soltani, et. al, 2012). From subtopic of 4.2.2.2, it was noted that the respondents who participated in this study were mostly experienced wheelchair users. That was why one of the questions about their independence had shown good results. The reason they use wheelchair were 66.66% not because of road accidents, but still 33.34% from the sample population became wheelchair users because of accidents. From 62 people, there were 23 people have spinal injury (37.1%). They had difficulty to move their spinal therefore they need to do their daily life in wheelchair; moreover, their posture is different compared to normal people (Paquet & Feathers, 2004).

Part 2 of questionnaire were about ablution activity evaluation in the mosque. One of the questions asked is about the frequency of the participants going to the mosque which is reflected on the accessibility of facilities in the mosque for them. As discussed in subtopic 4.2.3.1, there are 39.78% from the respondents who answered sometimes followed by 25.81% who answered usually. Main reason they did not always go to the mosque is accessibility of facilities which is not suitable for them. One of the facilities is ablution workstation. It is easier for them to pray at their room. This was proven when asking about place taking ablution. 48.39% from respondents prefer taking ablution at their home, followed by 34.41% from respondents who preferred their workplace or rehabilitation center. Only 17.2% chose to take ablution in mosque. When asked about comfort during each task of ablution, majority of them answered natural. But still, there are around 25.81%, 31.18%, 26.88%, 24.73% and 34.41% from respondents answered uncomfortable when washing face, washing hand, washing head, washing ears and washing feet respectively. These numbers were quite high and need to be emphasized. They really want to have ergonomics ablution workstation for them in future.

Facilities provided in mosques in Malaysia were covered in the list of questions in Part 3 of the questionnaire. The respondents were asked about the existence of part of ablution workstation in the existing mosque such as grab bar, seat, splash barrier, drain and ramp. They were also asked if they need that part or not. Based on the graph, Figure 4.7 shows that the grab bars were the least provided followed by ramp. These two facilities are important for wheelchair users when taking ablution. The number of respondents who needed grab bar and ramp are also high which was 52.69% and 44.09% respectively. The ramp is essential for wheelchair users when moving from one place to another, meanwhile the grab bars are necessary when they want to hold on something when they move forward or backward. Moreover, there were 66.67% and

70.97% of respondents who wish to have additional facilities such as sink and water tap at the feet level. Thus, these two are the criteria noted for the future of ablution workstation for them.

Last part of questionnaire was about overall satisfaction of wheelchair users on existing ablution workstation in Malaysia followed by the problem encountered during task and the suggestion for the next design of ablution workstation. All the results obtained will be taken note in consideration as criteria of ablution workstation for them. A total percentage of 32.3% answered that they were either very uncomfortable or uncomfortable while 28% answered that they were either very comfortable or comfortable with it. The number of respondents who answered uncomfortable were higher than those who answered comfortable. Thus, it is clearly proven that existing ablution workstation should be improved to become the ablution workstation that are wheelchair user- friendly.

5.3 ANTHROPOMETRY MEASUREMENT

The anthropometry measurements of 94 wheelchair users which consists of 69 males and 25 females in Malaysia were investigated in this study. The same method was also carried out by Steinfeld et al. (2002), Steinfeld, et. al (2010), Paquet & Feathers (2004); and Feathers, et. al, (2004). The data of the participants were analyzed and summarized, followed by the comparison of the data between wheelchair users and able-bodied adults. Based on the independent t-test results analysis, there are significant difference in dimensions regardless of male or female. 11 dimensions have significant differences between male Malaysian wheelchair users and male Malaysian able-bodied adults, while there are 8 dimensions with significant differences between female Malaysian wheelchair users and female Malaysian able-bodied adults. The comparison between anthropometry dimension between Male Wheelchair Users

Adults and Male Able-Bodied Adults in Malaysia are shown by visual at subtopic 4.3.3 and 4.3.4. The workstations or products may not be able to function effectively if there are mismatches between the users' anthropometric data and workstation dimensions (NIOSH, 2014). Modification of the workstation or product design is an alternative approach that can be used to overcome MSDs problems faced by the user (Deros et al., 2011). Thus, the dimensions of ablution workstation for wheelchair users need to be different with ablution workstation for normal people.

5.4 BACK POSTURAL ANGLES

The results of the back postural angles of the 23 participants consisting of 15 male and 8 female while performing ablution task on 3 different ablution workstations were recorded in the previous chapter. The back postural angles were analyzed from the upper trunk and pelvis to determine the specific postures of the participants during the ablution task. The posture angles between 3 ablution workstations were compared, which provided information of criteria in designing future ablution workstation for wheelchair users.

For upper trunk, the results using ablution workstation at Surau Al-Hidayah revealed that the upper trunk angle of the participants deviated from the sagittal plane between 6.03^{o} to 34.76^{o}, meanwhile the results using Sahala ablution workstation revealed that the upper trunk angle of the participants deviateed from the sagittal plane between 0.36^{o} to 28.80^{o}. For Salsabila ablution workstation, the upper trunk angle of the participants deviated from the sagittal plane between - 1.88^{o} to 27.42^{o}. The similarities from Surau Al-Hidayah, Sahala and Salsabila ablution workstation were that the majority of participants demonstrates upper trunk flexion which was 18, 15 and 15 people respectively. This condition indicated that the most owheelchair users from sample population tend to practice a forward posture while carrying out the ablution task. The forward posture was adopted for reaching tasks and a task which

need the eyes to focus downwards. The same posture was observed by Caneiro et al., (2010) and Szeto et al., (2009). Wheelchair users need to support a forward head and trunk posture in order to focus their eyes on the water while reaching for the water faucet. There was also a few participants who showed upper trunk extension while performing the ablution task. It was possible that the wheelchair users leaned against the backrest of wheelchair while carrying out the ablution task as they may have spinal injury that may limit their movement.

For pelvic angle, it could be seen from the results that most participants practice a forward pelvic rotation posture during ablution task. When using ablution workstation at Surau Al-Hidayah (PLPP Bangi), the range of forward pelvic rotation angle were within 0.85^{o} to 39.04^{o} while when using the Sahala ablution workstation, the range of forward pelvic rotation angle were within 0.29^{o} to 26.03^{o}. Then, when using the Salsabila ablution workstation, the range of forward pelvic rotation angle were within 0.12^{o} to 37.37^{o}. The resemblance from Surau Al-Hidayah, Sahala and Salsabila ablution workstation were the majority of participants demonstrates forward pelvic rotation posture which were 16, 13 and 15 people respectively.

The results of upper trunk angle and pelvic angle based on each activity also was recorded and tabulated in previous chapter. The results were then analysed by using Friedman's Anova test. The statistical result revealed that there was a significant difference in the upper trunk angle ($Z= 2$, $p=0.011$) between the 3 ablution workstations used. But, there is no significant difference in the pelvic angle ($Z=2$, $p=0.882$) because the p-value is bigger than 0.05. It was found that the upper trunk angle of Sahala ablution workstation were the highest compared to others. The lowest upper trunk angle was Salsabila ablution workstation. This clearly indicated that the back postural angles were influenced by task requirements. The Sahala ablution workstation were the most influenced during ablution task followed by the Surau Al-Hidayah ablution workstation.

5.5 RULA ANALYSIS

The RULA (Rapid Upper Limb Assessment) system was developed at the University of Nottingham's Institute for Occupational Ergonomics. It was developed to investigate the exposure of individual workers to risks associated with work related upper limb disorders (Niosh, 2014). In this study, RULA analysis was to investigate the exposure of wheelchair users to risks associated with ablution task related to upper limb disorders. The results showed that ablution at Surau Al- Hidayah and Sahala ablution workstation required further investigation and changes may also be required. But, for Salsabila ablution workstation, the posture was acceptable if it was not retained or repeated for longer period.

5.6 SUMMARY

Most participants preferred Salsabila ablution workstation. The criteria that it has are good for wheelchair users. The statistical analysis also showed that Salsabila ablution workstation is the best among others. The proposed ergonomic criteria of ablution workstation will be discussed in the next chapter.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The increasing number of Person with Disabilities including Wheelchair User in Malaysia means that the facilities for them cannot be underestimated. The facilities for them nowadays should be emphasized so that they can live on equal terms with other normal humans. This study has great relevance and timeliness. The study has highlighted the importance of ergonomics workstation design criteria to improve wheelchair users wellbeing.

Firstly, the problems encountered by wheelchair users to current ablution workstations are that they do not have suitable sink to prevent water splash. Then, they also do not provide water tap at foot rest. Moreover, some of them have water tap holders that require wheelchair users to rotate the holder whereas there are wheelchairs user who have deficiency in the fingers.

Secondly, there are significant differences of anthropometry measurement between wheelchair users adults and able-bodied adults. The visual comparison also showed that able-bodied adults are bigger than wheelchair user adults at most dimensions. Thus, it shows that there are significant anthropometry dimensions of wheelchair users for ablution workstation.

Thirdly, the statistical analysis on experiment of back postural using inclinometer which is the Friedman's ANOVA test results revealed that there is a significant difference in the upper trunk angle but not pelvic angle between the 3 different ablution workstations. This clearly indicated that the back postural angles in upper trunk are influenced by different design of ablution workstation.

Moreover, The RULA analysis showed that Salsabila ablution workstation is the best among three. The final score is 2 compared to other two that have final score of 3. The important criteria for ablution design can be taken as the recommendations made by wheelchair users which are to have same criteria as Salsabila ablution workstation. One of them is the sink with ergonomic curve. The water taps at foot rest prevents wheelchair users from bending their body severely. They also suggested having movable sink so that the sink can be moved forwards and backwards according to their preference and comfort. Some of the participants also suggested adding automatic water tap for future ablution workstation.

6.2 RECOMMENDATIONS FOR FUTURE WORK

6.2.1 The Proposed Ergonomics Design Criteria of Ablution Workstation for Wheelchair Users

The ergonomic design criteria of the workstation are essential to investigate before the designing process (Robertson, et. al, 2008). So, the criteria of ablution workstation are essential for designing the ablution workstation which are special to wheelchair users. Moreover, compiled anthropometry dimensions in this study were important to provide the suitable dimension for wheelchair users population as the dimensions are different with able-bodied adults population. For example, the height of sink for them are referred to elbow height which is 19.75cm.

Based on the 3 ablution workstation designs that were investigated in this study, majority of them preferred Salsabila ablution workstation compared to others. The criteria of Salsabila is suitable for wheelchair users. One of the criteria is the sink. The design of sink has ergonomic curve which support the arm of wheelchair users. Moreover, it has flexible of water hose that can be moved along with comfort of wheelchair users. The type of water tap handle is also important. The ball tap is the

most preferred handle. Other than that, Salsabila ablution workstation provides water tap at foot rest. The height of water tap at foot rest are at suitable height for wheelchair users.

The ergonomics design criteria of ablution workstation were listed based on their preferences and anthropometric dimension as well as the analysis results of RULA using CATIA software. Thus, the research findings have identified the important of design criteria in designing ablution workstation for wheelchair users, which are ergonomic shape of the sink, suitable water tap handle and flexible water tap for feet.

6.2.2 Recommendations

Every study should have recommendations for future work. The criteria of ergonomics design that are proposed in this study can be improved into the list of design of ablution workstations for wheelchair users and then, the study of product of ablution workstation design for wheelchair users.

Moreover, the recommendation for future work is to inquire and investigate the facilities provided for wheelchair users not only ablution workstation but every facility for them. Every facility should be suitable for wheelchair users and other People with Disabilities, not only for able- bodied population.

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